4.6.2 Public and Occupational Health and Safety Impacts

This section describes the radiological and hazardous chemical impacts which could result from the alternatives associated with the management of filter media residues. These impacts are presented for incident-free operation and postulated accident scenarios, respectively. The detailed site analyses are presented in Appendix D.

No construction of new processing facilities is included in any of the alternatives, but DOE may need to modify certain existing facilities and construct new waste storage buildings for some of the alternatives. Mitigation measures during modification would ensure that any radiological or hazardous chemical releases would be extremely small. Worker exposures to contaminated material would be limited to ensure that doses are maintained as low as reasonably achievable.

4.6.2.1 Incident-Free Operations

❒ **Radiological Impacts—**The radiological impacts to the public and the workers associated with incident-free operations of each technology are presented in **Table 4–28**. The impacts are those which are anticipated to occur as a result of process operations over whatever time period is necessary to process the entire inventory of filter media residues. The length of time necessary to process these residues will depend on which technology DOE decides to implement. Impacts associated with subsequent incident-free storage of stabilized residues, separated plutonium, and wastes would be much smaller than from processing.

- *IDC 331 Ful Flo Filter Media*—The highest estimated public maximally exposed individual dose from IDC 331 Ful Flo filter media operations is 5.7×10^{-6} mrem, which would occur during the sonic wash process at Rocky Flats. This hypothetical individual's latent fatal cancer risk would be increased by less than one in one hundred billion. The highest public population radiation dose from Ful Flo filter media operations would occur for both the sonic wash and mediated electrochemical oxidation processes, if DOE decides to implement either technology. The dose is estimated to be 0.00012 person-rem, which would cause far less than one additional latent fatal cancer among the population living near Rocky Flats.

  The highest involved worker population radiation dose for IDC 331 Ful Flo filter media operations would be 28 person-rem. This dose would occur if DOE decides to implement the neutralize/dry and store (No Action) technology and it would cause 0.011 additional latent cancer fatalities among the workers directly involved in the operation. Onsite workers who are not involved with the actual processing of the residues are designated as "noninvolved workers". The impacts to these workers would be expected to be much smaller than the impacts to the involved workers.

- *IDC 338 High-Efficiency Particulate Air Filter Media*—The highest estimated public maximally exposed individual dose from IDC 338 high-efficiency particulate air filter media operations is 0.000026 mrem, which would occur during the sonic wash process at Rocky Flats. This hypothetical individual's latent fatal cancer risk would be increased by less than one in ten-billion.

  The highest public population radiation dose from IDC 338 high-efficiency particulate air filter media operations would also occur for the sonic wash process, if DOE decides to implement this techology. This dose is estimated to be 0.00056 person-rem, which would cause far less than one additional latent fatal cancer among the population living near Rocky Flats.

Table 4–28 Radiological Impacts Due to Incident-Free Management of Filter Media Residues

	Offsite Public Maximally Exposed Individual		*Offsite Public Population*		*Maximally Exposed Individual Involved Worker*		*Involved Worker Population*	
	Dose (mrem)	*Probability of a Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*	*Dose (mrem/yr)*	*Probability of a Latent Cancer Fatality per year*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*
IDC 331 Ful Flo Filter Media								
Alternative 1 (No Action)								
Neutralize, Dry and Store at Rocky Flats	4.2×10^{-6}	2.1×10^{-12}	0.000088	4.4×10^{-8}	2,000	0.0008	28	0.011
Alternative 2 (without Plutonium Separation)								
Blend Down at Rocky Flats	**2.7×10^{-6}**	**1.4×10^{-12}**	**0.000057**	**2.9×10^{-8}**	**2,000**	**0.0008**	**5.5**	**0.0022**
Sonic Wash at Rocky Flats	5.7×10^{-6}	2.8×10^{-12}	0.00012	6.0×10^{-8}	2,000	0.0008	8.9	0.0036
Alternative 3 (with Plutonium Separation)								
Mediated Electrochemical Oxidation at Rocky Flats	5.5×10^{-6}	2.8×10^{-12}	0.00012	6.0×10^{-8}	2,000	0.0008	6.2	0.0025
IDC 338 High-Efficiency Particulate Air Filter Media								
Alternative 1 (No Action)								
Neutralize, Dry and Store at Rocky Flats	0.000019	9.5×10^{-12}	0.00041	2.0×10^{-7}	2,000	0.0008	82	0.033
Alternative 2 (without Plutonium Separation)								
Vitrify at Rocky Flats	4.1×10^{-6}	2.1×10^{-12}	0.00017	8.5×10^{-8}	2,000	0.0008	23	0.0092
Blend Down at Rocky Flats	0.000013	6.5×10^{-12}	0.00026	1.3×10^{-7}	2,000	0.0008	25	0.010
Sonic Wash at Rocky Flats	0.000026	1.3×10^{-11}	0.00056	2.8×10^{-7}	2,000	0.0008	39	0.016
Alternative 3 (with Plutonium Separation)								
Mediated Electrochemical Oxidation at Rocky Flats	0.000025	1.3×10^{-11}	0.00053	2.7×10^{-7}	2,000	0.0008	28	0.011
Alternative 4 (Combination)								
Neutralize and Dry at Rocky Flats	**0.000019**	**9.5×10^{-12}**	**0.00041**	**2.0×10^{-7}**	**2,000**	**0.0008**	**41**	**0.016**
Other High-Efficiency Particulate Air Filter Media								
Alternative 1 (No Action)								
Neutralize, Dry and Store at Rocky Flats	4.2×10^{-7}	2.1×10^{-13}	9.0×10^{-6}	4.5×10^{-9}	2,000	0.0008	2.1	0.00084
Alternative 2 (without Plutonium Separation)								
Vitrify at Rocky Flats	9.3×10^{-8}	4.7×10^{-14}	3.8×10^{-6}	1.9×10^{-9}	2,000	0.0008	0.51	0.00020
Blend Down at Rocky Flats	2.8×10^{-7}	1.4×10^{-13}	6.0×10^{-6}	3.0×10^{-9}	2,000	0.0008	1.7	0.00068
Sonic Wash at Rocky Flats	6.0×10^{-7}	3.0×10^{-13}	0.000013	6.5×10^{-9}	2,000	0.0008	0.88	0.00035
Alternative 3 (with Plutonium Separation)								
Mediated Electrochemical Oxidation at Rocky Flats	5.7×10^{-7}	2.9×10^{-13}	0.000012	6.0×10^{-9}	2,000	0.0008	0.64	0.00026
Alternative 4 (Combination)								
Repackage at Rocky Flats	**4.3×10^{-8}**	**2.2×10^{-14}**	**1.8×10^{-6}**	**9.0×10^{-10}**	**2,000**	**0.0008**	**1.6**	**0.00064**

Note: The impacts due to the preferred processing technology are presented in bold type.

The highest involved worker population radiation dose for IDC 338 high-efficiency particulate air filter media operations would be 82 person-rem. This dose would occur if DOE decides to implement the neutralize/dry and store (No Action) technology and it would cause 0.033 additional latent cancer fatalities among the workers directly involved in the operation. Onsite workers who are not involved with the actual processing of the residues are designated as "noninvolved workers." The impacts to these workers would be expected to be much smaller than the impacts to the involved workers.

- *Other High-Efficiency Particulate Air Filter Media*—The highest estimated public maximally exposed individual dose from other high-efficiency particulate air filter media operations is 6.0×10^{-7} mrem, which would occur during the sonic wash process at Rocky Flats. This hypothetical individual's latent fatal cancer risk would be increased by less than one in one trillion.

  The highest public population radiation dose from other high-efficiency particulate air filter media operations would also occur for the sonic wash process, if DOE decides to implement this technology. The dose is estimated to be 0.000013 person-rem, which would cause far less than one additional latent fatal cancer among the population living near Rocky Flats.

  The highest involved worker population radiation dose for other high-efficiency particulate air filter media operations would be 2.1 person-rem. This dose would occur if DOE decides to implement the neutralize/dry and store (No Action) technology and it would cause 0.00084 additional latent cancer fatalities among the workers directly involved in the operation. Onsite workers who are not involved with the actual processing of the residues are designated as "noninvolved workers." The impacts to these workers would be expected to be much smaller than the impacts to the involved workers.

❐ **Hazardous Chemical Impacts—**The processing of filter media residues at Rocky Flats would involve potential releases of the carcinogen carbon tetrachloride. Carbon tetrachloride is no longer used at Rocky Flats, but is present in small amounts in some of the residues. Under Alternative 2, the sonic wash processing has an estimated probability of excess latent cancer incidence for the offsite population maximally exposed individual of 7×10^{-12} for IDC 331 Ful Flo filter media, 3×10^{-11} for IDC 338 high-efficiency particulate air filter media, and 7×10^{-13} for other air filter media (**Table 4–29**). The impacts due to the preferred processing technologies are presented in bold type. This hypothetical individual's latent cancer chance would be increased by less than one in one billion. Less than one excess latent cancer incidence is estimated to occur in the offsite population of 2.4 million individuals living within an 80-km (50-mi) radius of Rocky Flats for both types of media. The maximally exposed individual worker probability of excess latent cancer incidence would be 4×10^{-10} for IDC 331 Ful Flo filter media, 2×10^{-9} for IDC 338 high-efficiency particulate air filter media, and 4×10^{-11} for other air filter media. This hypothetical individual's chance of incurring a latent cancer would be increased by about one in one hundred million. If all site workers were exposed to the maximally exposed individual worker concentrations of carbon tetrachloride, less than 1 excess latent cancer would be expected to occur in the workforce population.

4.6.2.2 Accidents

The potential radiological impacts to the public and the noninvolved onsite workers due to accidents with filter media residues are summarized and presented in this section. The detailed analysis of onsite accidents, with the associated assumptions, is presented in Appendix D, Section D.3. The detailed analysis considered a wide spectrum of potential accident scenarios, including fire, explosion, spill, criticality, earthquake, and aircraft crash. The accident scenarios with the highest consequences and risks were selected and carried forward to this section for the purpose of consequence and risk comparison. A composite of the risks due to major onsite accident scenarios in each spectrum (including the nonbounding accidents) was also computed and used for comparisons. The composite risk estimates are accurate enough for the purpose of comparing processing technologies against each other.

Table 4–29 Chemical Impacts Due to Incident-Free Management of Filter Media Residues

	Offsite Public Maximally Exposed Individual		*Offsite Public Population*	*Maximally Exposed Individual Worker*		*Worker Population*
	Probability of a Cancer Incidence	***Hazard Index***	***Number of Cancer Incidences***	***Probability of a Cancer Incidence***	***Hazard Index***	***Number of Cancer Incidences***
IDC 331 Ful Flo Filter Media						
Alternative 1 (No Action)						
Neutralize, Dry and Store at Rocky Flats [a]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 2 (without Plutonium Separation)						
Blend at Rocky Flats [a]	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**
Sonic Wash at Rocky Flats	7×10^{-12}	N/E	<1 [c]	4×10^{-10}	N/E	<1 [d]
Alternative 3 (with Plutonium Separation)						
Mediated Electrochemical Oxidation at Rocky Flats [a]	N/E	N/E	N/E	N/E	N/E	N/E
IDC 338 High-Efficiency Particulate Air Filter Media						
Alternative 1 (No Action)						
Neutralize, Dry and Store at Rocky Flats [a]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 2 (without Plutonium Separation)						
Vitrify at Rocky Flats [a]	N/E	N/E	N/E	N/E	N/E	N/E
Blend Down at Rocky Flats [a]	N/E	N/E	N/E	N/E	N/E	N/E
Sonic Wash at Rocky Flats [b]	3×10^{-11}	N/E	<1 [c]	2×10^{-9}	N/E	<1 [d]
Alternative 3 (with Plutonium Separation)						
Mediated Electrochemical Oxidation at Rocky Flats [a]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 4 (Combination)						
Neutralize and Dry at Rocky Flats	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**
Other High-Efficiency Particulate Air Filter Media						
Alternative 1 (No Action)						
Neutralize, Dry and Store at Rocky Flats [a]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 2 (without Plutonium Separation)						
Vitrify at Rocky Flats [a]	N/E	N/E	N/E	N/E	N/E	N/E
Blend Down at Rocky Flats [a]	N/E	N/E	N/E	N/E	N/E	N/E
Sonic Wash at Rocky Flats [b]	7×10^{-13}	N/E	<1 [c]	4×10^{-11}	N/E	<1 [d]
Alternative 3 (with Plutonium Separation)						
Mediated Electrochemical Oxidation at Rocky Flats [a]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 4 (Combination)						
Repackage at Rocky Flats	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**

N/E = No emissions.
[a] No hazardous chemicals are released from process; therefore, no associated health risks exist.
[b] No noncarcinogenic hazardous chemicals are released from the process; therefore, only cancer health risks are evaluated.
[c] In population of 2.4 million individuals living within 80 km (50 mi) of Rocky Flats.
[d] Based on extremely conservative assumption that entire Rocky Flats workforce is exposed to the maximally exposed individual worker concentration.
Note: The impacts due to the preferred processing technology are presented in bold type.

The accident frequencies and process durations of the selected accidents are presented in **Table 4–30**. The onsite accident frequencies are given on a per year basis because many accidents, such as earthquakes, are commonly expressed this way. The duration of each process is given in years. The actual probability of occurrence of each onsite accident can be obtained by multiplying the accident frequency times the technology's duration. In this way, the calculated probabilities are based on the total amount of residue in this category rather than a standard unit of time. The impacts of accidents during post-processing interim storage are presented for all the plutonium residues and scrub alloy combined in Section 4.14.

The consequences for the public and a noninvolved onsite worker are also presented in Table 4–30 for each of the filter media residue processing technologies. The public maximally exposed individual is a hypothetical individual who resides at the site boundary in the downwind direction. The public population is defined as the residential population within a radius of 80 km (50 mi). A noninvolved onsite worker is defined as an individual worker who is located 100 m (328 ft) or more downwind from the release point when an accidental release of radioactive material occurs.

The risks associated with each accident are calculated by multiplying the probability times the consequences. The risks to the public and an onsite worker are presented in **Table 4–31** for each of the five filter media residue processing technologies. The risk associated with the highest risk accident and a composite risk associated with all major accidents are both presented.

❐ **IDC 331 Ful Flo Filter Media -** The highest consequences to all three receptors would occur if DOE decides to implement the mediated electrochemical oxidation technology at Rocky Flats and a major earthquake occurs strong enough to collapse Building 371 during the processing of the residues prior to final calcination.

The highest risk to the public maximally exposed individual is estimated to be 9.1×10^{-8} and would occur due to an earthquake during processing of the residue in Rocky Flats Building 707 for the blend down technology. This individual's chance of incurring a latent cancer fatality would be increased by less than one in ten million. The highest risk to the public population is estimated at 0.0016 and would also occur due to an earthquake during processing of the residue in Rocky Flats Building 707 for the blend down technology. The highest risk to the noninvolved worker is estimated to be 8.5×10^{-7} and would occur due to the same accident as for the maximally exposed individual and public population. This individual's chance of incurring a latent cancer fatality would be increased by less than one in a million.

❐ **IDC 338 High-Efficiency Particulate Filter Media -** The highest consequences to all three receptors would occur if DOE decides to implement the mediated electrochemical oxidation technology at Rocky Flats and a major earthquake occurs strong enough to collapse Building 371 during the processing of the residues prior to final calcination.

The highest risk to the public maximally exposed individual is estimated to be 4.3×10^{-7} and would occur due to an earthquake during processing of the residue in Rocky Flats Building 707 for the blend down technology. This individual's chance of incurring a latent cancer fatality would be increased by less than one in a million. The highest risk to the public population is estimated at 0.0076 and would also occur due to an earthquake during processing of the residue in Rocky Flats Building 707 for the blend down technology. The highest risk to the noninvolved worker is estimated to be 4.0×10^{-6} and would occur due to an earthquake during processing of the residue in Rocky Flats Building 707 for the blend down technology or an earthquake during final calcination of the residue in Rocky Flats Building 707A for the mediated electrochemical oxidation technology. This individual's chance of incurring a latent cancer fatality would be increased by less than one in a hundred thousand.

Table 4–30 Accident Frequencies, Process Durations, and Consequences for Accidents with Filter Media Residues

				Offsite Public Maximally Exposed Individual Consequences		*Offsite Public Population Consequences*		*Noninvolved Onsite Worker Consequences*	
	Accident Scenario	*Accident Frequency (per year)*	*Process Duration (years)*	*Dose (mrem)*	*Probability of a Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*	*Dose (mrem)*	*Probability of a Latent Cancer Fatality*
IDC 331 Ful Flo Filter Media									
Alternative 1 (No Action) Neutralize, Dry and Store at Rocky Flats [a]	Earthquake (Bldg. 371)	0.000094	0.24	439	0.00022	5,120	2.6	3,420	0.0014
Alternative 2 (without Plutonium Separation) **Blend Down at Rocky Flats**	**Earthquake (Bldg. 371)** **Earthquake (Bldg. 707) [b]**	**0.000094** **0.0026**	**0.19** **0.19**	**555** **370**	**0.00028** **0.00019**	**6,480** **6,480**	**3.2** **3.2**	**4,320** **4,320**	**0.0017** **0.0017**
Sonic Wash at Rocky Flats	Earthquake (Bldg. 371)	0.000094	0.13	544	0.00027	6,350	3.2	4,230	0.0017
Alternative 3 (with Plutonium Separation) Mediated Electrochemical Oxidation at Rocky Flats	Earthquake (Bldg. 371) [c] Earthquake (Bldg. 707A) [d]	0.000094 0.0026	0.07 0.08	1,590 570	0.00080 0.00029	18,500 11,900	9.3 6.0	12,400 9,980	0.0050 0.0040
IDC 338 High-Efficiency Particulate Air Filter Media									
Alternative 1 (No Action) Neutralize, Dry and Store at Rocky Flats [a]	Earthquake (Bldg. 371)	0.000094	1.13	439	0.00022	5,120	2.6	3,420	0.0014
Alternative 2 (without Plutonium Separation) Vitrify at Rocky Flats	Earthquake (Bldg. 707)	0.0026	0.21	914	0.00046	16,000	8.0	10,700	0.0043
Blend Down at Rocky Flats	Earthquake (Bldg. 371) Earthquake (Bldg. 707) [b]	0.000094 0.0026	0.90 0.90	555 370	0.00028 0.00019	6,480 6,480	3.2 3.2	4,320 4,320	0.0017 0.0017
Sonic Wash at Rocky Flats	Earthquake (Bldg. 371)	0.000094	0.58	544	0.00027	6,350	3.2	4,230	0.0017
Alternative 3 (with Plutonium Separation) Mediated Electrochemical Oxidation at Rocky Flats	Earthquake (Bldg. 371) [c] Earthquake (Bldg. 707A) [d]	0.000094 0.0026	0.31 0.38	1,590 570	0.00080 0.00029	18,500 11,900	9.3 6.0	12,400 9,980	0.0050 0.0040
Alternative 4 (Combination) **Neutralize and Dry at Rocky Flats**	**Earthquake (Bldg. 371)**	**0.000094**	**1.13**	**439**	**0.00022**	**5,120**	**2.6**	**3,420**	**0.0014**

	Accident Scenario	*Accident Frequency (per year)*	*Process Duration (years)*	*Offsite Public Maximally Exposed Individual Consequences*		*Offsite Public Population Consequences*		*Noninvolved Onsite Worker Consequences*	
				Dose (mrem)	*Probability of a Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*	*Dose (mrem)*	*Probability of a Latent Cancer Fatality*
Other High-Efficiency Particulate Air Filter Media									
Alternative 1 (No Action)									
Neutralize, Dry and Store at Rocky Flats [a]	Earthquake (Bldg. 371)	0.000094	0.02	439	0.00022	5,120	2.6	3,420	0.0014
Alternative 2 (without Plutonium Separation)									
Vitrify at Rocky Flats	Earthquake (Bldg. 707)	0.0026	0.01	914	0.00046	16,000	8.0	10,700	0.0043
Blend Down at Rocky Flats	Earthquake (Bldg. 371)	0.000094	0.02	555	0.00028	6,480	3.2	4,320	0.0017
	Earthquake (Bldg. 707) [b]	0.0026	0.02	370	0.00019	6,480	3.2	4,320	0.0017
Sonic Wash at Rocky Flats	Earthquake (Bldg. 371)	0.000094	0.01	544	0.00027	6,350	3.2	4,230	0.0017
Alternative 3 (with Plutonium Separation)									
Mediated Electrochemical Oxidation at Rocky Flats	Earthquake (Bldg. 371) [c]	0.000094	0.01	1,590	0.00080	18,500	9.3	12,400	0.0050
	Earthquake (Bldg. 707A) [d]	0.0026	0.01	570	0.00029	11,900	6.0	9,980	0.0040
Alternative 4 (Combination)									
Repackage at Rocky Flats	**Earthquake (Bldg. 707)**	**0.0026**	**0.021**	**353**	**0.00018**	**6,170**	**3.1**	**4,120**	**0.0016**

[a] The accident impacts of 20 years of storage are presented in Section 4.14 for all the materials combined under Alternative 1.
[a] Building 707 is designated as an alternate location for the Shred and Blend Down process at Rocky Flats.
[b] Mediated electrochemical oxidation process in Building 371.
[c] Final calcination process in Building 707A.
Note: The impacts due to the preferred processing technology are presented in bold type.

Table 4–31 Risks Due to Accidents with Filter Media Residues

	Accident Scenario	*Offsite Public Maximally Exposed Individual Risk (Probability of a Latent Cancer Fatality)*	*Offsite Public Population Risk (Number of Latent Cancer Fatalities)*	*Noninvolved Onsite Worker Risk (Probability of a Latent Cancer Fatality)*
IDC 331 Ful Flo Filter Media				
Alternative 1 (No Action)				
Neutralize, Dry and Store at Rocky Flats [a]	Earthquake (Bldg. 371) Composite	4.9×10^{-9} 7.0×10^{-9}	0.000058 0.000082	3.1×10^{-8} 4.3×10^{-8}
Alternative 2 (without Plutonium Separation)				
Blend Down at Rocky Flats	**Earthquake (Bldg. 371)** **Composite (Bldg. 371)** **Earthquake (Bldg. 707) [b]** **Composite (Bldg. 707) [b]**	$\mathbf{5.0\times10^{-9}}$ $\mathbf{7.0\times10^{-9}}$ $\mathbf{9.1\times10^{-8}}$ $\mathbf{9.3\times10^{-8}}$	**0.000058** **0.000082** **0.0016** **0.0016**	$\mathbf{3.1\times10^{-8}}$ $\mathbf{4.4\times10^{-8}}$ $\mathbf{8.5\times10^{-7}}$ $\mathbf{8.7\times10^{-7}}$
Sonic Wash at Rocky Flats	Earthquake (Bldg. 371) Composite	3.3×10^{-9} 4.7×10^{-9}	0.000039 0.000055	2.1×10^{-8} 2.9×10^{-8}
Alternative 3 (with Plutonium Separation)				
Mediated Electrochemical Oxidation at Rocky Flats	Earthquake (Bldg. 371) Composite Earthquake (Bldg. 707A) Composite	5.2×10^{-9} 1.0×10^{-8} 5.9×10^{-8} 6.0×10^{-8}	0.000061 0.00011 0.0012 0.0013	3.3×10^{-8} 4.7×10^{-8} 8.3×10^{-7} 8.4×10^{-7}
IDC 338 High-Efficiency Particulate Filter Media				
Alternative 1 (No Action)				
Neutralize, Dry and Store at Rocky Flats [a]	Earthquake (Bldg. 371) Composite	2.3×10^{-8} 3.3×10^{-8}	0.00027 0.00038	1.4×10^{-7} 2.1×10^{-7}
Alternative 2 (without Plutonium Separation)				
Vitrify at Rocky Flats	Earthquake (Bldg. 707) Composite	2.5×10^{-7} 2.5×10^{-7}	0.00044 0.00044	2.3×10^{-6} 2.4×10^{-6}
Blend Down at Rocky Flats	Earthquake (Bldg. 371) Composite (Bldg. 371) Earthquake (Bldg. 707) [b] Composite (Bldg. 707) [b]	2.3×10^{-8} 3.3×10^{-8} 4.3×10^{-7} 4.4×10^{-7}	0.00027 0.00039 0.0076 0.0077	1.5×10^{-7} 2.1×10^{-7} 4.0×10^{-6} 4.1×10^{-6}
Sonic Wash at Rocky Flats	Earthquake (Bldg. 371) Composite	1.5×10^{-8} 2.1×10^{-8}	0.00017 0.00024	9.2×10^{-8} 1.3×10^{-7}
Alternative 3 (with Plutonium Separation)				
Mediated Electrochemical Oxidation at Rocky Flats	Earthquake (Bldg. 371) Composite Earthquake (Bldg. 707A) Composite	2.3×10^{-8} 4.5×10^{-8} 2.8×10^{-7} 2.9×10^{-7}	0.00027 0.00049 0.0059 0.0060	1.4×10^{-7} 2.1×10^{-7} 4.0×10^{-6} 4.2×10^{-6}

	Accident Scenario	*Offsite Public Maximally Exposed Individual Risk (Probability of a Latent Cancer Fatality)*	*Offsite Public Population Risk (Number of Latent Cancer Fatalities)*	*Noninvolved Onsite Worker Risk (Probability of a Latent Cancer Fatality)*
Alternative 4 (Combination)				
Neutralize and Dry at Rocky Flats	**Earthquake (Bldg. 371)**	**2.3×10^{-8}**	**0.00027**	**1.4×10^{-7}**
	Composite	**3.3×10^{-8}**	**0.00038**	**2.1×10^{-7}**
Other High-Efficiency Particulate Air Filter Media				
Alternative 1 (No Action)				
Neutralize, Dry and Store at Rocky Flats [a]	Earthquake (Bldg. 371)	4.1×10^{-10}	4.8×10^{-6}	2.6×10^{-9}
	Composite	5.8×10^{-10}	6.8×10^{-6}	3.6×10^{-9}
Alternative 2 (without Plutonium Separation)				
Vitrify at Rocky Flats (High-Efficiency Particulate Air only)	Earthquake (Bldg. 707)	1.2×10^{-8}	0.00021	1.1×10^{-7}
	Composite	1.2×10^{-8}	0.00021	1.1×10^{-7}
Blend Down at Rocky Flats	Earthquake (Bldg. 371)	5.2×10^{-10}	6.1×10^{-6}	3.2×10^{-9}
	Composite (Bldg. 371)	7.4×10^{-10}	8.6×10^{-6}	4.6×10^{-9}
	Earthquake (Bldg. 707) [b]	9.6×10^{-9}	0.00017	9.0×10^{-8}
	Composite (Bldg. 707) [b]	9.8×10^{-9}	0.00017	9.2×10^{-8}
Sonic Wash at Rocky Flats	Earthquake (Bldg. 371)	2.6×10^{-10}	3.0×10^{-6}	1.6×10^{-9}
	Composite	3.6×10^{-10}	4.2×10^{-6}	2.2×10^{-9}
Alternative 3 (with Plutonium Separation)				
Mediated Electrochemical Oxidation at Rocky Flats	Earthquake (Bldg. 371)	7.5×10^{-10}	8.7×10^{-6}	4.7×10^{-9}
	Composite	1.4×10^{-9}	0.000016	6.7×10^{-9}
	Earthquake (Bldg. 707A)	7.4×10^{-9}	0.00015	1.0×10^{-7}
	Composite	7.5×10^{-9}	0.00016	1.1×10^{-7}
Alternative 4 (Combination)				
Repackage at Rocky Flats	**Earthquake (bldg. 707)**	**9.6×10^{-9}**	**0.00017**	**9.0×10^{-8}**
	Composite (bldg. 707)	**9.8×10^{-9}**	**0.00017**	**9.1×10^{-8}**

[a] The accident impacts of 20 years of storage are presented in Section 4.14 for all the materials combined under Alternative 1.
[b] Building 707 is designated as an alternate location for the Shred and Blend Down process at Rocky Flats.
Note: The impacts due to the preferred processing technology are presented in bold type.

- **Other Filter Media -** The highest consequences to all three receptors would occur if DOE decides to implement the mediated electrochemical oxidation technology at Rocky Flats and a major earthquake occurs strong enough to collapse Building 371 during the processing of the residues prior to final calcination.

  The highest risk to the public maximally exposed individual is estimated to be 1.2×10^{-8} and would occur due to an earthquake during processing of the residue in Rocky Flats Building 707 for the vitrification technology. This individual's chance of incurring a latent cancer fatality would be increased by less than one in ten million. The highest risk to the public population is estimated at 0.00021 and would also occur due to an earthquake during processing of the residue in Rocky Flats Building 707 for the vitrification technology. The highest risk to the noninvolved worker is estimated to be 1.1×10^{-7} and would occur due to the same accident as for the maximally exposed individual and public population. This individual's chance of incurring a latent cancer fatality would be increased by less than one in a million.

4.7 IMPACTS OF MANAGING SLUDGE RESIDUES

The inventory of sludge residues weighs 619 kg (1,364 lb), including 26.7 kg (58.9 lb) of plutonium. The entire inventory is stored in 54 drums (with about 270 internal metal containers) and 34 other small individual containers.

As discussed in Chapter 2, the alternatives for sludge residues include one technology under the No Action Alternative, two technologies under the Process without Plutonium Separation Alternative, one technology under the Process with Plutonium Separation Alternative, and one technology under Alternative 4. The preferred processing technology is to filter/dry the residue at Rocky Flats. A small portion of the sludge residue inventory (7 kg [15 lb]) is broken out into a separate subcategory because no processing technology is available for this material under the Process With Plutonium Separation Alternative and it has a different technology under Alternative 4.

This section presents the environmental impacts of managing the entire inventory of sludge residues under each of the technlogies. The results in this section were used in the calculation of the total impacts of the No Action Alternative and the Preferred Alternative which are presented in Sections 4.20 and 4.21, respectively, and of the management approaches which are presented in Section 4.22.

4.7.1 Products and Wastes

Every processing technology for sludge residues would generate some quantity of transuranic waste and would prepare this waste for disposal in WIPP. Every technology would also generate some quantity of low-level waste, which would be disposed of routinely using existing procedures at Rocky Flats. A small portion of the low-level waste generated at Rocky Flats could possibly be low-level mixed waste, but this waste would also be disposed of routinely using existing procedures. The No Action Alternative would generate stabilized residues that would have to remain in storage indefinitely. The Process without Plutonium Separation Alternative would generate transuranic waste directly from the residue. In some of the processing technologies the stabilized residues and transuranic waste would be placed in pipe components inside 208-liter (55-gal) drums as shown in Figure 2-13 in Chapter 2. If DOE applies variances to the stabilized residues (Alternative 4), then the stabilized residues could be disposed in WIPP as transuranic waste.

High-level waste and saltstone will not be generated from sludge residues because none of the technologies involve shipping the residues to the Savannah River Site for plutonium separation. If plutonium is separated at Rocky Flats, it would be stored securely onsite until a decision is made on its disposition. No increase in proliferation risk would result and this plutonium would not be used for nuclear explosive purposes. This separated plutonium would also contain the americium from the sludge residues.

The solid plutonium-bearing products and wastes that would be generated from sludge residues under each of the technologies are presented in **Table 4–32**. The shaded areas of Table 4–32 indicate types of solid products and wastes that would not be generated under the various technologies. The products and wastes from the preferred processing technologies are presented in bold type. The largest amount of transuranic waste (653 drums) would be generated in the dissolve and oxidize technology. The two technlogies under Alternative 2 would generate only about one-third as much transuranic waste. The stabilized residues generated in Alternative 4 could be disposed of in WIPP, just like transuranic waste. Thus, this technology would generate over 1,100 drums (stabilized residues plus transuranic waste) to be sent to WIPP. The quantity of low-level waste would also be highest under the dissolve and oxidize technology, and much lower under all the other technologies. The site would manage this waste using routine procedures. The maximum amount of plutonium that could be separated from sludge residues is 25 kg (55 lb).

4.7.2 Public and Occupational Health and Safety Impacts

This section describes the radiological and hazardous chemical impacts which could result from the alternatives associated with the management of sludge residues. These impacts are presented for incident-free operation and postulated accident scenarios, respectively. The detailed site analyses are presented in Appendix D. No construction of new processing facilities is included in any of the alternatives, but DOE may need to modify certain existing facilities and construct new waste storage buildings for some of the alternatives. Mitigation measures during modifications would ensure that any radiological or hazardous chemical releases would be extremely small. Worker exposures to contaminated material would be limited to ensure that doses are maintained as low as reasonably achievable.

4.7.2.1 Incident-Free Operations

- **Radiological Impacts—**The radiological impacts to the public and the workers associated with incident-free operations of each technology are presented in **Table 4–33**. The impacts are those which are anticipated to occur as a result of process operations over whatever time period is necessary to process the entire inventory of sludge residues. The length of time necessary to process these residues will depend on which technology DOE decides to implement. Impacts associated with subsequent incident-free storage of stabilized residues, separated plutonium, and wastes would be much smaller than from processing.

  The highest estimated public maximally exposed individual dose in Table 4–33 is 7.3×10^{-6} mrem, which would occur during the acid dissolve process at Rocky Flats. This hypothetical individual's latent fatal cancer risk would be increased by less than one in one-hundred billion. The highest public population radiation dose listed in Table 4–33 would also occur for the acid dissolve process, if DOE decides to implement this technology. This dose is estimated to be 0.00016 person-rem, which would cause far less than one additional latent fatal cancer among the population living near Rocky Flats.

  The highest involved worker population radiation dose would be 38 person-rem, which would occur if DOE decides to implement the acid dissolve technology. This dose would cause 0.015 additional latent cancer fatalities among the workers directly involved in the operation. Onsite workers who are not involved with the actual processing of the residues are designated as "noninvolved workers." The impacts to these workers would be expected to be much smaller than the impacts to the involved workers.

- **Hazardous Chemical Impacts—**The impacts of exposure to hazardous chemicals from the processing of sludge residues at Rocky Flats were not evaluated because hazardous chemicals are not expected to be released from the proposed operations at this site.

Table 4–32 Products and Wastes from Sludge Residues

	Stabilized Residues (Drums) [a]	*Transuranic Waste (Drums)* [a]	*High-Level Waste (Canisters of Glass)* [b]	*Separated Plutonium (kg)* [c]	*Low-Level Waste (Drums)* [a]	*Saltstone (cubic meters)*
IDC 089, 099 and 332 Sludge Residues						
Alternative 1 (No Action) Filter/Dry and Store at Rocky Flats	45	2			1	
Alternative 2 (without Plutonium Separation) Vitrify at Rocky Flats		3			1	
Blend Down at Rocky Flats		8			1	
Alternative 4 (Combination) **Repackage at Rocky Flats**	**6** [d]	**2**			**1**	
Other Sludge Residues						
Alternative 1 (No Action) Filter/Dry and Store at Rocky Flats	1,095	60			127	
Alternative 2 (without Plutonium Separation) Vitrify at Rocky Flats		216			127	
Blend Down at Rocky Flats		212			127	
Alternative 3 (with Plutonium Separation) Dissolve and Oxidize at Rocky Flats		653		25	1,468	
Alternative 4 (Combination) **Filter/Dry at Rocky Flats**	**1,095**[d]	**60**			**127**	

[a] Standard 55-gallon (208-liter) drums. (208 liters is equal to 0.208 cubic meters.)
[b] Each canister is 2 feet (61 cm) in diameter, 10 feet (300 cm) tall, and contains approximately 3,700 pounds (1,680 kg) of high-level waste glass.
[c] To convert to pounds, multiply by 2.2.
[d] These stabilized residues could be disposed of in WIPP as transuranic waste.

Notes: Shaded areas indicate the types of solid products and waste that would not be generated. The storage capacities at each site are adequate to store the products and wastes listed in this table. The impacts due to the preferred processing technologies are presented in bold type.

Table 4–33 Radiological Impacts Due to Incident-Free Management of Sludge Residues

	Offsite Public Maximally Exposed Individual Risk		*Offsite Public Population*		*Maximally Exposed Individual Involved Worker*		*Involved Worker Population*	
	Dose (mrem)	*Probability of a Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*	*Dose (mrem/yr)*	*Probability of a Latent Cancer Fatality per year*	*Dose (person-rem)*	*Number of Cancer Incidences*
IDC 089, 099 and 332 Sludge Residues								
Alternative 1 (No Action) Filter, Dry and Store at Rocky Flats	$1.4{\times}10^{-7}$	$7.0{\times}10^{-14}$	$2.8{\times}10^{-6}$	$1.4{\times}10^{-9}$	2,000	0.0008	1.0	0.00040
Alternative 2 (without Plutonium Separation) Vitrify at Rocky Flats	$4.6{\times}10^{-8}$	$2.3{\times}10^{-14}$	$1.9{\times}10^{-6}$	$9.5{\times}10^{-10}$	2,000	0.0008	0.23	0.000092
Blend Down at Rocky Flats	$3.8{\times}10^{-8}$	$1.9{\times}10^{-14}$	$1.6{\times}10^{-6}$	$8.0{\times}10^{-10}$	2,000	0.0008	0.23	0.000092
Alternative 4 (Combination) **Repackage at Rocky Flats**	$\mathbf{4.0{\times}10^{-8}}$	$\mathbf{2.0{\times}10^{-14}}$	$\mathbf{1.6{\times}10^{-6}}$	$\mathbf{8.0{\times}10^{-10}}$	**2,000**	**0.0008**	**0.18**	**0.000072**
Other Sludge Residues								
Alternative 1 (No Action) Filter, Dry and Store at Rocky Flats	$3.6{\times}10^{-6}$	$1.8{\times}10^{-12}$	0.000077	$3.9{\times}10^{-8}$	2,000	0.0008	25	0.010
Alternative 2 (without Plutonium Separation) Vitrify at Rocky Flats	$1.3{\times}10^{-6}$	$6.5{\times}10^{-13}$	0.000050	$2.5{\times}10^{-8}$	2,000	0.0008	6.4	0.0026
Blend Down at Rocky Flats	$3.6{\times}10^{-6}$	$1.8{\times}10^{-12}$	0.000077	$3.9{\times}10^{-8}$	2,000	0.0008	6.4	0.0026
Alternative 3 (with Plutonium Separation) Acid Dissolve at Rocky Flats	$7.3{\times}10^{-6}$	$3.7{\times}10^{-12}$	0.00016	$8.0{\times}10^{-8}$	2,000	0.0008	38	0.015
Alternative 4 (Combination) **Filter and Dry at Rocky Flats**	$\mathbf{3.6{\times}10^{-6}}$	$\mathbf{1.8{\times}10^{-12}}$	**0.000077**	$\mathbf{3.9{\times}10^{-8}}$	**2,000**	**0.0008**	**11**	**0.0044**

Note: The impacts due to the preferred processing technology are presented in bold type.

4.7.2.2 Accidents

The potential radiological impacts to the public and the noninvolved onsite workers due to accidents with sludge residues are summarized and presented in this section. The detailed analysis of onsite accidents, with the associated assumptions, is presented in Appendix D, Section D.3. The detailed analysis considered a wide spectrum of potential accident scenarios, including fire, explosion, spill, criticality, earthquake, and aircraft crash. The accident scenarios with the highest consequences and risks were selected and carried forward to this section for the purpose of consequence and risk comparison. A composite of the risks due to major onsite accident scenarios in each spectrum (including the nonbounding accidents) was also computed and used for comparisons. The composite risk estimates are accurate enough for the purpose of comparing processing technologies against each other.

The accident frequencies and process durations of the selected accidents are presented in **Table 4–34**. The onsite accident frequencies are given on a per year basis because many accidents, such as earthquakes, are commonly expressed this way. The duration of each process is given in years. The actual probability of occurrence of each onsite accident can be obtained by multiplying the accident frequency times the technology's duration. In this way, the calculated probabilities are based on the total amount of residue in this category rather than a standard unit of time. The impacts of accidents during post-processing interim storage are presented for all the plutonium residues and scrub alloy combined in Section 4.14.

The consequences for the public and a noninvolved onsite worker are also presented in Table 4–33, for each of the sludge residue processing technologies. The public maximally exposed individual is a hypothetical individual who resides at the site boundary in the downwind direction. The public population is defined as the residential population within a radius of 80 km (50 mi). A noninvolved onsite worker is defined as an individual worker who is located 100 m (328 ft) or more downwind from the release point when an accidental release of radioactive material occurs.

The highest consequences to all three receptors for sludge residues other than IDC 089, 099 and 332, would occur if DOE decides to implement the blend down technology and a major earthquake strong enough to cause the breach of Building 371 occurs during the 0.062 years of residue processing at Rocky Flats.

The risks associated with each accident are calculated by multiplying the probability times the consequences. The risks to the public and an onsite worker are presented in **Table 4–35**, for each of the four sludge residue processing technologies. The risk associated with the highest risk accident and a composite risk associated with all major accidents are both presented.

The highest risk to the public maximally exposed individual for sludge residues other than IDC 089, and 99 and 332, is estimated to be 1.2×10^{-7}, which is due to an earthquake during processing of the residue with the blend down technology in Rocky Flats Building 707. This individual's chance of incurring a latent cancer fatality would be increased by less than one in one million. The highest risk to the public population is estimated to be 0.0022 latent cancer fatalities, which is also due to an earthquake during processing of the residue with the blend down technology in Building 707. The highest risk to the individual noninvolved onsite worker is estimated to be 1.1×10^{-6}, which is due to the same accident scenario in the same technology. This individual's chance of incurring a latent cancer fatality would be increased by less than one in a hundred thousand.

4.8 IMPACTS OF MANAGING GLASS RESIDUES

The inventory of glass residues weighs 134 kg (295 lb), including 5.1 kg (11.2 lb) of plutonium. The entire inventory is stored in 10 drums with no internal metal containers.

Table 4–34 Accident Frequencies, Process Durations, and Consequences for Accidents with Sludge Residues

				Offsite Public Maximally Exposed Individual Consequences		*Offsite Public Population Consequences*		*Noninvolved Onsite Worker Consequences*	
	Accident Scenario	*Accident Frequency (per year)*	*Process Duration (years)*	*Dose (mrem)*	*Probability of a Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*	*Dose (mrem)*	*Probability of a Latent Cancer Fatality*
IDC 089, 099 and 332 Sludge Residues									
Alternative 1 (No Action) Filter, Dry and Store at Rocky Flats [a]	Earthquake (Bldg. 371)	0.000094	0.01	521	0.00026	6,080	3.0	4,050	0.0016
Alternative 2 (without Plutonium Separation) Vitrify at Rocky Flats	Explosion (Bldg. 707) [b]	0.00005	0.002	960	0.00048	16,800	8.4	11,200	0.0045
	Earthquake (Bldg. 707) [c]	0.0026	0.002	914	0.00046	16,000	8.0	10,700	0.0043
Blend Down at Rocky Flats	Earthquake (Bldg. 707)	0.0026	0.035	105	0.000053	1,830	0.9	1,220	0.00049
	Earthquake (Bldg. 371) [d]	0.000094	0.035	157	0.000079	1,830	0.9	1,220	0.00049
Alternative 4 (Combination) **Repackage at Rocky Flats**	**Earthquake (Bldg. 707)**	**0.0026**	**0.015**	**228**	**0.00011**	**4,000**	**2.0**	**2,670**	0.0011
Other Sludge Residues									
Alternative 1 (No Action) Filter, Dry and Store at Rocky Flats [a]	Earthquake (Bldg. 371)	0.000094	0.20	692	0.00035	8,070	4.0	5,380	0.0022
Alternative 2 (without Plutonium Separation) Vitrify at Rocky Flats	Explosion (Bldg. 707) [b]	0.00005	0.062	960	0.00048	16,800	8.4	11,200	0.0045
	Earthquake (Bldg. 707) [c]	0.0026	0.062	914	0.00046	16,000	8.0	10,700	0.0043
Blend Down at Rocky Flats	Earthquake (Bldg. 707)	0.0026	0.062	1,520	0.00076	26,700	13	17,800	0.0071
	Earthquake (Bldg. 371) [d]	0.000094	0.062	2,290	0.0011	26,700	13	17,800	0.0071
Alternative 3 (with Plutonium Separation) Dissolve and Oxidize at Rocky Flats	Criticality (Bldg. 371) [e]	0.0001	0.88	790	0.00040	6,980	3.5	321	0.00013
	Earthquake (Bldg. 707A) [f]	0.0026	0.061	760	0.00038	15,800	7.9	13,300	0.0053
Alternative 4 (Combination) **Filter and Dry at Rocky Flats**	**Earthquake (Bldg. 371)**	**0.000094**	**0.20**	**692**	**0.00035**	**8,070**	**4.0**	**5,380**	**0.0022**

[a] The accident impacts of 20 years of storage are presented in Section 4.14 for all the materials combined under Alternative 1.
[b] Highest consequence accident for this processing technology.
[c] Highest risk accident for this processing technology.
[d] Building 371 is designated as an alternate location for the Blend Down process at Rocky Flats.
[e] Acid dissolution process in Building 371.
[f] Final calcination process in Building 707A.
Note: The impacts due to the preferred processing technology are presented in bold type.

Table 4–35 Risks Due to Accidents with Sludge Residues

	Accident Scenario	*Offsite Public Maximally Exposed Individual Risk (Probability of a Latent Cancer Fatality)*	*Offsite Public Population Risk (Number of Latent Cancer Fatalities)*	*Noninvolved Onsite Worker Risk (Probability of a Latent Cancer Fatality)*
IDC 089, 099 and 332 Sludge Residues				
Alternative 1 (No Action) Filter, Dry and Store at Rocky Flats [a]	Earthquake (Bldg. 371) Composite	2.5×10^{-10} 4.0×10^{-10}	2.9×10^{-6} 4.6×10^{-6}	1.5×10^{-9} 2.5×10^{-9}
Alternative 2 (without Plutonium Separation) Vitrify at Rocky Flats	Earthquake (Bldg. 707) Composite	2.4×10^{-9} 2.5×10^{-9}	0.000042 0.000043	2.2×10^{-8} 2.3×10^{-8}
Blend Down at Rocky Flats	Earthquake (Bldg. 707) Composite (Bldg. 707) Earthquake (Bldg. 371) [b] Composite (Bldg. 371) [b]	4.8×10^{-9} 5.8×10^{-9} 2.6×10^{-10} 5.5×10^{-10}	0.000083 0.00010 3.0×10^{-6} 6.4×10^{-6}	4.4×10^{-8} 5.4×10^{-8} 1.6×10^{-9} 3.4×10^{-9}
Alternative 4 (Combination) **Repackage at Rocky Flats**	**Earthquake (Bldg. 707)** **Composite (Bldg. 707)**	4.5×10^{-9} 4.7×10^{-9}	**0.000078** **0.000083**	4.2×10^{-8} 4.4×10^{-8}
Other Sludge Residues				
Alternative 1 (No Action) Filter, Dry and Store at Rocky Flats [a]	Earthquake (Bldg. 371) Composite	6.5×10^{-9} 1.0×10^{-8}	0.000076 0.00012	4.0×10^{-8} 6.4×10^{-8}
Alternative 2 (without Plutonium Separation) Vitrify at Rocky Flats	Earthquake (Bldg. 707) Composite	7.4×10^{-8} 7.7×10^{-8}	0.0013 0.0013	6.9×10^{-7} 7.1×10^{-7}
Blend Down at Rocky Flats	Earthquake (Bldg. 707) Composite (Bldg. 707) Earthquake (Bldg. 371) [b] Composite (Bldg. 371) [b]	1.2×10^{-7} 1.3×10^{-7} 6.6×10^{-9} 9.7×10^{-9}	0.0022 0.0022 0.000078 0.00011	1.1×10^{-6} 1.2×10^{-6} 4.1×10^{-8} 6.0×10^{-8}
Alternative 3 (with Plutonium Separation) Dissolve and Oxidize at Rocky Flats	Criticality (Bldg. 371) [c] Composite Earthquake (Bldg. 707A) [d] Composite	3.5×10^{-8} 4.3×10^{-8} 6.0×10^{-8} 6.2×10^{-8}	0.00031 0.00042 0.0013 0.0013	1.1×10^{-8} 8.1×10^{-8} 8.4×10^{-7} 6.0×10^{-7}
Alternative 4 (Combination) **Filter and Dry at Rocky Flats**	**Earthquake (Bldg. 371)** **Composite**	6.5×10^{-9} 1.0×10^{-8}	**0.000076** **0.00012**	4.0×10^{-8} 6.4×10^{-8}

[a] The accident impacts of 20 years of storage are presented in Section 4.14 for all the materials combined under Alternative 1.
[a] Building 371 is designated as an alternate location for the Blend Down process at Rocky Flats.
[b] Acid dissolution process in Building 371.
[c] Final calcination process in Building 707A.
Note: The impacts due to the preferred processing technology are presented in bold type.

As discussed in Chapter 2, the alternatives for glass residues include one technology under the No Action Alternative, three technologies under the Process without Plutonium Separation Alternative, one technology under the Process with Plutonium Separation Alternative and one technology under Alternative 4. The preferred processing technology is to neutralize and dry the glass residues at Rocky Flats.

This section presents the environmental impacts of managing the entire inventory of glass residues under each of the six technologies. The results in this section were used in the calculation of the total impacts of the No Action Alternative and the Preferred Alternative which are presented in Sections 4.20 and 4.21, respectively, and of the management approaches which are presented in Section 4.22.

4.8.1 Products and Wastes

Every processing technology for glass residues would generate some quantity of transuranic waste and would prepare this waste for disposal in WIPP. Every technology would also generate some quantity of low-level waste, which would be disposed of routinely using existing procedures at Rocky Flats. A small portion of the low-level waste generated at Rocky Flats could possibly be low-level mixed waste, but this waste would also be disposed of routinely using existing procedures. The No Action Alternative would generate stabilized residues, containing plutonium in excess of the safeguards termination limits. The Process without Plutonium Separation Alternative would generate transuranic waste directly from the residue. In some of the processing technologies the stabilized residues and transuranic waste would be placed in pipe components inside 208-liter (55-gal) drums as shown in Figure 2-13 in Chapter 2. If DOE applies variances to the stabilized residues (Alternative 4), then the stabilized residues could be disposed of in WIPP as transuranic waste.

High-level waste and saltstone will not be generated from glass residues because none of the technologies involve shipping the residues to the Savannah River Site for plutonium separation. If plutonium is separated at Rocky Flats, it would be stored securely onsite until a decision is made on its disposition. No increase in proliferation risk would result and this plutonium would not be used for nuclear explosive purposes. This separated plutonium would also contain the americium from glass residues.

The solid plutonium-bearing products and wastes that would be generated from glass residues under each of the technologies are presented in **Table 4–36**. The shaded areas of Table 4–36 indicate types of solid products and wastes that would not be generated under the various technologies. The products and wastes from the preferred processing technology are presented in bold type. The largest amount of transuranic waste (145 drums) would be generated in the mediated electrochemical oxidation technology. The three technologies under Alternative 2 would generate only about one-third as much transuranic waste. The stabilized residues generated in Alternative 4 could be disposed of in WIPP, just like transuranic waste. Thus, this technology would generate only 18 drums (stabilized residues plus transuranic waste) to be sent to WIPP. The quantity of low-level waste would also be highest under the mediated electrochemical oxidation technology, and much lower under all the other technologies. The site would manage this waste using routine procedures. The maximum amount of plutonium that could be separated from glass residues is 5 kg (11 lb).

4.8.2 Public and Occupational Health and Safety Impacts

This section describes the radiological and hazardous chemical impacts that could result from the alternatives associated with the management of glass residues. These impacts are presented for incident-free operation and postulated accident scenarios, respectively. The detailed site analyses are presented in Appendix D.

No construction of new processing facilities is included in any of the alternatives, but DOE may need to modify certain existing facilities and construct new waste storage buildings for some of the alternatives. Mitigation measures during modifications would ensure that any radiological or hazardous chemical releases would be extremely small. Worker exposures to contaminated material would be limited to ensure that doses are maintained as low as reasonably achievable.

Table 4–36 Products and Wastes from Glass Residues

	Stabilized Residues (Drums) [a]	*Transuranic Waste (Drums)* [a]	*High-Level Waste (Canisters of Glass)* [b]	*Separated Plutonium (kg)* [c]	*Low-Level Waste (Drums)* [a]	*Saltstone (cubic meters)*
Alternative 1 (No Action)						
Neutralize, Dry and Store at Rocky Flats	7	11			27	
Alternative 2 (without Plutonium Separation)						
Vitrify at Rocky Flats		41			27	
Blend Down at Rocky Flats		41			27	
Sonic Wash at Rocky Flats		48			27	
Alternative 3 (with Plutonium Separation)						
Mediated Electrochemical Oxidation at Rocky Flats		145		5	321	
Alternative 4 (Combination)						
Neutralize and Dry at Rocky Flats	**7**[d]	**11**			**27**	

[a] Standard 55-gallon (208-liter) drums. (208 liters is equal to 0.208 cubic meters.)
[b] Each canister is 2 feet (61 cm) in diameter, 10 feet (300 cm) tall, and contains approximately 3,700 pounds (1,680 kg) of high-level waste glass.
[c] To convert to pounds, multiply by 2.2.
[d] These stabilized residues could be disposed of in WIPP as transuranic waste.

Notes:

Shaded areas indicate the types of solid products and waste that would not be generated; the products and wastes from the preferred processing technology are presented in bold type. The storage capacities at each site are adequate to store the products and wastes listed in this table.

4.8.2.1 Incident-Free Operations

- **Radiological Impacts—**The radiological impacts to the public and the workers associated with incident-free operations of each technology are presented in **Table 4–37**. The impacts due to the preferred processing technology are presented in bold type. The impacts are those which are anticipated to occur as a result of process operations over whatever time period is necessary to process the entire inventory of Raschig ring and glass residues. The length of time necessary to process these residues will depend on which technology DOE decides to implement. Impacts associated with subsequent incident-free storage of stabilized residues, separated plutonium, and wastes would be much smaller than from processing.

  The highest estimated public maximally exposed individual dose in Table 4–37 is 1.8×10^{-6} mrem, which would occur during the mediated electrochemical oxidation process at Rocky Flats. This hypothetical individual's latent fatal cancer risk would be increased by less than one in one trillion. The highest public population radiation dose listed in Table 4–37 would also occur for the mediated electrochemical oxidation process, if DOE decides to implement this technology. This dose is estimated to be 0.000038 person-rem, which would cause far less than one additional latent fatal cancer among the population living near Rocky Flats.

  The highest total involved worker population radiation dose would be 1.9 person-rem, which would occur if DOE decides to implement either the sonic wash or mediated electrochemical oxidation technology. This dose would cause far less than one additional latent fatal cancer among the workers directly involved in either operation. Onsite workers who are not involved with the actual processing of the residues are designated as "noninvolved workers." The impacts to these workers would be expected to be much smaller than the impacts to the involved workers.

- **Hazardous Chemical Impacts—**The impacts of exposure to hazardous chemicals from the processing of glass residues at Rocky Flats were not evaluated because hazardous chemicals are not expected to be released from the proposed operations at this site.

4.8.2.2 Accidents

The potential radiological impacts to the public and the noninvolved onsite workers due to accidents with glass residues are summarized and presented in this section. The detailed analysis of onsite accidents, with the associated assumptions, is presented in Appendix D, Section D.3. The detailed analysis considered a wide spectrum of potential accident scenarios, including fire, explosion, spill, criticality, earthquake, and aircraft crash. The accident scenarios with the highest consequences and risks were selected and carried forward to this section for the purpose of consequence and risk comparison. A composite of the risks due to major onsite accident scenarios in each spectrum (including the nonbounding accidents) was also computed and used for comparisons. The composite risk estimates are accurate enough for the purpose of comparing processing technologies against each other.

The accident frequencies and process durations of the selected accidents are presented in **Table 4–38**. The impacts due to the preferred processing technology are presented in bold type. The onsite accident frequencies are given on a per year basis because many accidents, such as earthquakes, are commonly expressed this way. The duration of each process is given in years. The actual probability of occurrence of each onsite accident can be obtained by multiplying the accident frequency times the technology's duration. In this way, the calculated probabilities are based on the total amount of residue in this category rather than a standard unit of time. The impacts of accident during post-emergency interim storage are presented for all the plutonium residues and scrub alloy combined in Section 4.14.

Table 4–37 Radiological Impacts Due to Incident-Free Management of Glass Residues

	Offsite Public Maximally Exposed Individual		*Offsite Public Population*		*Maximally Exposed Individual Involved Worker*		*Involved Worker Population*	
	Dose (mrem)	*Probability of Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*	*Dose (mrem/yr)*	*Probability of a Latent Cancer Fatality per year*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*
Alternative 1 (No Action)								
Neutralize, Dry and Store at Rocky Flats	N/E	–	N/E	–	2,000	0.0008	1.6	0.00064
Alternative 2 (without Plutonium Separation)								
Vitrify at Rocky Flats	2.1×10^{-7}	1.0×10^{-13}	8.6×10^{-6}	4.3×10^{-9}	2,000	0.0008	1.0	0.00040
Blend Down at Rocky Flats	7.1×10^{-7}	3.6×10^{-13}	0.000015	7.5×10^{-9}	2,000	0.0008	1.1	0.00044
Sonic Wash at Rocky Flats	N/E	–	N/E	–	2,000	0.0008	1.9	0.00076
Alternative 3 (with Plutonium Separation)								
Mediated Electrochemical Oxidation at Rocky Flats	1.8×10^{-6}	9.0×10^{-13}	0.000038	1.9×10^{-8}	2,000	0.0008	1.9	0.00076
Alternative 4 (Combination)								
Neutralize and Dry at Rocky Flats	**N/E**	**–**	**N/E**	**–**	**2,000**	**0.0008**	**1.5**	**0.00060**

N/E = no emissions—therefore, there are no radiological impacts to the public

Note: The impacts due to the preferred processing technology are presented in bold type.

Table 4–38 Accident Frequencies, Process Durations, and Consequences for Accidents with Glass Residues

				Offsite Public Maximally Exposed Individual Consequences		*Offsite Public Population Consequences*		*Noninvolved Onsite Worker Consequences*	
	Accident Scenario	***Accident Frequency (per year)***	***Process Duration (years)***	***Dose (mrem)***	***Probability of a Latent Cancer Fatality***	***Dose (person-rem)***	***Number of Latent Cancer Fatalities***	***Dose (mrem)***	***Probability of a Latent Cancer Fatality***
Alternative 1 (No Action)									
Neutralize, Dry, and Store at Rocky Flats [a]	Earthquake (Bldg. 371)	0.000094	0.037	754	0.00038	8,800	4.4	5,870	0.0024
Alternative 2 (without Plutonium Separation)	Explosion (Bldg. 707) [b]	0.00005	0.012	960	0.00048	16,800	8.4	11,200	0.0045
Vitrify at Rocky Flats	Earthquake (Bldg. 707) [c]	0.0026	0.012	914	0.00046	16,000	8.0	10,700	0.0043
Blend Down at Rocky Flats	Earthquake (Bldg. 371)	0.000094	0.014	2,000	0.0010	23,300	12	15,600	0.0062
	Earthquake (Bldg. 707) [d]	0.0026	0.014	1,330	0.00067	23,300	23	15,600	0.0062
Sonic Wash at Rocky Flats	Earthquake (Bldg. 371)	0.000094	0.037	453	0.00023	5,280	2.6	3,520	0.0014
Alternative 3 (with Plutonium Separation)									
Mediated Electrochemical Oxidation at Rocky Flats	Earthquake (Bldg. 371) [e]	0.000094	0.019	1,480	0.00074	17,200	8.6	11,500	0.0046
	Earthquake (Bldg. 707A) [f]	0.0026	0.0064	1,400	0.00070	29,100	15	24,400	0.020
Alternative 4 (Combination)									
Neutralize and Dry at Rocky Flats	**Earthquake (Bldg. 371)**	**0.000094**	**0.037**	**754**	**0.00038**	**8,800**	**4.4**	**5,870**	**0.0024**

[a] The accident impacts of 20 years of storage are presented in Section 4.14 for all the materials combined under Alternative 1.
[b] Highest consequence accident for this processing technology.
[c] Highest risk accident for this processing technology.
[d] Building 707 is designated as an alternate location for the Blend Down process at Rocky Flats.
[e] Mediated electrochemical oxidation process in Building 371.
[f] Final calcination process in Building 707A.
Note: The impacts due to the proposed processing technology are presented in bold type.

The consequences for the public and a noninvolved onsite worker are also presented in Table 4–38, for each of the six glass residue processing technologies. The public maximally exposed individual is a hypothetical individual who resides at the site boundary in the downwind direction. The public population is defined as the residential population within a radius of 80 km (50 mi). A noninvolved onsite worker is defined as an individual worker who is located 100 m (328 ft) or more downwind from the release point when an accidental release of radioactive material occurs. The highest consequences to the maximally exposed individual would occur if DOE decides to implement the blend down technology and a major earthquake strong enough to cause the breach of Building 371 occurs during the 0.014 years of residue processing at Rocky Flats. The highest consequences to the public population would occur if DOE decides to implement the blend down technology and a major earthquake strong enough to cause the breach of Building 707 occurs during the 0.014 years of residue processing at Rocky Flats. The highest consequences to the noninvolved onsite worker would occur if DOE decides to implement the mediated electrochemical oxidation technology and a major earthquake strong enough to cause the breach of Building 707A occurs during the final calcination process at Rocky Flats.

The risks associated with each accident are calculated by multiplying the probability times the consequences. The risks to the public and an onsite worker are presented in **Table 4–39**, for each of the five glass residue processing technologies. The risk associated with the highest risk accident and a composite risk due to all major accidents are both presented. The risks associated with the preferred processing technology are presented in bold type.

The highest risk to the public maximally exposed individual is estimated to be 2.4×10^{-8}, which is due to an earthquake during processing of the residue in Building 707 with the blend down technology at Rocky Flats. This individual's chance of incurring a latent cancer fatality would be increased by less than one in ten million. The highest risk to the public population is estimated to be 0.00042 latent cancer fatalities, which is also due to an earthquake during processing of the residue with the blend down technology. The highest risk to the individual noninvolved onsite worker is estimated to be 3.3×10^{-7}, which is due to a major earthquake strong enough to cause the collapse of Building 707A during the final calcination for the mediated electrochemical oxidation process at Rocky Flats. This individual's chance of incurring a latent cancer fatality would be increased by less than one in a million.

Table 4–39 Risks Due to Accidents with Glass Residues

	Accident Scenario	*Offsite Public Maximally Exposed Individual Risk (Probability of a Latent Cancer Fatality)*	*Offsite Public Population Risk (Number of Latent Cancer Fatalities)*	*Noninvolved Onsite Worker Risk (Probability of a Latent Cancer Fatality)*
Alternative 1 (No Action)				
Neutralize, Dry, and Store at Rocky Flats [a]	Earthquake (Bldg. 371) Composite	1.3×10^{-9} 1.9×10^{-9}	0.000015 0.000022	8.2×10^{-9} 1.2×10^{-8}
Alternative 2 (without Plutonium Separation)				
Vitrify at Rocky Flats	Earthquake (Bldg. 707) Composite	1.4×10^{-8} 1.5×10^{-8}	0.00025 0.00026	1.3×10^{-7} 1.4×10^{-7}
Blend Down at Rocky Flats	Earthquake (Bldg. 371) Composite (Bldg. 371) Earthquake (Bldg. 707) [b] Composite (Bldg. 707) [b]	1.3×10^{-9} 1.9×10^{-9} 2.4×10^{-8} 2.5×10^{-8}	0.000015 0.000022 0.00042 0.00044	8.2×10^{-9} 1.2×10^{-8} 2.3×10^{-7} 2.3×10^{-7}
Sonic Wash at Rocky Flats	Earthquake (Bldg. 371) Composite	7.9×10^{-10} 1.1×10^{-9}	9.2×10^{-6} 0.000013	4.9×10^{-9} 6.9×10^{-9}
Alternative 3 (with Plutonium Separation)				
Mediated Electrochemical Oxidation at Rocky Flats	Earthquake (Bldg. 371) [c] Composite Earthquake (Bldg. 707A) [d] Composite	1.3×10^{-9} 2.6×10^{-9} 1.2×10^{-8} 1.2×10^{-8}	0.000015 0.000028 0.00024 0.00025	8.2×10^{-9} 1.2×10^{-8} 3.3×10^{-7} 3.3×10^{-7}
Alternative 4 (Combination)				
Neutralize and Dry at Rocky Flats	**Earthquake (Bldg. 371)** **Composite**	$\mathbf{1.3\times10^{-9}}$ $\mathbf{1.9\times10^{-9}}$	**0.000015** **0.000022**	$\mathbf{8.2\times10^{-9}}$ $\mathbf{1.2\times10^{-8}}$

[a] The accident impacts of 20 years of storage are presented in Section 4.14 for all the materials combined under Alternative 1.
[b] Building 707 is designated as an alternate location for the Blend Down process at Rocky Flats.
[c] Mediated electrochemical oxidation process in Building 371.
[d] Final calcination process in Building 707A.
Note: The impacts due to the proposed processing technology are presented in bold type.

4.9 IMPACTS OF MANAGING GRAPHITE RESIDUES

The inventory of graphite residues weighs 1,880 kg (4,141 lb), including 97.4 kg (214.7 lb) of plutonium. The entire inventory is stored in 106 drums (with about 530 internal metal containers) and 39 small individual containers.

As discussed in Chapter 2, the alternatives for graphite residues include one technology under the No Action Alternative, three technologies under the Process without Plutonium Separation Alternative, two technologies under the Process with Plutonium Separation Alternative, and one technology under Alternative 4. The preferred processing technology is to repackage the graphite residues at Rocky Flats.

This section presents the environmental impacts of managing the entire inventory of graphite residues under each of the seven technologies. The results in this section were used in the calculation of the total impacts of the No Action Alternative and the Preferred Alternative which are presented in Sections 4.20 and 4.21, respectively, and of the management approaches which are presented in Section 4.22.

4.9.1 Products and Wastes

Every processing technology for graphite residues would generate some quantity of transuranic waste and would prepare this waste for disposal in WIPP. Every technology would also generate some quantity of low-level waste, which would be disposed of routinely using existing procedures at each site. A small portion of the low-level waste generated at Rocky Flats could possibly be low-level mixed waste, but this waste would also be disposed of routinely using existing procedures. The No Action Alternative would generate stabilized residues, containing plutonium in excess of the safeguards termination limits. The Process without Plutonium Separation Alternative would generate transuranic waste directly from the residue. In some of the processing technologies the stabilized residues and transuranic waste would be placed in pipe components inside 208-liter (55-gal) drums as shown in Figure 2-13 in Chapter 2. If DOE applies variances to the stabilized residues (Alternative 4), then these stabilized residues could be disposed of in WIPP as transuranic waste.

High-level waste and saltstone would be generated only at the Savannah River Site if the residues were shipped to that site for plutonium separation. The final form for the high-level waste would be glass poured into stainless steel canisters, which would be stored at the Savannah River Site until a monitored geologic repository is ready to receive them. Saltstone is a cement form of low-level waste that is generated as a by-product of Savannah River Site tank farm operations and is routinely disposed of onsite in concrete vaults. If plutonium is separated at Rocky Flats or the Savannah River Site, it would be stored securely onsite until a decision is made on its disposition. No increase in proliferation risk would result and this plutonium would not be used for nuclear explosive purposes. Any plutonium separated at Rocky Flats would contain americium, while at the Savannah River Site the americium would go into the high-level waste.

The solid plutonium-bearing products and wastes that would be generated from graphite residues under each of the technologies are presented in **Table 4–40**. The shaded areas of Table 4–40 indicate types of solid products and wastes that would not be generated under the various technologies. The products and wastes from the preferred processing technology are presented in bold type. The largest amount of transuranic waste (over 2,000 drums) would be generated in the technology to perform mediated electrochemical oxidation at Rocky Flats. The three technologies under Alternative 2 would each generate only about one-third as much transuranic waste as would the technology to perform mediated electrochemical oxidation at Rocky Flats, under Alternative 3. The other technology under Alternative 3 (preprocess at Rocky Flats, then mediated electrochemical oxidation and Purex at Savannah River Site) would only generate 119 drums of transuranic waste. The stabilized residues generated in Alternative 4 could be disposed of in WIPP, just like transuranic waste. Thus, this technology would generate almost 750 drums (stabilized residues plus transuranic waste) to be sent to WIPP. The quantity of low-level waste generated (almost 4,500 drums) would also be highest

Table 4–40 Products and Wastes from Graphite Residues

	Stabilized Residues[a] (Drums)	*Transuranic Waste (Drums)[a]*	*High-Level Waste (Canisters of Glass)[b]*	*Separated Plutonium (kg)[c]*	*Low-Level Waste (Drums)[a]*	*Saltstone (cubic meters)*
Alternative 1 (No Action)						
Repackage and Store at Rocky Flats	575	171			376	
Alternative 2 (without Plutonium Separation)						
Cement at Rocky Flats		756			376	
Vitrify at Rocky Flats		650			153	
Blend Down at Rocky Flats		650			153	
Alternative 3 (with Plutonium Separation)						
Mediated Electrochemical Oxidation at Rocky Flats		2,055		95	4,495	
Preprocess at Rocky Flats		75	–	–	153	–
Mediated Electrochemical Oxidation/Purex at Savannah River Site		44	8	96	63	104
Alternative 4 (Combination)						
Repackage at Rocky Flats	**575**[d]	**171**			**376**	

[a] Standard 55-gallon (208-liter) drums. (208 liters is equal to 0.208 cubic meters.)
[b] Each canister is 2 feet (61 cm) in diameter, 10 feet (300 cm) tall, and contains approximately 3,700 pounds (1,680 kg) of high-level waste glass.
[c] To convert to pounds, multiply by 2.2.
[d] These stabilized residues could be disposed of in WIPP as transuranic waste.

Note: Shaded areas indicate the types of solid products and waste that would not be generated. The products and wastes from the preferred processing technology are presented in bold type. The storage capacities at each site are adequate to store the products and wastes in this table.

under the mediated electrochemical oxidation technology at Rocky Flats, and would be much lower under all the other technologies. The site would manage this waste using routine procedures. The maximum amount of plutonium that could be separated from graphite residues is 96 kg (212 lb).

4.9.2 Public and Occupational Health and Safety Impacts

This section describes the radiological and hazardous chemical impacts which could result from the alternatives associated with the management of graphite residues. These impacts are presented for incident-free operation and postulated accident scenarios. The detailed site and transportation analyses are presented in Appendices D and E, respectively.

The round-trip highway distance from Rocky Flats to the Savannah River Site is 5,233 km (3,250 mi). If DOE decides to ship the graphite residues to the Savannah River Site for mediated electrochemical oxidation/Purex processing, then 16 shipments would be required and the total round-trip shipping distance would be 83,700 km (51,900 mi).

No construction of new processing facilities is included in any of the alternatives, but DOE may need to modify certain existing facilities and construct new waste storage buildings for some of the alternatives. Mitigation measures during modifications would ensure that any radiological or hazardous chemical releases would be extremely small. Worker exposures to contaminated material would be limited to ensure that doses are maintained as low as reasonably achievable.

4.9.2.1 Incident-Free Operations

Radiological Impacts—The radiological impacts to the public and the workers associated with incident-free operations of each technology are presented in **Table 4–41**. The impacts due to the preferred processing technology are presented in bold type. The impacts are those which are anticipated to occur as a result of process operations and transportation over whatever time period is necessary to process the entire inventory of graphite residues. The length of time necessary to process the graphite residues will depend on which technology DOE decides to implement. Impacts associated with subsequent incident-free storage of stabilized residues, separated plutonium, and wastes would be much smaller than from processing or transportation.

The highest estimated public maximally exposed individual risk in Table 4–41 is 11 mrem, which could occur only during transportation. This hypothetical individual's cancer risk would be increased by less than one in one hundred thousand. The public maximally exposed individual risks near the sites would be much lower under all of the technologies. The highest total of the public population radiation doses listed in Table 4–41 would occur if DOE decides to implement the mediated electrochemical oxidation technology at the Savannah River Site. The sum of these doses is 1.6 person-rem, which would cause far less than one additional cancer among the population living near both sites and traveling along the truck route. The population living near the truck route would receive a much smaller radiation dose.

The highest involved worker population radiation dose would be approximately 43 person-rem, which would occur if DOE decides to implement the mediated electrochemical oxidation technology at the Savannah River Site. This dose would cause 0.017 additional latent cancer fatalities among the workers directly involved in the operation. Onsite workers who are not involved with the actual processing of the residues are designated as "noninvolved workers." The impacts to these workers would be much smaller than the impacts to the involved workers.

Table 4–41 Radiological Impacts Due to Incident-Free Management of Graphite Residues

	Offsite Public Maximally Exposed Individual		***Offsite Public Population***		***Maximally Exposed Individual Involved Worker***		***Individual Involved Worker Population***	
	Dose (mrem)	***Probability of a Latent Cancer Fatality***	***Dose (person-rem)***	***Number of Latent Cancer Fatalities***	***Dose (mrem/yr)***	***Probability of a Latent Cancer Fatality per year***	***Dose (person-rem)***	***Number of Latent Cancer Fatalities***
Alternative 1 (No Action)								
Repackage and Store at Rocky Flats	N/E	–	N/E	–	2,000	0.0008	25	0.010
Alternative 2 (without Plutonium Separation)								
Cement at Rocky Flats	2.8×10^{-6}	1.4×10^{-12}	0.00060	3.0×10^{-7}	2,000	0.0008	34	0.014
Vitrify at Rocky Flats	4.0×10^{-6}	2.0×10^{-12}	0.00016	8.0×10^{-8}	2,000	0.0008	19	0.0076
Blend Down at Rocky Flats	0.000014	6.8×10^{-12}	0.00028	1.4×10^{-7}	2,000	0.0008	19	0.0076
Alternative 3 (with Plutonium Separation)								
Mediated Electrochemical Oxidation at Rocky Flats	0.000034	1.7×10^{-11}	0.00072	3.6×10^{-7}	2,000	0.0008	36	0.014
Preprocess at Rocky Flats	6.9×10^{-6}	3.4×10^{-12}	0.00015	7.5×10^{-8}	2,000	0.0008	15	0.0060
Transport to Savannah River Site	11	5.5×10^{-6}	1.6	0.0008	100	0.00004	2.5	0.0010
Mediated Electrochemical Oxidation/Purex at Savannah River Site[a]	0.00012	6.0×10^{-11}	0.014	7.0×10^{-6}	2,000	0.0008	25	0.010
Alternative 4 (Combination)								
Repackage at Rocky Flats	**N/E**	**–**	**N/E**	**–**	**2,000**	**0.0008**	**18**	**0.0072**

N/E = no emissions—therefore, there are no radiological impacts to the public

[a] Impacts to the public and workers are presented for F-Canyon operations. It has been determined that H-Canyon operations result in lower impacts to these groups.

Note: The impacts due to the preferred processing technology are presented in bold type.

Hazardous Chemical Impacts—The processing of graphite residues at Rocky Flats would not involve airborne releases of hazardous chemicals. No carcinogenic chemicals would be released from the mediated electrochemical oxidation process at Savannah River Site. Noncancer health risks resulting from releases of phosphoric acid and ammonium nitrate are low; the Hazard Index values presented in **Table 4–42** are much less than one. The impacts due to the preferred processing technology are presented in bold type.

4.9.2.2 Accidents

The potential radiological impacts to the public and the noninvolved onsite workers due to accidents with graphite residues are summarized and presented in this section. The detailed analysis of onsite accidents, with the associated assumptions, is presented in Appendix D, Section D.3. The detailed analysis considered a wide spectrum of potential accident scenarios, including fire, explosion, spill, criticality, earthquake, and aircraft crash. The accident scenarios with the highest consequences and risks were selected and carried forward to this section for the purpose of consequence and risk comparison. A composite of the risks due to major onsite accident scenarios in each spectrum (including the nonbounding accidents) was also computed and used for comparisons. The composite risk estimates are accurate enough for the purpose of comparing processing technologies against each other. The detailed analysis of transportation accidents, with the associated assumptions, is presented in Appendix E, Sections E.5 and E.6.

The accident frequencies and process durations of the selected accidents are presented in **Table 4–43**. The impacts due to the preferred processing technology are presented in bold type. The onsite accident frequencies are given on a per year basis because many accidents, such as earthquakes, are commonly expressed this way. The duration of each process is given in years. The actual probability of occurrence of each onsite accident can be obtained by multiplying the accident frequency times the technology's duration. In this way, the calculated probabilities are based on the total amount of residue in this category rather than a standard unit of time. The impacts of accidents during post-processing interim storage are presented for all the plutonium residues and scrub alloy combined in Section 4.14.

The calculation of accident probability is slightly different for traffic accident fatalities. The frequency of traffic accidents is given in terms of the number of fatal accidents per round trip shipment from Rocky Flats to Savannah River Site. The process duration for traffic accidents is given as the number of round trip shipments. Thus, the actual probability of a fatal traffic accident can be obtained by multiplying the frequency (fatal accidents per round-trip shipment) times the duration (number of round-trip shipments).

The consequences for the public and a noninvolved onsite worker are also presented in Table 4–43, for each of the seven graphite residue processing technologies. The public maximally exposed individual is a hypothetical individual who resides at the site boundary in the downwind direction. The public population is defined as the residential population within a radius of 80 km (50 mi). A noninvolved onsite worker is defined as an individual worker who is located 100 m (328 ft) or more downwind from the release point when an accidental release of radioactive material occurs.

The highest consequences to the maximally exposed individual and public population would occur if DOE decides to implement the mediated electrochemical oxidation/Purex technology at the Savannah River Site and a major earthquake strong enough to cause the breach of Building 371 occurs during the 0.22 years of processing at Rocky Flats. The highest consequences to the noninvolved onsite worker would occur if DOE decides to implement the mediated electrochemical oxidation/Purex technology at the Savannah River Site and a major earthquake strong enough to cause the breach of the H-Canyon occurs during the 0.42 years of processing at the Savannah River Site.

Table 4–42 Chemical Impacts Due to Incident-Free Management of Graphite Residues

	Offsite Public Maximally Exposed Individual		*Offsite Public Population*	*Maximally Exposed Individual Worker*		*Worker Population*
	Probability of a Cancer Incidence	*Hazard Index*	*Number of Cancer Incidences or Fatalities*[a]	*Probability of a Cancer Incidence*	*Hazard Index*	*Number of Cancer Incidences or Fatalities*[a]
Alternative 1 (No Action)						
Repackage and Store at Rocky Flats[b]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 2 (without Plutonium Separation)						
Cement at Rocky Flats[b]	N/E	N/E	N/E	N/E	N/E	N/E
Vitrify at Rocky Flats[b]	N/E	N/E	N/E	N/E	N/E	N/E
Blend Down at Rocky Flats[b]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 3 (with Plutonium Separation)						
Mediated Electrochemical Oxidation at Rocky Flats[b]	N/E	N/E	N/E	N/E	N/E	N/E
Preprocess at Rocky Flats[b]	N/E	N/E	N/E	N/E	N/E	N/E
Transport to Savannah River Site	N/A	N/A	0.00021[c]	N/A	N/A	(c)
Mediated Electrochemical Oxidation/Purex at Savannah River Site[d, e]	N/E	2×10^{-9}	N/E	N/E	2×10^{-8}	N/E
Alternative 4 (Combination)						
Repackage at Rocky Flats	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**

N/E = no emissions N/A = not applicable—the maximally exposed individual is undefined for vehicle emissions

[a] Cancer incidences and fatalities are calculated for process emissions and transportation emissions, respectively.

[b] No hazardous chemicals are released from this process; therefore, no associated health risks exist.

[c] Cancer fatalities due to vehicle emissions into the air. This impact is listed only once under public population because the vehicle emissions affect the public and worker populations collectively. However, the risk to the public dominates. See Appendix E, Section E.4 for additional information.

[d] Impacts are presented for F-Canyon operations. H-Canyon operations are expected to result in similar or lower impacts.

[e] No carcinogenic chemicals are released from the process; therefore, only noncancer health risks are evaluated.

Note: The impacts due to the preferred processing technology are presented in bold type.

Table 4–43 Accident Frequencies, Process Durations, and Consequences for Accidents with Graphite Residues

				Offsite Public Maximally Exposed Individual Consequences		***Offsite Public Population Consequences***		***Noninvolved Onsite Worker Consequences***	
	Accident Scenario	***Accident Frequency (per year)***	***Process Duration (years)***	***Dose (mrem)***	***Probability of a Latent Cancer Fatality***	***Dose (Person-rem)***	***Number of Latent Cancer or Traffic Fatalities***	***Dose (mrem)***	***Probability of a Latent Cancer Fatality***
Alternative 1 (No Action)									
Repackage and Store at Rocky Flats [a]	Earthquake (Bldg. 707)	0.0026	0.23	1,520	0.00076	26,700	13	17,800	0.0071
Alternative 2 (without Plutonium Separation)	Earthquake (Bldg. 371)	0.000094	0.32	1,000	0.00050	11,700	5.9	7,780	0.0031
Cement at Rocky Flats	Explosion (Bldg. 707)[b, c]	0.00005	0.32	960	0.00048	16,800	8.4	11,200	0.0045
	Earthquake (Bldg. 707) [c]	0.0026	0.32	667	0.00033	11,700	5.9	7,780	0.0031
Vitrify at Rocky Flats	Explosion (Bldg. 707) [b]	0.00005	0.23	960	0.00048	16,800	8.4	11,200	0.0045
	Earthquake (Bldg. 707) [d]	0.0026	0.23	914	0.00046	16,000	8.0	10,700	0.0043
Blend Down at Rocky Flats	Earthquake (Bldg. 707)	0.0026	0.23	1,520	0.00076	26,700	13	17,800	0.0071
	Earthquake (Bldg. 371) [e]	0.000094	0.23	2,290	0.0011	26,700	13	17,800	0.0071
Alternative 3 (with Plutonium Separation)	Earthquake (Bldg. 371) [f]	0.000094	0.33	1,580	0.00079	18,500	9.3	12,300	0.0049
Mediated Electrochemical Oxidation at Rocky Flats	Earthquake (Bldg. 707A) [g]	0.0026	0.31	570	0.00029	11,900	6.0	9,980	0.0040
Preprocess at Rocky Flats	Earthquake (Bldg. 371)	0.000094	0.22	2,470	0.0012	28,800	14	19,200	0.0077
Transport to Savannah River Site	Traffic Fatality	0.00010 per shipment	16 shipments	N/A	N/A	N/A	1.0 [h]	N/A	(i)
Mediated Electrochemical Oxidation/ Purex at Savannah River Site	Earthquake (H-Canyon) [j]	0.000182	0.42	65	0.000033	2,930	1.5	20,800	0.017
Alternative 4 (Combination)									
Repackage at Rocky Flats	**Earthquake (Bldg. 707)**	**0.0026**	**0.23**	**1,520**	**0.00076**	**26,700**	**13**	**17,800**	**0.0071**

N/A = not applicable

[a] The accident impacts of 20 years of storage are presented in Section 4.14 for all the materials combined under Alternative 1.
[b] Highest consequence accident for this processing technology.
[c] Building 707 is designated as an alternate location for the Cement process at Rocky Flats.
[d] Highest risk accident for this processing technology.
[e] Building 371 is designated as an alternate location for the Blend Down process at Rocky Flats.
[f] Mediated electrochemical oxidation process in Building 371.
[g] Final calcination process in Building 707A.
[h] This fatality is due to the mechanical impact of the accident, not cancer due to radiation. The radiological consequences of a radioactive release on the highway are impossible to list in a single number because the accident could occur at any point along the route and meteorological conditions and population distributions vary greatly along the route.
[i] The consequence of a high-speed traffic accident would be at least one fatality among the transportation workers due to trauma.
[j] HB-Line operates 60 percent of the time. Dose estimates assumed the HB-Line was operating at the time of the accident.

Note: The impacts due to the preferred processing technology are presented in bold type.

The risks associated with each accident are calculated by multiplying the probability by the consequences. The risks to the public and an onsite worker are presented in **Table 4–44**, for each of the six graphite residue processing technologies. The risk associated with the highest risk accident and a composite risk due to all major accidents are both presented. The risks associated with the preferred processing technology are presented in bold type.

The highest risk to the public maximally exposed individual is estimated to be 4.6×10^{-7}, which is due to an earthquake during processing of the residue with the repackage (under Alternatives 1 or 4) or the blend down technology in Rocky Flats Building 707. This individual's chance of incurring a latent cancer fatality would be increased by less than one in one million. The highest risk to the public population is estimated to be 0.0080 latent cancer fatalities, which is also due to an earthquake during processing of the residue with either the repackage or the blend down technology in Building 707. The highest risk to the individual noninvolved onsite worker is estimated to be 4.3×10^{-6}, which is also due to an earthquake during processing of the residue with either the repackage or the blend down technology in Building 707. This individual's chance of incurring a latent cancer fatality would be increased by less than one in one hundred thousand.

4.10 IMPACTS OF MANAGING INORGANIC RESIDUES

The inventory of inorganic residues weighs 448 kg (988 lb), including 17.7 kg (39 lb) of plutonium. The entire inventory is stored in 44 drums (with no internal metal containers) and 41 other small individual containers.

As discussed in Chapter 2, the alternatives for inorganic residues include one technology under the No Action Alternative, two technologies under the Process without Plutonium Separation Alternative, two technologies under the Process with Plutonium Separation Alternative, and one technology under Alternative 4. The preferred processing technology is to repackage the inorganic residues at Rocky Flats with a variance.

This section presents the environmental impacts of managing the entire inventory of inorganic residues under each of the six technologies. The results in this section were used in the calculation of the total impacts of the No Action Alternative and the Preferred Alternative which are presented in Sections 4.20 and 4.21, respectively, and of the management approaches which are presented in Section 4.22.

4.10.1 Products and Wastes

Every processing technology for inorganic residues would generate some quantity of transuranic waste and would prepare this waste for disposal in WIPP. Every technology would also generate some quantity of low-level waste, which would be disposed of routinely using existing procedures at each site. A small portion of the low-level waste generated at Rocky Flats could possibly be low-level mixed waste, but this waste would also be disposed of routinely using existing procedures. The No Action Alternative would generate stabilized residues, containing plutonium in excess of the safeguards termination limits. The Process without Plutonium Separation Alternative would generate transuranic waste directly from the residue. In some of the processing technologies the stabilized residues and transuranic waste would be placed in pipe components inside 208-liter (55-gal) drums as shown in Figure 2-13 in Chapter 2. If DOE applies variances to the stabilized residues (Alternative 4), then these stabilized residues could be disposed of in WIPP as transuranic waste.

High-level waste and saltstone would be generated only at the Savannah River Site if the residues are shipped to that site for plutonium separation. The final form for the high-level waste would be glass poured into stainless steel canisters, which would be stored at the Savannah River Site until a monitored geologic repository is ready to receive them. Saltstone is a cement form of low-level waste that is generated as a by-product of the Savannah River Site tank farm operations and is routinely disposed of onsite in concrete vaults.

Table 4–44 Risks Due to Accidents with Graphite Residues

	Accident Scenario	*Offsite Public Maximally Exposed Individual Risk (Probability of a Latent Cancer Fatality)*	*Offsite Public Population Risk (Number of Latent Cancer or Traffic Fatalities)*	*Noninvolved Onsite Worker Risk (Probability of a Latent Cancer Fatality)*
Alternative 1 (No Action)				
Repackage and Store at Rocky Flats [a]	Earthquake (Bldg. 707)	4.6×10^{-7}	0.0080	4.3×10^{-6}
	Composite	4.7×10^{-7}	0.0082	4.4×10^{-6}
Alternative 2 (without Plutonium Separation)				
Cement at Rocky Flats	Earthquake (Bldg. 371)	1.5×10^{-8}	0.00018	9.3×10^{-8}
	Composite (Bldg. 371)	2.3×10^{-8}	0.00027	1.4×10^{-7}
	Earthquake (Bldg. 707) [b]	2.8×10^{-7}	0.0049	2.6×10^{-6}
	Composite (Bldg. 707) [b]	2.9×10^{-7}	0.0051	2.7×10^{-6}
Vitrify at Rocky Flats	Earthquake (Bldg. 707)	2.7×10^{-7}	0.0048	2.6×10^{-6}
	Composite	2.8×10^{-7}	0.0050	2.7×10^{-6}
Blend Down at Rocky Flats	Earthquake (Bldg. 707)	4.6×10^{-7}	0.0080	4.3×10^{-6}
	Composite (Bldg. 707)	4.7×10^{-7}	0.0082	4.4×10^{-6}
	Earthquake (Bldg. 371) [c]	2.5×10^{-8}	0.00029	1.5×10^{-7}
	Composite (Bldg. 371) [c]	3.6×10^{-8}	0.00042	2.2×10^{-7}
Alternative 3 (with Plutonium Separation)				
Mediated Electrochemical Oxidation at Rocky Flats	Earthquake (Bldg. 371) [d]	2.5×10^{-8}	0.00029	1.5×10^{-7}
	Composite	4.9×10^{-8}	0.00054	2.3×10^{-7}
	Earthquake (Bldg. 707A) [e]	2.3×10^{-8}	0.0048	3.2×10^{-6}
	Composite	2.4×10^{-8}	0.0049	3.3×10^{-6}
Preprocess at Rocky Flats	Earthquake (Bldg. 371)	2.6×10^{-8}	0.00030	1.6×10^{-7}
	Composite	3.7×10^{-8}	0.00043	2.3×10^{-7}
Transport to Savannah River Site	Traffic Fatality	N/A	0.0016 [f]	N/A
	Radioactive Release	N/A	2.1×10^{-7}	N/A
Mediated Electrochemical Oxidation/Purex at Savannah River Site	Earthquake (H-Canyon) [g]	1.6×10^{-9}	0.000073	8.3×10^{-7}
	Composite [g]	3.1×10^{-9}	0.00015	8.4×10^{-7}
Alternative 4 (Combination)				
Repackage at Rocky Flats	**Earthquake (Bldg. 707)**	$\mathbf{4.6\times10^{-7}}$	**0.0080**	$\mathbf{4.3\times10^{-6}}$
	Composite	$\mathbf{4.7\times10^{-7}}$	**0.0082**	$\mathbf{4.4\times10^{-6}}$

N/A= not applicable

[a] The accident impacts of 20 years of storage are presented in Section 4.14 for all the materials combined under Alternative 1.

[b] Building 707 is designated as an alternate location for the Cement process at Rocky Flats.

[c] Building 371 is designated as an alternate location for the Blend Down process at Rocky Flats.

[d] Mediated electrochemical oxidation process in Building 371.

[e] Final calcination process in Building 707A.

[f] The risk is due to the mechanical impact of the accident, not cancer due to radiation. This risk includes members of the public and transportation workers.

[g] The H-Canyon operates 100 percent of the time and the HB-Line operates 60 percent of the time.

Note: The risks due to the preferred processing technology are presented in bold type.

If plutonium is separated at Rocky Flats or the Savannah River Site, it would be stored securely onsite until a decision is made on its disposition. No increase in proliferation risk would result and this plutonium would not be used for nuclear explosive purposes. Any plutonium separated at Rocky Flats would also contain americium, while at the Savannah River Site the americium would go into the high-level waste.

The solid plutonium-bearing products and wastes that would be generated from inorganic residues under each of the technologies are presented in **Table 4–45**. The shaded areas of Table 4–45 indicate types of solid products and wastes that would not be generated under the various technologies. The products and wastes from the preferred processing technology are presented in bold type. The largest amount of transuranic waste (485 drums) would be generated in the mediated electrochemical oxidation technology at Rocky Flats. This amount is much higher than the other technologies, which would generate no more than 120 drums of transuranic waste. The stabilized residues generated in Alternative 4 could be disposed of in WIPP, just like transuranic waste. Thus, this technology would generate over 140 drums (stabilized residues plus transuranic waste) to be sent to WIPP. The quantity of low-level waste would also be highest under the mediated electrochemical oxidation technology at Rocky Flats, and much lower under all the other technologies. The quantities of high-level waste and saltstone would be low under the Purex processing technology at the Savannah River Site, and the site would manage these wastes using routine procedures. The maximum amount of plutonium that could be separated is 18 kg (40 lb).

4.10.2 Public and Occupational Health and Safety Impacts

This section describes the radiological and hazardous chemical impacts that could result from the alternatives associated with the management of inorganic residues. These impacts are presented for incident-free operation and postulated accident scenarios. The detailed site and transportation analyses are presented in Appendices D and E, respectively.

The round-trip highway distance from Rocky Flats to the Savannah River Site is 5,233 km (3,250 mi). If DOE decides to ship the inorganic residues to the Savannah River Site for mediated electrochemical oxidation/Purex processing, then four shipments would be required and the total round-trip shipping distance would be 20,900 km (13,000 mi).

No construction of new processing facilities is included in any of the alternatives, but DOE may need to modify certain existing facilities and construct new waste storage buildings for some of the alternatives. Mitigation measures during modifications would ensure that any radiological or hazardous chemical releases would be extremely small. Worker exposures to contaminated material would be limited to ensure that doses are maintained as low as reasonably achievable.

4.10.2.1 Incident-Free Operations

Radiological Impacts—The radiological impacts to the public and the workers associated with incident-free operations of each technology are presented in **Table 4–46**. The impacts due to the preferred processing technology are presented in bold type. The impacts are those which are anticipated to occur as a result of process operations and transportation over whatever time period is necessary to process the entire inventory of inorganic residues. The length of time necessary to process the inorganic residues will depend on which technology DOE decides to implement. Impacts associated with subsequent incident-free storage of stabilized residues, separated plutonium, and wastes would be much smaller than from processing or transportation.

Table 4–45 Products and Wastes from Inorganic Residues

	Stabilized Residues (Drums)[a]	*Transuranic Waste (Drums)*[a]	*High-Level Waste (Canisters of Glass)*[b]	*Separated Plutonium (kg)*[c]	*Low-Level Waste (Drums)*[a]	*Saltstone (cubic meters)*
Alternative 1 (No Action)						
Repackage and Store at Rocky Flats	106	37			94	
Alternative 2 (without Plutonium Separation)						
Vitrify at Rocky Flats		119			40	
Blend Down at Rocky Flats		120			40	
Alternative 3 (with Plutonium Separation)						
Mediated Electrochemical Oxidation at Rocky Flats		485		17	1,075	
Preprocess at Rocky Flats		14	–	–	40	–
Mediated Electrochemical Oxidation/Purex at the Savannah River Site		10	1	18	12	19
Alternative 4 (Combination)						
Repackage at Rocky Flats	**106**[d]	**37**			**94**	

[a] Standard 55-gallon (208-liter) drums. (208 liters is equal to 0.208 cubic meters.)
[b] Each canister is 2 feet (61 cm) in diameter, 10 feet (300 cm) tall, and contains approximately 3,700 pounds (1,680 kg) of high-level waste glass.
[c] To convert to pounds, multiply by 2.2.
[d] These stabilized residues could be disposed of in WIPP as transuranic waste.

Notes:

Shaded areas indicate the types of solid products and waste that would not be generated. The products and wastes from the preferred processing technology are presented in bold type. The storage capacities at each site are adequate to store the products and wastes listed in this table.

Table 4–46 Radiological Impacts Due to Incident-Free Management of Inorganic Residues

	Offsite Public Maximally Exposed Individual		***Offsite Public Population***		***Maximally Exposed Individual Involved Worker***		***Involved Worker Population***	
	Dose (mrem)	***Probability of Latent Cancer Fatality***	***Dose (person-rem)***	***Number of Latent Cancer Fatalities***	***Dose (mrem/ year)***	***Probability of a Latent Cancer Fatality per year***	***Dose (person-rem)***	***Number of Cancer Fatalities***
Alternative 1 (No Action)								
Repackage and Store at Rocky Flats	N/E	–	N/E	–	2,000	0.0008	4.7	0.0019
Alternative 2 (without Plutonium Separation)								
Vitrify at Rocky Flats	8.4×10^{-7}	4.2×10^{-13}	0.000034	1.7×10^{-8}	2,000	0.0008	3.8	0.0015
Blend Down at Rocky Flats	2.5×10^{-6}	1.2×10^{-12}	0.000052	2.6×10^{-8}	2,000	0.0008	4.8	0.0019
Alternative 3 (with Plutonium Separation)								
Mediated Electrochemical Oxidation at Rocky Flats	6.3×10^{-6}	3.2×10^{-12}	0.00013	6.5×10^{-8}	2,000	0.0008	7.4	0.0030
Preprocess at Rocky Flats	1.3×10^{-6}	6.5×10^{-13}	0.000027	1.4×10^{-8}	2,000	0.0008	3.5	0.0014
Transport to Savannah River Site	11	5.5×10^{-6}	0.39	0.0002	100	0.00004	0.62	0.00025
Mediated Electrochemical Oxidation/Purex at Savannah River Site[a]	0.000021	1.0×10^{-11}	0.0023	1.2×10^{-6}	2,000	0.0008	4.5	0.0018
Alternative 4 (Combination)								
Repackage at Rocky Flats	**N/E**	**–**	**N/E**	**–**	**2,000**	**0.0008**	**3.3**	**0.0013**

N/E = no emissions—therefore, there are no radiological impacts to the public

[a] Impacts to the public and workers are presented for F-Canyon operations. It has been determined that H-Canyon operations result in lower impacts to these groups.

Note: The impacts due to the preferred processing technology are presented in bold type.

The highest estimated public maximally exposed individual dose in Table 4–46 is 11 mrem, which could occur only during transportation. This hypothetical individual's latent fatal cancer risk would be increased by less than one in one hundred thousand. The public maximally exposed individual risks near the sites would be much lower under all of the technologies. The highest total of the public population radiation doses listed in Table 4–46 would occur if DOE decides to implement the mediated electrochemical oxidation technology at the Savannah River Site. The sum of these doses is 0.39 person-rem, which would cause far less than one additional latent fatal cancer among the population living near both sites and traveling along the truck route. The population living near the truck route would receive a much smaller radiation dose.

The highest involved worker population radiation dose would be approximately 8.6 person-rem, which would occur if DOE decides to implement the mediated electrochemical oxidation technology at the Savannah River Site. This dose would cause 0.0035 additional latent cancer fatalities among the workers directly involved in the operation. Onsite workers who are not involved with the actual processing of the residues are designated as "noninvolved workers." The impacts to these workers would be much smaller than the impacts to the involved workers.

Hazardous Chemical Impacts—The processing of inorganic residues at Rocky Flats would not involve airborne releases of hazardous chemicals. No carcinogenic chemicals are released from the mediated electrochemical oxidation process at the Savannah River Site. Noncancer health risks resulting from releases of phosphoric acid and ammonium nitrate are low; the Hazard Index values presented in **Table 4–47** are much less than one. The impacts due to the preferred processing technology are presented in bold type.

4.10.2.2 Accidents

The potential radiological impacts to the public and the noninvolved onsite workers due to accidents with inorganic residues are summarized and presented in this section. The detailed analysis of onsite accidents, with the associated assumptions, is presented in Appendix D, Section D.3. The detailed analysis considered a wide spectrum of potential accident scenarios, including fire, explosion, spill, criticality, earthquake, and aircraft crash. The accident scenarios with the highest consequences and risks were selected and carried forward to this section for the purpose of consequence and risk comparison. A composite of the risks due to major onsite accident scenarios in each spectrum (including the nonbounding accidents) was also computed and used for comparisons. The composite risk estimates are accurate enough for the purpose of comparing processing technologies against each other. The detailed analysis of transportation accidents, with the associated assumptions, is presented in Appendix E, Sections E.5 and E.6.

The accident frequencies and process durations of the selected accidents are presented in **Table 4–48**. The impacts due to the preferred processing technology are presented in bold type. The onsite accident frequencies are given on a per year basis because many accidents, such as earthquakes, are commonly expressed this way. The duration of each process is given in years. The actual probability of occurrence of each onsite accident can be obtained by multiplying the accident frequency times the technology's duration. In this way, the calculated probabilities are based on the total amount of residue in this category rather than a standard unit of time. The impacts of accidents during post-processing interim storage are presented for all the plutonium residues and scrub alloy combined in Section 4.14.

Table 4–47 Chemical Impacts Due to Incident-Free Management of Inorganic Residues

	Offsite Public Maximally Exposed Individual		***Offsite Public Population***	***Maximally Exposed Individual Worker***		***Worker Population***
	Probability of Cancer Incidence	***Hazard Index***	***Number of Cancer Incidences or Fatalities[a]***	***Probability of Cancer Incidence***	***Hazard Index***	***Number of Cancer Incidences or Fatalities[a]***
Alternative 1 (No Action)						
Repackage and Store at Rocky Flats[b]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 2 (without Plutonium Separation)						
Vitrify at Rocky Flats[b]	N/E	N/E	N/E	N/E	N/E	N/E
Blend Down at Rocky Flats[b]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 3 (with Plutonium Separation)						
Mediated Electrochemical Oxidation at Rocky Flats	N/E	N/E	N/E	N/E	N/E	N/E
Preprocess at Rocky Flats[b]	N/E	N/E	N/E	N/E	N/E	N/E
Transport to Savannah River Site	N/A	N/A	0.00005[c]	N/A	N/A	(c)
Mediated Electrochemical Oxidation/Purex at Savannah River Site[d, e]	N/E	2×10^{-9}	N/E	N/E	2×10^{-8}	N/E
Alternative 4 (Combination)						
Repackage at Rocky Flats	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**

N/E = no emissions   N/A = not applicable—the maximally exposed individual is undefined for vehicle emissions

[a] Cancer incidences and fatalities are calculated for process emissions and transportation emissions, respectively.

[b] No hazardous chemicals are released from process; therefore, no associated health risks exist.

[c] Cancer fatalities due to vehicle emissions into the air. This impact is listed only once under public population because the vehicle emissions affect the public and worker populations collectively. However, the risk to the public dominates. See Appendix E, Section E.4 for additional information.

[d] Impacts are presented for F-Canyon operations. H-Canyon operations are expected to result in similar or lower impacts.

[e] No carcinogenic chemicals are released from the process; therefore, only noncancer health risks are evaluated.

Note: The impacts due to the preferred processing technology are presented in bold type.

Table 4–48 Accident Frequencies, Process Durations, and Consequences for Accidents with Inorganic Residues

				Offsite Public Maximally Exposed Individual Consequences		*Offsite Public Population Consequences*		*Noninvolved Onsite Worker Consequences*	
	Accident Scenario	***Accident Frequency (per year)***	***Process Duration (years)***	***Dose (mrem)***	***Probability of a Latent Cancer Fatality***	***Dose (person-rem)***	***Number of Latent Cancer or Traffic Fatalities***	***Dose (mrem)***	***Probability of a Latent Cancer Fatality***
Alternative 1 (No Action)									
Repackage and Store at Rocky Flats [a]	Explosion (Bldg. 707) [b]	0.00005	0.043	960	0.00048	16,800	8.4	11,200	0.0045
	Earthquake (Bldg. 707) [c]	0.0026	0.043	562	0.00028	9,830	4.9	6,550	0.0026
Alternative 2 (without Plutonium Separation)									
Vitrify at Rocky Flats	Explosion (Bldg. 707) [b]	0.00005	0.043	960	0.00048	16,800	8.4	11,200	0.0045
	Earthquake (Bldg. 707) [c]	0.0026	0.043	337	0.00017	5,900	3.0	3,930	0.0016
Blend Down at Rocky Flats	Explosion (Bldg. 707) [b]	0.00005	0.043	960	0.00048	16,800	8.4	11,200	0.0045
	Earthquake (Bldg. 707) [c]	0.0026	0.043	562	0.00028	9,830	4.9	6,550	0.0026
	Earthquake (Bldg. 371)[b, d]	0.000094	0.043	843	0.00042	9,830	4.9	6,550	0.0026
	Room Fire (Bldg. 371) [c, d]	0.0005	0.043	173	0.000087	2,020	1.0	1,350	0.00054
Alternative 3 (with Plutonium Separation)									
Mediated Electrochemical Oxidation at Rocky Flats	Criticality (Bldg. 371) [e]	0.0001	0.063	790	0.00040	6,980	3.5	321	0.00013
	Explosion (Bldg. 707A) [b, f]	0.00005	0.058	236	0.00012	4,920	2.5	4,130	0.0017
	Earthquake (Bldg. 707A) [c, f]	0.0026	0.058	207	0.00010	4,310	2.2	3,620	0.0015
Preprocess at Rocky Flats	Earthquake (Bldg. 371) [b]	0.000094	0.051	698	0.00035	8,140	4.1	5,430	0.0022
	Room Fire (Bldg. 371) [c]	0.0005	0.051	143	0.000072	1,670	0.84	1,110	0.00044
Transport to Savannah River Site	Traffic Fatality	0.00010 per shipment	4 shipments	N/A	N/A	N/A	1.0 [g]	N/A	(h)
Mediated Electrochemical Oxidation/Purex at Savannah River Site	Earthquake (H-Canyon) [i]	0.000182	0.42	65	0.000033	2,930	1.5	20,800	0.017
Alternative 4 (Combination)									
Repackage at Rocky Flats	**Explosion (Bldg. 707) [b]**	**0.00005**	**0.043**	**960**	**0.00048**	**16,800**	**8.4**	**11,200**	**0.0045**
	Earthquake (Bldg. 707) [c]	**0.0026**	**0.043**	**562**	**0.00028**	**9,830**	**4.9**	**6,550**	**0.0026**

N/A = not applicable

[a] The accident impacts of 20 years of storage are presented in Section 4.14 for all the materials combined under Alternative 1.
[b] Highest consequence accident for this processing technology.
[c] Highest risk accident for this processing technology.
[d] Building 371 is designated as an alternate location for the Blend Down process at Rocky Flats.
[e] Mediated electrochemical oxidation process in Building 371.
[f] Final calcination process in Building 707A.
[g] This fatality is due to the mechanical impact of the accident, not cancer due to radiation. The radiological consequences of a radioactive release on the highway are impossible to list in a single number because the accident could occur at any point along the route and meteorological conditions and population distributions vary greatly along the route.
[h] The consequence of a high-speed traffic accident would be at least one fatality among the transportation workers due to trauma.
[i] HB-Line operates 60 percent of the time. Dose estimates assumed the HB-Line was operating at the time of the accident.

Note: The impacts due to the preferred processing technology are presented in bold type.

The calculation of accident probability is slightly different for traffic accident fatalities. The frequency of traffic accidents is given in terms of the number of fatal accidents per round trip shipment from Rocky Flats to the Savannah River Site. The process duration for traffic accidents is given as the number of round trip shipments. Thus, the actual probability of a fatal traffic accident can be obtained by multiplying the frequency (fatal accidents per round-trip shipment) times the duration (number of round-trip shipments).

The consequences for the public and a noninvolved onsite worker are also presented in Table 4–48 for each of the six inorganic residue processing technologies. The public maximally exposed individual is a hypothetical individual who resides at the site boundary in the downwind direction. The public population is defined as the residential population within a radius of 80 km (50 mi). A noninvolved onsite worker is defined as an individual worker who is located 100 m (328 ft) or more downwind from the release point when an accidental release of radioactive material occurs. The highest consequences to all three receptors would occur if DOE decides to implement either the repackage (under Alternative 1 or 4), the vitrification, or the blend down technology and an explosion occurs in Building 707 during the 0.043 years of residue processing at Rocky Flats.

The risks associated with each accident are calculated by multiplying the probability times the consequences. The risks to the public and an onsite worker are presented in **Table 4–49** for each of the five inorganic residue processing technologies. The risk due to the highest risk accident and a composite risk associated with all major accidents are both presented. The risks due to the preferred processing technology are presented in bold type.

The highest risk to the public maximally exposed individual is estimated to be 3.1×10^{-8}, which is due to an earthquake during processing of the residue with the repackage or the blend down technology in Rocky Flats Building 707. This individual's chance of incurring a latent cancer fatality would be increased by less than one in ten million. The highest risk to the public population is estimated to be 0.00055 latent cancer fatalities, which is also due to an earthquake during processing of the residue with the repackage or the blend down technology in Building 707. The highest risk to the individual noninvolved onsite worker is estimated to be 8.3×10^{-7}, which is due to an earthquake during processing of the residue with the mediated electrochemical oxidation technology in the Savannah River Site H-Canyon. This individual's chance of incurring a latent cancer fatality would be increased by less than one in one million.

4.11 IMPACTS OF MANAGING SCRUB ALLOY

The inventory of scrub alloy weighs approximately 700 kg (1,540 lb), including approximately 200 kg (440 lb) of plutonium. The entire inventory is stored in 42 packages in shipping containers, 57 packages ready to be loaded into shipping containers, and 177 small individual containers.

As discussed in Chapter 2, the alternatives for scrub alloy include one technology under the No Action Alternative, one technology under the Process without Plutonium Separation Alternative, and one technology under the Process with Plutonium Separation Alternative. There is no processing technology under Alternative 4. The preferred processing technology is to repackage the scrub alloy at Rocky Flats and to use Purex at the Savannah River Site.

This section presents the environmental impacts of managing the entire inventory of scrub alloy under each of the three technologies. The results in this section were used in the calculation of the total impacts of the No Action Alternative and the Preferred Alternative which are presented in Sections 4.20 and 4.21, respectively, and of the management approaches which are presented in Section 4.22.

Table 4–49 Risks Due to Accidents with Inorganic Residues

	Accident Scenario	*Offsite Public Maximally Exposed Individual Risk (Probability of a Latent Cancer Fatality)*	*Offsite Public Population Risk (Number of Latent Cancer or Traffic Fatalities)*	*Noninvolved Onsite Worker Risk (Probability of a Latent Cancer Fatality)*
Alternative 1 (No Action)				
Repackage and Store at Rocky Flats [a]	Earthquake (Bldg. 707)	3.1×10^{-8}	0.00055	2.9×10^{-7}
	Composite	3.4×10^{-8}	0.00059	3.1×10^{-7}
Alternative 2 (without Plutonium Separation)				
Vitrify at Rocky Flats	Earthquake (Bldg. 707)	1.9×10^{-8}	0.00033	1.8×10^{-7}
	Composite	2.1×10^{-8}	0.00036	1.9×10^{-7}
Blend Down at Rocky Flats	Earthquake (Bldg. 707)	3.1×10^{-8}	0.00055	2.9×10^{-7}
	Composite (Bldg. 707)	3.4×10^{-8}	0.00059	3.1×10^{-7}
	Room Fire (Bldg. 371) [b]	1.9×10^{-9}	0.000022	1.2×10^{-8}
	Composite (Bldg. 371) [b]	3.6×10^{-9}	0.000042	2.2×10^{-8}
Alternative 3 (with Plutonium Separation)				
Mediated Electrochemical Oxidation at Rocky Flats	Criticality (Bldg. 371) [c]	2.5×10^{-9}	0.000022	8.1×10^{-10}
	Composite	6.0×10^{-9}	0.000063	2.3×10^{-8}
	Earthquake (Bldg. 707A) [d]	1.6×10^{-8}	0.00032	2.2×10^{-7}
	Composite	1.7×10^{-8}	0.00035	2.3×10^{-7}
Preprocess at Rocky Flats	Room Fire (Bldg. 371)	1.8×10^{-9}	0.000021	1.1×10^{-8}
	Composite	3.5×10^{-9}	0.000041	2.2×10^{-8}
Transport to Savannah River Site	Traffic Fatality	N/A	0.0004 [e]	N/A
	Radioactive Release	N/A	4.0×10^{-8}	N/A
Mediated Electrochemical Oxidation/Purex at Savannah River Site	Earthquake (H-Canyon) [f]	1.6×10^{-9}	0.000073	8.3×10^{-7}
	Composite [f]	3.1×10^{-9}	0.00015	8.4×10^{-7}
Alternative 4 (Combination)				
Repackage at Rocky Flats	**Earthquake (Bldg. 707)**	$\mathbf{3.1\times10^{-8}}$	**0.00055**	$\mathbf{2.9\times10^{-7}}$
	Composite	$\mathbf{3.4\times10^{-8}}$	**0.00059**	$\mathbf{3.1\times10^{-7}}$

N/A = not applicable

[a] The accident impacts of 20 years of storage are presented in Section 4.14 for all the materials combined under Alternative 1.

[b] Building 371 is designated as an alternate location for the Blend Down process at Rocky Flats.

[c] Mediated electrochemical oxidation process in Building 371.

[d] Final calcination process in Building 707A.

[e] This risk is due to the mechanical impact of a potential accident, not cancer due to radiation. This risk includes members of the public and transportation workers.

[f] The H-Canyon operates 100 percent of the time and the HB-Line operates 60 percent of the time.

Note: The risks due to the preferred processing technology are presented in bold type.

4.11.1 Products and Wastes

Every processing technology for scrub alloy would generate some quantity of transuranic waste and would prepare this waste for disposal in WIPP. Every technology would also generate some quantity of low-level waste, which would be disposed of routinely using existing procedures at each site. A small portion of the low-level waste generated at Rocky Flats could possibly be low-level mixed waste, but this waste would also be disposed of routinely using existing procedures. The No Action Alternative would generate repackaged scrub alloy that would have to remain in storage indefinitely. The Process without Plutonium Separation Alternative would generate transuranic waste directly from the residue. In one of the processing technologies the repackaged scrub alloy and transuranic waste would be placed in pipe components inside 208-liter (55-gal) drums as shown in Figure 2-13 in Chapter 2.

High-level waste and saltstone would be generated only at the Savannah River Site if the scrub alloy were shipped to that site for plutonium separation. The final form for the high-level waste would be glass poured into stainless steel canisters, which would be stored at the Savannah River Site until a monitored geologic repository is ready to receive them. Saltstone is a cement form of low-level waste that is generated as a byproduct of the Savannah River Site tank farm operations and is routinely disposed of onsite in concrete vaults. If plutonium is separated at the Savannah River Site, it would be stored securely onsite until a decision is made on its disposition. No increase in proliferation risk would result and this plutonium would not be used for nuclear explosive purposes.

The solid plutonium-bearing products and wastes that would be generated from scrub alloy under each of the technologies are presented in **Table 4–50**. The shaded areas of Table 4–50 indicate types of solid products and wastes that would not be generated under the various technologies. The products and wastes from the preferred processing technology are presented in bold type. The largest amount of transuranic waste (2,809 drums) would be generated in the calcine and vitrify technology. Most of this amount would be generated directly from processing the scrub alloy. Transuranic waste that is derived directly from scrub alloy was not included in the Rocky Flats inventory in the WIPP Supplemental EIS, so additional analysis would be required before most of these 2,809 drums of transuranic waste could be disposed of in WIPP (see Section 2.4.10.2). Furthermore, this amount is much higher than the other technolgies, which would generate no more than 61 drums of transuranic waste. The quantities of high-level waste, low-level waste, and saltstone would be low under all the technologies and the sites would manage these wastes using routine procedures. The maximum amount of plutonium that could be separated is 200 kg (440 lb).

4.11.2 Public and Occupational Health and Safety Impacts

This section describes the radiological and hazardous chemical impacts which could result from the alternatives associated with the management of scrub alloy. These impacts are presented for incident-free operation and postulated accident scenarios. The detailed site and transportation analyses are presented in Appendices D and E, respectively.

The round-trip highway distance from Rocky Flats to the Savannah River Site is 5,233 km (3,250 mi). If DOE decides to ship the scrub alloy to the Savannah River Site for Purex processing, then six shipments would be required and the total round-trip shipping distance would be 31,400 km (19,500 mi).

Table 4–50 Products and Wastes from Scrub Alloy

	Repackaged Scrub Alloy (Drums)[a]	***Transuranic Waste (Drums)***[a]	***High-Level Waste (Canisters of Glass)***[b]	***Separated Plutonium (kg)***[c]	***Low-Level Waste (Drums)***[a]	***Saltstone (cubic meters)***
Alternative 1 (No Action)						
Repackage and Store at Rocky Flats	276	59			140	
Alternative 2 (without Plutonium Separation)						
Calcine and Vitrify at Rocky Flats		2,809			140	
Alternative 3 (with Plutonium Separation)						
Repackage at Rocky Flats		**38**	**–**	**–**	**85**	**–**
Purex at Savannah River Site		**23**	**0.3**	**200**	**82**	**103**

[a] Standard 55-gallon (208-liter) drums. (208 liters is equal to 0.208 cubic meters.)
[b] Each canister is 2 feet (61 cm) in diameter, 10 feet (300 cm) tall, and contains approximately 3,700 pounds (1,680 kg) of high-level waste glass.
[c] To convert to pounds, multiply by 2.2.
Notes: Shaded areas indicate the types of solid products and waste that would not be generated. The products and wastes from the preferred processing technology are presented in bold type. The storage capacities at each site are adequate to store the products and wastes listed in this table.

No construction of new processing facilities is included in any of the alternatives, but DOE may need to modify certain existing facilities and construct new waste storage buildings for some of the alternatives. Mitigation measures during modifications would ensure that any radiological or hazardous chemical releases would be extremely small. Worker exposures to contaminated material would be limited to ensure that doses are maintained as low as reasonably achievable.

4.11.2.1 Incident-Free Operations

Radiological Impacts—The radiological impacts to the public and the workers associated with incident-free operations of each technology are presented in **Table 4–51**. The impacts due to the preferred technology are presented in bold type. The impacts are those which are anticipated to occur as a result of process operations and transportation over whatever time period is necessary to process the entire inventory of scrub alloy. The length of time necessary to process the scrub alloy will depend on which technology DOE decides to implement. Impacts associated with subsequent incident-free storage of stabilized scrub alloy, separated plutonium, and wastes would be much smaller than from processing or transportation.

The highest estimated public maximally exposed individual dose in Table 4–51 is 11 mrem, which could occur only during transportation. This hypothetical individual's latent fatal cancer risk would be increased by less than one in one hundred thousand. The public maximally exposed individual risks near the sites would be much lower under all of the technologies. The highest total of the public population radiation doses listed in Table 4–51 would occur if DOE decides to implement the Purex processing technology at the Savannah River Site. The sum of these doses is 0.62 person-rem, which would cause far less than one additional latent fatal cancer among the population living near both sites and traveling along the truck route. The population living near the truck route would receive a much smaller radiation dose

The highest involved worker population radiation dose would be approximately 142 person-rem, which would occur if DOE decides to implement the calcine and vitrify technology at Rocky Flats. This dose would cause 0.057 additional latent cancer fatalities among the workers directly involved in the operation. Onsite workers who are not involved with the actual processing of the scrub alloy are designated as "noninvolved workers." The impacts to these workers would be much smaller than the impacts to the involved workers.

Hazardous Chemical Impacts—The processing of scrub alloy at Rocky Flats would not involve airborne releases of hazardous chemicals. No carcinogenic chemicals would be released from the Purex process at the Savannah River Site. Noncancer health risks resulting from the release of phosphoric acid and ammonium nitrate are low; the Hazard Index values presented in **Table 4–52** are much less than one. The impacts due to the preferred processing technology are presented in bold type.

4.11.2.2 Accidents

The potential radiological impacts to the public and the noninvolved onsite workers due to accidents with scrub alloy are summarized and presented in this section. The detailed analysis of onsite accidents, with the associated assumptions, is presented in Appendix D, Section D.3. The detailed analysis considered a wide spectrum of potential accident scenarios, including fire, explosion, spill, criticality, earthquake, and aircraft crash. The accident scenarios with the highest consequences and risks were selected and carried forward to this section for the purpose of consequence and risk comparison. A composite of the risks due to major onsite accident scenarios in each spectrum (including the nonbounding accidents) was also computed and used for comparisons. The composite risk estimates are accurate for the purpose of comparing processing technologies against each other. The detailed analysis of transportation accidents, with the associated assumptions, is presented in Appendix E, Sections E.5 and E.6.

Table 4–51 Radiological Impacts Due to Incident-Free Management of Scrub Alloy

	Offsite Public Maximally Exposed Individual		*Offsite Public Population*		*Maximally Exposed Individual Involved Worker*		*Involved Worker Population*	
	Dose (mrem)	***Probability of a Latent Cancer Fatality***	***Dose (person-rem)***	***Number of Latent Cancer Fatalities***	***Dose (mrem/yr)***	***Probability of a Latent Cancer Fatality per year***	***Dose (person-rem)***	***Number of Latent Cancer Fatalities***
Alternative 1 (No Action)								
Repackage and Store at Rocky Flats	0.000042	2.1×10^{-11}	0.0017	8.5×10^{-7}	2,000	0.0008	35	0.014
Alternative 2 (without Plutonium Separation)								
Calcine and Vitrify at Rocky Flats	0.000063	3.2×10^{-11}	0.0025	1.2×10^{-6}	2,000	0.0008	142	0.057
Alternative 3 (with Plutonium Separation)								
Repackage at Rocky Flats	**0.000066**	$\mathbf{3.3\times10^{-11}}$	**0.0014**	$\mathbf{7.0\times10^{-7}}$	**2,000**	**0.0008**	**34**	**0.014**
Transport to Savannah River Site	**11**	$\mathbf{5.5\times10^{-6}}$	**0.59**	**0.00030**	**100**	**0.00004**	**0.93**	**0.0004**
Purex at Savannah River Site[a]	**0.00024**	$\mathbf{1.2\times10^{-10}}$	**0.0255**	**0.000013**	**2,000**	**0.0008**	**25**	**0.010**

[a] Impacts to the public and workers are presented for F-Canyon operations. It has been determined that H-Canyon operations result in lower impacts to these groups.

Note: The impacts due to the preferred processing technology are presented in bold type.

Table 4–52 Chemical Impacts Due to Incident-Free Management of Scrub Alloy

	Offsite Public Maximally Exposed Individual		*Offsite Public Population*	*Maximally Exposed Individual Worker*		*Worker Population*
	Probability of a Cancer Incidence	*Hazard Index*	*Number of Cancer Incidences or Fatalities*[a]	*Probability of a Cancer Incidence*	*Hazard Index*	*Number of Cancer Incidences or Fatalities*[a]
Alternative 1 (No Action)						
Repackage and Store at Rocky Flats[b]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 2 (without Plutonium Separation)						
Calcine and Vitrify at Rocky Flats[b]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 3 (with Plutonium Separation)						
Repackage at Rocky Flats[b]	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**
Transport to Savannah River Site	**N/A**	**N/A**	**0.00008[c]**	**N/A**	**N/A**	**(c)**
Purex at Savannah River Site[d, e]	**N/E**	**2×10^{-9}**	**N/E**	**N/E**	**2×10^{-8}**	**N/E**

N/E = no emissions N/A = not applicable—the maximally exposed individual is undefined for vehicle emissions

[a] Cancer incidences and fatalities are calculated for process emissions and transportation emissions, respectively.

[b] No hazardous chemicals are released from process; therefore, no associated health risks exist.

[c] Cancer fatalities due to vehicle emissions into the air. This impact is listed only once under public population because the vehicle emissions affect the public and worker populations collectively. However, the risk to the public dominates. See Appendix E, Section E.4 for additional information.

[d] Impacts are presented for F-Canyon operations. H-Canyon operations are expected to result in similar or lower impacts.

[e] No carcinogenic chemicals are released from the process; therefore, only noncancer health risks are evaluated.

Note: The impacts due to the preferred processing technology are presented in bold type.

The accident frequencies and process durations of the selected accidents are presented in **Table 4–53**. The impacts due to the preferred processing technology are presented in bold type. The onsite accident frequencies are given on a per year basis because many accidents, such as earthquakes, are commonly expressed this way. The duration of each process is given in years. The actual probability of occurrence of each onsite accident can be obtained by multiplying the accident frequency times the technology's duration. In this way, the calculated probabilities are based on the total amount of residue in this category rather than a standard unit of time. The impacts of accidents during post-processing interim storage are presented for all the plutonium residues and scrub alloy combined in Section 4.14.

The calculation of accident probability is slightly different for traffic accident fatalities. The frequency of traffic accidents is given in terms of the number of fatal accidents per round trip shipment from Rocky Flats to the Savannah River Site. The process duration for traffic accidents is given as the number of round trip shipments. Thus, the actual probability of a fatal traffic accident can be obtained by multiplying the frequency (fatal accidents per round-trip shipment) times the duration (number of round-trip shipments).

The consequences for the public and a noninvolved onsite worker are also presented in Table 4–53, for each of the three scrub alloy processing technologies. The public maximally exposed individual is a hypothetical individual who resides at the site boundary in the downwind direction. The public population is defined as the residential population within a radius of 80 km (50 mi). A noninvolved onsite worker is defined as an individual worker who is located 100 m (328 ft) or more downwind from the release point when an accidental release of radioactive material occurs. The highest consequences to all three receptors would occur if DOE decides to implement the Purex technology at the Savannah River Site and a major earthquake strong enough to cause a breach in the H-Canyon during the 0.50 years of scrub alloy processing at the Savannah River Site.

The risks associated with each accident are calculated by multiplying the probability times the consequences. The risks to the public and an onsite worker are presented in **Table 4–54** for each of the three scrub alloy processing technologies. The risk associated with the highest risk accident and a composite risk due to all major accidents are both presented. The risks associated with the preferred processing technology are presented in bold type.

The highest risk to the public maximally exposed individual is estimated to be 2.0×10^{-8}, which is due to an earthquake during repackaging of the scrub alloy at Rocky Flats. This individual's chance of incurring a latent cancer fatality would be increased by less than one in ten million. The highest risk to the public population is estimated to be 0.00082 latent cancer fatalities, which is due to an earthquake during processing of the scrub alloy with the Purex technology at the Savannah River Site. The highest risk to the individual noninvolved onsite worker is estimated to be 9.9×10^{-6}, and is due to the same accident scenario at the Savannah River Site. This individual's chance of incurring a latent cancer fatality would be increased by less than one in one hundred thousand.

4.12 Air Quality

The potential human health impacts of hazardous chemicals (carbon tetrachloride, phosphoric acid, hydrochloric acid, and ammonium nitrate) are evaluated in the hazardous chemical impacts subsections for each material category (Sections 4.2-4.11). In addition to hazardous chemicals, some of the processing technologies could release criteria and other regulated air pollutants. These chemical and air pollutant concentrations are compared in this section to the corresponding Federal and State air pollution standards or guidelines. Radiological air emissions are discussed and compared to the National Emission Standards for Hazardous Air Pollutants in the Cumulative Impact Section (4.25).

Table 4–53 Accident Frequencies, Process Durations, and Consequences for Accidents with Scrub Alloy

				Offsite Public Maximally Exposed Individual Consequences		*Offsite Public Population Consequences*		*Noninvolved Onsite Worker Consequences*	
	Accident Scenario	*Accident Frequency (per year)*	*Process Duration (years)*	*Dose (mrem)*	*Probability of a Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer or Traffic Fatalities*	*Dose (mrem)*	*Probability of a Latent Cancer Fatality*
Alternative 1 (No Action)									
Repackage and Store at Rocky Flats [a]	Earthquake (Bldg. 707)	0.0026	0.11	142	0.000071	2,640	1.3	1,730	0.00069
Alternative 2 (without Plutonium Separation)									
Calcine and Vitrify at Rocky Flats	Earthquake (Bldg. 707) [b]	0.0026	2.21	4.3	2.2×10^{-6}	79	0.040	52	0.000021
	Dock Fire (Bldg. 707) [c]	2.0×10^{-6}	2.21	25	0.000013	468	0.23	306	0.00012
Alternative 3 (with Plutonium Separation)									
Repackage at Rocky Flats	**Earthquake (Bldg. 371) [c]**	**0.000094**	**0.12**	**131**	**0.000066**	**1,550**	**0.78**	**1,010**	**0.00040**
	Room Fire (Bldg. 371) [b]	**0.0005**	**0.12**	**27**	**0.000014**	**318**	**0.16**	**208**	**0.000083**
Transport to Savannah River Site	**Traffic Fatality**	**0.00010 per shipment**	**6 shipments**	**N/A**	**N/A**	**N/A**	**1.0 [d]**	**N/A**	**e**
Purex at Savannah River Site	**Earthquake (H-Canyon)**	**0.000182**	**0.50**	**407**	**0.00020**	**18,100**	**9.1**	**136,000**	**0.11**

N/A = not applicable
[a] The accident impacts of 20 years of storage are presented in Section 4.14 for all the materials combined under Alternative 1.
[b] Highest risk accident for this processing technology.
[c] Highest consequence accident for this processing technology.
[d] This fatality is due to the mechanical impact of the accident, not cancer due to radiation. The radiological consequences of a radioactive release on the highway are impossible to list in a single number because the accident could occur at any point along the route and meteorological conditions and population distributions vary greatly along the route.
[e] The consequence of a high-speed traffic accident would be at least one fatality among the transportation workers due to trauma.
Note: The impacts due to the preferred processing technology are presented in bold type.

Table 4–54 Risks Due to Accidents with Scrub Alloy

	Accident Scenario	*Offsite Public Maximally Exposed Individual Risk (Probability of a Latent Cancer Fatality)*	*Offsite Public Population Risk (Number of Latent Cancer or Traffic Fatalities)*	*Noninvolved Onsite Worker Risk (Probability of a Latent Cancer Fatality)*
Alternative 1 (No Action)				
Repackage and Store at Rocky Flats [a]	Earthquake (Bldg. 707)	2.0×10^{-8}	0.00038	2.0×10^{-7}
	Composite	2.1×10^{-8}	0.00039	2.1×10^{-7}
Alternative 2 (without Plutonium Separation)				
Calcine and Vitrify at Rocky Flats	Earthquake (Bldg. 707)	1.2×10^{-8}	0.00023	1.2×10^{-7}
	Composite	1.3×10^{-8}	0.00024	1.3×10^{-7}
Alternative 3 (with Plutonium Separation)				
Preprocess at Rocky Flats	**Room Fire (Bldg. 371)**	**8.1×10^{-10}**	**9.6×10^{-6}**	**5.0×10^{-9}**
	Composite	**1.6×10^{-9}**	**0.000018**	**9.6×10^{-9}**
Transport to Savannah River Site	**Traffic Fatality**	**N/A**	**0.0006 [b]**	**N/A**
	Radioactive Release	**N/A**	**4.3×10^{-8}**	**N/A**
Purex at Savannah River Site	**Earthquake (H-Canyon)**	**1.9×10^{-8}**	**0.00082**	**9.9×10^{-6}**
	Composite	**2.9×10^{-8}**	**0.0013**	**9.9×10^{-6}**

N/A = not applicable

[a] The accident impacts of 20 years of storage are presented in Section 4.14 for all the materials combined under Alternative 1.

[b] This risk is due to the mechanical impact of a potential accident, not cancer due to radiation. This risk includes members of the public and transportation workers.

Note: The risks due to the preferred processing technology are presented in bold type.

Tables 4–55 (Rocky Flats) and **4–56** (Savannah River Site) present the sites' existing modeled concentrations of criteria and hazardous air pollutants and the modeled concentrations associated with the proposed processing at each site and compares them to existing Federal and State air quality standards and guidelines. The Industrial Source Complex air dispersion model ISC3 was used to develop these estimates (see Appendix D, Section D.4). The types of air pollutants differ by site because of differences in the chemical constituents of the residue materials and in the chemical reactants required for the various processes. These modeled concentrations represent the maximum predicted releases at each site from processing residues and scrub alloy. The impacts from each residue and scrub alloy processing technology have been combined and assumed to occur concurrently at each site. This is a very conservative assumption made because nonradiological air emissions and corresponding concentrations associated with the various processing alternatives are small and are not considered by DOE to be a discriminator between alternatives.

For Rocky Flats, nitrogen oxide (NO_x) is the only criteria pollutant expected to be released. Concentrations of this pollutant are compared to the annual standard for nitrogen dioxide (NO_2). In addition, concentrations of the hazardous air pollutants carbon tetrachloride and hydrochloric acid at Rocky Flats are presented. There are no Federal or State guidelines or standards for these hazardous pollutants. Consequently, these concentrations are compared to EPA established cancer inhalation unit risk factors (for carbon tetrachloride) and Reference Concentrations (for hydrochloric acid) in the health effects of hazardous chemicals subsections of this chapter. When the contribution from the alternatives is combined with the concentrations from existing facilities at Rocky Flats, the concentrations are well below the standards and guidelines.

Ambient air concentrations based on monitoring data and modeled data from nearby non-DOE sources are discussed in Section 3.1.3. If these ambient air concentrations are combined with the concentrations in Table 4-55, the resulting concentrations would also be well below the air quality standards and guidelines. Note that combining the site's concentrations with the ambient concentrations is very conservative, as it is expected that the monitors would be impacted by Rocky Flats emission sources in addition to non-DOE sources.

For the Savannah River Site, nitrogen oxide concentrations are compared to the annual standard for nitrogen dioxide. No other criteria pollutants are expected to be emitted. In addition, concentrations of total suspended particulates, nitric acid, hydrogen fluoride, and phosphoric acid at the Savannah River Site are compared to the State standards. The modeled concentrations are very small. When these concentrations are combined with the concentrations from existing facilities at the Savannah River Site the concentrations are well below the standards and guidelines.

Ambient air concentrations based on monitoring data are discussed in Section 3.2.3. If these ambient air concentrations are combined with the concentrations in Table 4-56, the resulting concentrations would be below the air quality standards and guidelines, except for the State's annual total suspended particulates standard of 75 $\mu g/m^3$. The combined annual total suspended particulates concentration would be 80 $\mu g/m^3$. Note that combining the site's concentrations with the ambient concentrations is very conservative, as it is expected that the monitors would be impacted by Savannah River Site emission sources as well as any non-DOE sources. In addition, the State air quality agency does not require the site to add monitored concentrations to modeled concentrations for demonstrating compliance with the air quality standards (SRS 1998).

The Los Alamos National Laboratory is not included in the table because no hazardous chemicals and only a very small quantity of criteria air pollutants would be released to the atmosphere due to the very limited processing that would take place at that site under any of the processing technologies. Air pollutant emissions and concentrations will be unchanged and are expected to continue to meet the ambient standards.

Table 4–55 Air Quality Impacts from Process Emissions at Rocky Flats

Pollutant	*Averaging Time*	*Most Stringent Regulation or Guideline (μg/m³)*[a]	*Site Baseline Concentration (μg/m³)*[b]	*Modeled Concentration*[h] *(μg/m³)*	*Combined Concentration from Rocky Flats Sources (μg/m³)*	*Percent of Standard or Guideline*
Criteria Pollutants						
CO	8-Hour	10,000[c]	304	0	304	3.0
	1-Hour	40,000[c]	1,160	0	1,160	2.9
NO_2	Annual	100[c]	1.4	0.00014	1.4	1.4
Ozone	8-Hour	157[c,e]	(e)	(e)	(e)	NC
	1-Hour	160[d,e]	(e)	(e)	(e)	NC
PM_{10}	Annual	50[c,f]	14.0	0	14.0	28
	24-Hour	150[c,f]	32.0	0	32.0	21
$PM_{2.5}$	Annual	15[c,f]	(f)	(f)	(f)	NC
	24-Hour	65[c,f]	(f)	(f)	(f)	NC
SO_2	Annual	80[c]	0.1	0	0.1	0.13
	24-Hour	365[c]	91.2	0	91.2	25
	3-Hour	700[d]	270	0	270	39
Lead	Calendar Quarter	1.5[c]	< 0.001	0	<0.001	<0.1
	30-Day	1.5[d]	< 0.001	0	<0.001	<0.1
Other Regulated Pollutants						
Hydrogen Sulfide	1-Hour	142[d]	35.4	0	35.4	25
Total Suspended Particulates	Annual	75[d]	31.0	0	31.0	41
	24-Hour	150[d]	73.0	0	73.0	49
Toxic/Hazardous Pollutants						
Carbon Tetrachloride	Annual	(g)	0.0024	0.000031	0.0024	NC
Hydrochloric Acid	Annual	(g)	0.0052	4.2×10^{-7}	0.0052	NC

NC = not calculated

Note: Only toxic pollutants emitted from the alternatives being evaluated are presented. The Draft EIS listed additional toxic pollutants which would not be emitted from any of the proposed alternatives and so are not necessary to assess baseline or cumulative air quality impacts.

[a] The more stringent of the Federal and State standards is presented.

[b] Concentrations based on Rocky Flats Cumulative Impacts Document, 1997. Monthly lead concentration conservatively used to estimate quarterly concentration.

[c] Federal standard.

[d] State standard.

[e] Ozone, as a criteria pollutant, is not directly emitted or monitored by the site. EPA recently revised the air quality standards for ozone. The new standards, finalized on July 18, 1997, change the ozone primary and secondary standards from a 1-hour concentration of 235 μg/m³ (0.12 ppm) to an 8-hour concentration of 157 μg/m³ (0.08 ppm). During a transition period, the 1-hour ozone standard would continue to apply in nonattainment areas such as Rocky Flats.

[f] EPA recently revised the air quality standards for particulate matter. The current PM_{10} annual standard is retained and two $PM_{2.5}$ (particulate matter less than or equal to 2.5 micrometers) standards are added. The standards are set at 15 μg/m³ (3-year arithmetic mean based on community-oriented monitors) and 65 μg/m³ (3-year average of the 98th percentile of 24-hour concentrations at population-oriented monitors). The current 24-hour PM_{10} standard is revised to be based on the 99th percentile of 24-hour concentrations. Insufficient emissions, modeling and monitoring data exist for estimating concentrations of $PM_{2.5}$.

[g] No State or Federal standard exists.

[h] Based on emissions from combining all processing technologies for residues and scrub alloy.

Source: Adapted from DOE 1996a

Table 4–56 Air Quality Impacts from Process Emissions at Savannah River Site

Pollutant	*Averaging Time*	*Most Stringent Regulation or Guideline ($\mu g/m^3$)*[a]	*Site Baseline Concentration ($\mu g/m^3$)*[b]	*Modeled Concentration*[h] *($\mu g/m^3$)*	*Combined Concentration from Savannah River Sources ($\mu g/m^3$)*	*Percent of Standard or Guideline*
Criteria Pollutants						
CO	8-Hour	10,000[c]	632	0	632	6.3
	1-Hour	40,000[c]	5,000	0	5,000	13
NO_2	Annual	100[c]	8.8	0.039	8.8	8.8
Ozone	8-Hour	157[c,f]	(f)	(f)	(f)	NC
PM_{10}	Annual	50[c,d]	4.8	0	4.8	9.6
	24-Hour	150[c,d]	80.6	0	80.6	54
$PM_{2.5}$	Annual	15[c,d]	(d)	(d)	(d)	NC
	24-Hour	65[c,d]	(d)	(d)	(d)	NC
SO_2	Annual	80[c]	16.3	0	16.3	20
	24-hour	365[c]	215	0	215	59
	3-Hour	1,300[c]	690	0	690	53
Lead	Calendar Quarter	1.5[c]	<0.01	0	<0.01	<0.1
Other Regulated Pollutants						
Hydrogen Fluoride	30-Day	0.8[e]	0.09	0.00036	0.09	11
	7-Day	1.6[e]	0.39	0.0032[g]	0.39	25
	24-Hour	2.9[e]	1.04	0.0032	1.04	36
	12-Hour	3.7[e]	1.99	0.0051	2.00	54
Total Suspended Particulates	Annual	75[e]	43.3	0	43.3	58
Toxic/Hazardous Pollutants						
Nitric Acid	24-Hour	125.0[e]	50.96	0.65	51.61	41
Phosphoric Acid	24-Hour	25.0[e]	0.462	0.0016	0.464	1.9

NC = not calculated

Note: Only toxic pollutants emitted from the alternatives being evaluated are presented. The Draft EIS listed additional toxic pollutants which would not be emitted from any of the proposed alternatives and so are not necessary to assess baseline or cumulative air quality impacts.

[a] The more stringent of the Federal and State standards is presented.

[b] Concentration based on *Draft Tritium Extraction Facility EIS*, (DOE 1998a) (1994 emissions data), except for hydrogen fluoride, nitric acid, and phosphoric acid which are based on *Storage and Disposition of Weapons - Usable Fissile Materials Final PEIS*, (DOE 1996a) (1990 emissions data).

[c] Federal standard.

[d] EPA recently revised the air quality standards for particulate matter. The current PM_{10} annual standard is retained and two $PM_{2.5}$ (particulate matter less than or equal to 2.5 micrometers) standards are added. The standards are set at 15 $\mu g/m^3$ (3-year arithmetic mean based on community-oriented monitors) and 65 $\mu g/m^3$ (3-year average of the 98th percentile of 24-hour concentrations at population-oriented monitors). The current 24-hour PM_{10} standard is revised to be based on the 99th percentile of 24-hour concentrations. Insufficient emissions, modeling and monitoring data exist for estimating concentrations of $PM_{2.5}$.

[e] State standard.

[f] Ozone, as a criteria pollutant, is not directly emitted or monitored by the site. EPA recently revised the air quality standards for ozone. The new standards, finalized on July 18, 1997, change the ozone primary and secondary standards from a 1-hour concentration of 235 $\mu g/m^3$ (0.12 ppm) to an 8-hour concentration of 157 $\mu g/m^3$ (0.08 ppm).

[g] 7-day concentration conservatively estimated using 24-hour concentration.

[h] Based on emissions from combining all processing technologies for residues and scrub alloy.

Source: Adapted from DOE 1998a and DOE 1996a.

In addition to the releases of criteria pollutants from processing facilities, the shipment of residues and scrub alloy between sites would also contribute to the emissions of criteria pollutants. The impacts of these mobile sources of pollutants on air quality would be very low. See the Cumulative Impacts discussion in Section 4.25.4 for additional information.

The increase in NO_2 annual average concentrations from processing at Rocky Flats and Savannah River Site are a small fraction of the Prevention of Significant Deterioration Class II area increment of 25 $\mu g/m^3$. Any contribution to NO_2 concentrations at a Class I area, such as Rocky Mountain National Park near Rocky Flats, would be a very small fraction of the Prevention of Significant Deterioration Class I increment of 2.5 $\mu g/m^3$. None of these alternatives have emissions large enough to require a Prevention of Significant Deterioration permit.

The EPA has established National Ambient Air Quality Standards throughout the U.S. for the six criteria pollutants, and each State is responsible for measuring its air quality to determine if and when the air fails to meet these standards. Each State also has a State Implementation Plan to eliminate or reduce the severity and number of violations of the National Ambient Air Quality Standards. Areas with a history of violations are called "nonattainment areas". Federal actions, such as the actions described in this EIS, must conform to each State's State Implementation Plan to avoid contributing to a violation of the National Ambient Air Quality Standards (EPA 1993). If a proposed Federal action would 1) occur in a "nonattainment area" and 2) could release significant quantities of criteria pollutants, then the Federal agency is required to perform a conformity analysis to determine if the proposed Federal action would conform to the State Implementation Plan.

The National Ambient Air Quality Standards attainment status of the areas around the Savannah River Site and the Los Alamos National Laboratory are discussed in Sections 3.2.3 and 3.3.3, respectively. These sites are not located in "nonattainment areas", so no conformity analysis is required for these sites in this EIS.

As discussed in Section 3.1.3, however, Rocky Flats is located in a "nonattainment area" for ozone (O_3) and carbon monoxide (CO). Ozone itself is not emitted from Rocky Flats, but is formed in the atmosphere through a complex reaction of ozone precursor pollutants, sunlight, and temperature. Two ozone precursors could be emitted from Rocky Flats: nitrogen dioxide (NO_2) and volatile organic chemicals. DOE considered the quantities of NO_2, volatile organic chemicals, and CO that could be released at Rocky Flats due to the actions in this EIS. Total direct and indirect emissions, including transportation emissions, have been estimated based on the process descriptions at Rocky Flats and the maximum number of shipments from Rocky Flats. The number of shipments along with EPA's MOBILE 5 model was used to estimate exhaust emissions from the safe, secure trailers and escort vehicles traveling through the "nonattainment area." The total estimated emissions are 89 kg/yr (196 lb/yr) of NO_2, 17 kg/yr (37 lb/yr) of VOCs, and 56 kg/yr (123 lb/yr) of CO and are mainly due to transportation. These emission levels are all far below the applicability level which would trigger a conformity analysis (90,000 kg/yr [200,000 lb/yr] for each of these chemicals) (40 CFR 51; 40 CFR 93). Furthermore, these estimated emissions would be much smaller than the normal emissions from vehicles in the Denver area. Thus, DOE did not perform a conformity analysis for O_3 or CO in the Rocky Flats area.

Rocky Flats is also in a "nonattainment area" for particulate matter of 10 microns or smaller in diameter (PM_{10}). Transportation is the only action in this EIS that would be expected to generate PM_{10}, from reentrainment of road dust and from diesel-powered truck exhaust. The maximum number of shipments involved in this EIS, however, is tiny compared to the amount of transportation that occurs normally in the Denver area, so the PM_{10} emissions attributable to this EIS, 102 kg/yr (225 lb/yr), would be a small fraction of the total emissions in the Denver area. The PM_{10} emissions were estimated using shipment information along with EPA's PART 5 model. Thus, DOE did not perform a conformity analysis for PM_{10} in the Rocky Flats area.

4.13 WATER QUALITY

None of the processing technologies at any of the sites would discharge untreated process effluents to surface water or ground water. Effluents would be processed at existing site facilities as follows:

- All process effluents produced from Rocky Flats processes are either directly stabilized for disposal or reused in the process water system (a closed-cycle system).

- All process effluents produced from Savannah River Site processes (in the F-Canyon or H-Canyon) would be pumped directly to the High-Level Waste system for treatment and disposal of residuals or to the Z-Area Saltstone Treatment and Disposal Facility.

- All process effluents produced from Los Alamos National Laboratory processes would be transferred to the Radioactive Liquid Waste Treatment Facility for treatment.

Any water released from the above treatment processes to the surface or groundwater would meet the applicable water quality requirements of the State. Thus, there would be no impact on water quality at any of the three sites under incident-free conditions.

The sections below provide additional detail on the specific types and amounts of effluents that would result from the processing technologies at the three sites and the treatments for those effluents prior to any water being discharged to the surface or groundwater.

Analyses have been performed on the impacts of accidents on water pathways. Using a bounding case analysis, DOE considered the worst accidents (identified in Appendix D), calculated the maximum concentrations of radioactivity deposited to the ground surface, and calculated the drinking water pathway exposure for that worst accident. From this, DOE calculated the highest dose to the maximally exposed individual located at the site boundary and from drinking water from a hypothetical water supply pond.

In the event of a major earthquake or an airplane crash at a facility that is processing plutonium residues or scrub alloy, radioactive material might be released into surface waters. The amount of material that may be released from the facility to the surface water and subsequently flow offsite would be very small. Analyses have shown that for weapons grade plutonium accidents, inhalation is the only exposure of importance. Ingestion of both food and water contributes less than 0.2 percent of the total dose to the population. (EG&G 1993). A traffic accident involving a truck carrying containers of plutonium residues or scrub alloy would have no impact on water quality because the containers are all designed to contain the material, even if the containers are submerged in water after the traffic accident.

4.13.1 Rocky Flats

The materials to be processed at Rocky Flats would be processed in Buildings 707 or 371. Effluents would consist of water (some with potassium hydroxide and potassium nitrate), filtrate, and evaporator bottoms. Most of the processing technologies would not generate any effluents. The processing technologies that would generate effluents are listed in **Table 4–57**.

Table 4–57 Process Effluents at Rocky Flats

Residue Category	Processing Technology	Effluent Description
Combustible (Aqueous-contaminated)	Neutralize/Dry and Store	5,250 kg water with potassium hydroxide and potassium nitrate
Combustible	Sonic Wash	11,000 kg water
Combustible	Catalytic Chemical Oxidation	40 kg hydrochloric acid 164 kg water
Combustible	Mediated Electrochemical Oxidation	2,900 kg evaporator bottoms, with 0.1 kg Pu
Combustible (Aqueous-contaminated)	Neutralize/Dry with Variance	5,250 kg water with potassium hydroxide and potassium nitrate
Plutonium Fluoride	Dissolve, Oxidize and Store	1,960 kg filtrate
Plutonium Fluoride	Dissolve and Oxidize	1,960 kg filtrate
All Filter Media	Neutralize/Dry and Store	25,700 kg water with potassium hydroxide and potassium nitrate
All Filter Media	Sonic Wash	25,500 kg water
All Filter Media	Mediated Electrochemical Oxidation	6,800 kg evaporator bottoms, with 1.0 kg Pu
Ful Flo (IDC 331) and HEPA (IDC 338) Filters	Neutralize/Dry with Variance	24,400 kg water with potassium hydroxide and potassium nitrate
All Sludge	Filter/Dry and Store	31 kg decant water
Other Sludge	Acid Dissolve	3,700 filtrate
Other Sludge	Filter/Dry with Variance	31 kg decant water
Glass	Neutralize/Dry and Store	1,340 kg water with potassium hydroxide and potassium nitrate and with 5.0 kg Pu
Glass	Mediated Electrochemical Oxidation	370 kg evaporator bottoms, with 0.1 kg Pu
Glass	Neutralize/Dry with Variance	1,340 kg water with potassium hydroxide and potassium nitrate and with 5.0 kg Pu
Graphite	Mediated Electrochemical Oxidation	6,100 kg acid, with 0.1 kg Pu

There would be no direct discharge of contaminants to the surface or ground water for any of the Rocky Flats processing technologies in any of the alternatives. All aqueous waste produced would either be directly stabilized for disposal or reused in the process water system. All plutonium-containing waste waters generated at the site are treated by evaporation and, in some cases, preceded by an initial carrier precipitation step. The solids and concentrated solution from these treatment steps are immobilized and stored pending disposal at an approved disposal facility. The resulting treated solution must meet the State of Colorado Reuse Criteria specified in 6 CCR-1007-3, Part 261.2(e)(ii), and is recycled to the site process water system where it is used as make-up water for the site steam plant and cooling towers. Although it is largely a closed system, there are occasional process water system discharges of excess water to the site sewage treatment plant, based on overall water balance considerations. All sewage treatment plant effluent must meet National Pollution Discharge Elimination System permit requirements. Thus, none of the effluents from the waste water treatment facility are discharged to the surface or groundwater.

4.13.2 Savannah River Site

If any materials are sent to the Savannah River Site under this EIS, they would be processed through either F-Canyon or H-Canyon. Effluents would consist of various aqueous solutions. The materials, processing technologies, and effluents are presented in **Table 4–58**.

Table 4–58 Process Effluents at the Savannah River Site

Residue Category	*Processing Technology*	*Effluent Description*
Incinerator Ash	Purex	Aqueous solution containing tin, fly ash, residual plutonium and spent processing reagents
Incinerator Ash	MEO/Purex	Aqueous solution containing fly ash, residual plutonium and spent processing reagents
Sand, Slag and Crucible	Purex	Aqueous solution containing tin, calcium, magnesium, residual plutonium and spent processing reagents
Graphite Fines	MEO/Purex	Aqueous solution containing residual plutonium and spent processing reagents
All Salt Residues	Purex, after salt scrub at Rocky Flats	Aqueous solution containing americium, aluminum, residual plutonium and spent processing reagents
Plutonium Fluoride	Purex	Aqueous solution containing tin, fluoride, residual plutonium, impurities and spent processing reagents
Graphite	MEO/Purex	Aqueous solution containing graphite, residual plutonium and spent processing reagents
Inorganic	MEO/Purex	Aqueous solution containing inorganics, residual plutonium and spent processing reagents
Scrub Alloy	Purex	Aqueous solution containing americium, aluminum, residual plutonium and spent processing reagents

No process effluents would be released to surface water or groundwater. All the process effluents would be pumped from the canyon to the High-Level Waste system. The liquids would be stored in tanks pending processing. The impacts of these operations would be low (DOE 1994c). The americium and residual plutonium would be vitrified in canisters in the Defense Waste Processing Facility. The numbers of canisters that would be generated from each processing technology are presented in Sections 4.2 through 4.11.

Decontaminated aqueous solutions containing tin, fly ash, carbon steel, calcium, magnesium, graphite, inorganics, aluminum, fluoride, spent processing reagents and other impurities would be transferred to the Z-Area Saltstone Treatment and Disposal Facility. The resultant non-hazardous stabilized waste form (saltstone) would be disposed of in engineered vaults in accordance with the permit from the State of South Carolina. The impacts on groundwater quality from saltstone disposal would be very low (DOE 1994c). The number of cubic meters of saltstone that would be generated from each processing technology are presented in Sections 4.2 through 4.11.

4.13.3 Los Alamos National Laboratory

If any materials are sent to the Los Alamos National Laboratory under this EIS, they would be processed at Technical Area 55 (TA-55). Effluents would consist of water and filtrate. The materials, processing technologies, and effluents are presented in **Table 4–59**.

Table 4–59 Process Effluents at Los Alamos National Laboratory

Residue Category	Processing Technology	Effluent Description
IDC 365, 413 & 427 Salts	Acid Dissolve	755 kg water 9,320 kg filtrate
Other Direct Oxide Reduction Salts	Acid Dissolve	1,445 kg water 18,310 kg filtrate

No process effluents would be released to surface water or groundwater. All the process effluents would be transferred from TA-55 to the Radioactive Liquid Waste Treatment Facility at TA-50, where they would be treated using "as low as reasonably achievable" and "best available technology" processes. Any water released from that facility would be small and in accordance with the facility's National Pollution Discharge Elimination System permits.

4.14 IMPACTS OF POST-PROCESSING STORAGE

Under all of the alternatives, the products and some of the wastes from processing would be placed in storage for some period of time following processing. Under Alternative 1, stabilized residues would be placed in indefinite storage at Rocky Flats. Under Alternative 3, plutonium oxide would be stored for an extended period, until such time as it is processed for disposition. Materials designated for disposal at WIPP (i.e., stabilized residues and other transuranic wastes) would need to be stored until they could be scheduled for transportation to WIPP. If WIPP does not open or if its opening is delayed, it may be necessary to store these materials for an extended period of time.

The estimated amounts of products and wastes that would be generated at each site under the Preferred Alternative are presented in Section 4.21.1. Similarly, the estimated maximum amount of each product and waste that could be generated at each site is presented in Section 4.23. These generation estimates represent upper limits of storage requirements. DOE might need to construct new waste storage buildings if shipments to WIPP are delayed. The impacts of this construction would be low because the buildings would be light-weight metal or fabric structures on previously-disturbed land.

4.14.1 Impacts of Incident-Free Storage

Under incident-free conditions, the impacts of storage would be limited to radiological exposures to involved workers. No member of the public would be exposed to radiation from materials in storage unless a serious accident occurred. Similarly, there would be no potential exposures from nonradioactive hazardous chemicals because stabilization activities under all alternatives would prevent chemical exposures. The maximally exposed individual worker would receive a dose no higher than 2,000 mrem per year. Based on past experience at Rocky Flats, dose to the involved worker population from storage of stabilized residues is assumed to be directly proportional to the number of drums in storage. The involved worker dose rate from storage of stabilized residues is assumed to be 6.4 person-rem per year per 10,000 drums in storage.

Plutonium produced by separation processing at the Savannah River Site would be stored in the Actinide Packaging and Storage Facility (currently under construction) when it becomes operational (currently scheduled for 2001). Worker dose from storage in this facility is expected to be zero because no workers will go inside the facility. All inspections and handling will be performed with robotics. Nevertheless, in this section DOE made the conservative assumption that the worker doses for plutonium storage would be equal to those for stabilized residues storage: 6.4 person-rem per year per 10,000 drums.

4.14.1.1 Interim Storage of Stabilized Residues in the No Action Alternative

Under the No Action Alternative (Alternative 1), the stabilized residues would remain at Rocky Flats indefinitely. For the purpose of analysis, the storage period is assumed to be 20 years. This assumption is consistent with DOE's Notice of Intent (DOE 1996e) and DOE's Waste Management PEIS (DOE 1997c). The total number of drums of stabilized residues in the No Action Alternative could be as high as about 20,300 drums. This alternative would require the construction of new light-weight storage buildings at Rocky Flats. Multiplying the number of drums by 20 years and 6.4 person-rem per year per 10,000 drums yields a total of 260 person-rem for the total worker dose. The number of latent cancer fatalities associated with this dose is 0.1 latent cancer fatalities. This is much less than one, so DOE would not expect any workers to incur a latent cancer fatality from this storage.

4.14.1.2 Lag Storage

Lag storage would occur for transuranic waste under all alternatives and for stabilized residues with variances under Alternative 4. These materials would be waiting for shipment to WIPP. Lag storage would also occur for plutonium oxide from the processing of salt residues at Los Alamos National Laboratory. It is not possible to predict the duration of lag storage for any alternative because the duration would depend on the future availability of transportation, capacity at the receiving facility, etc.

Under the Preferred Alternative, DOE would generate about 18,400 drums of stabilized residues, 3,200 drums of transuranic waste, and 607 kg of plutonium at all three sites combined. All of this material could require some lag storage for some period of time. Assuming DOE places four kilograms of plutonium in each plutonium storage container, there could be a total of about 21,800 drums requiring lag storage at various times and for various durations at the three sites. If the average lag storage duration for all these materials is assumed to be one-half year, then multiplying by 6.4 person-rem per year per 10,000 drums yields a total worker dose of 7.0 person-rem. The number of latent cancer fatalities associated with this dose is 0.003 latent cancer fatalities. This is much less than one, so DOE would not expect any workers to incur a latent cancer fatality from this storage.

By examining the tables of products and wastes in Sections 4.2 through 4.11, the maximum amount of material that could require lag storage at all three sites under any combination of processing technologies can be estimated. The result is that there could be a total of about 42,000 drums requiring lag storage at various times and for various durations at the three sites. If the average lag storage duration is again assumed to be one-half year, then the total worker dose would be less than 14 person-rem. DOE would not expect any workers to incur a latent cancer fatality from such a small dose.

4.14.1.3 Storage of Transuranic Waste if Shipments to WIPP are Delayed

Every processing technology in this EIS would generate some transuranic waste and DOE plans to dispose of it in WIPP. The processing technologies in Alternative 4 would also generate stabilized residues, which could be disposed of in WIPP as transuranic waste. If the shipments to WIPP are delayed, then the inventories of transuranic waste and stabilized residues with variances would be placed in interim storage at the processing sites.

As discussed under lag storage above, DOE would generate about 18,400 drums of stabilized residues and 3,200 drums of transuranic waste under the Preferred Alternative. If all 21,600 drums of this material were placed in interim storage, then the worker dose would be about 14 person-rem per year. The number of latent cancer fatalities associated with this dose rate is 0.007 latent cancer fatalities per year. This is much less than one, so DOE would not expect any workers to incur a latent cancer fatality from this storage.

By examining the tables of products and wastes in Sections 4.2 through 4.11, the maximum amount of stabilized residues and transuranic waste that could require interim storage at all three sites under any combination of processing technologies can be estimated. The result is that there could be a combined total of about 42,000 drums requiring such storage in shipments to WIPP are delayed. The total worker dose rate could be as high as about 27 person-rem per year at all three sites combined. The number of latent cancer fatalities associated with this dose rate is about 0.01 latent cancer fatalities per year. This is much less than one, so DOE would not expect any workers to incur a latent cancer fatality from this storage.

4.14.2 Impacts of Accidents During Storage

In accident situations, it would be possible for some radioactive material to be released from the containers, so the offsite public could be affected. The impacts due to accidents during storage would not be directly proportional to the number of drums in storage, but rather they would depend more on the form of the packaging and the amounts of plutonium in the materials. The estimated impacts of storing stabilized residues, transuranic waste, and plutonium oxide are presented in **Tables 4–60** and **4–61**. The details of the impact calculations for accidents during storage are given in Appendix D.

Except for the 20 years of storage assumed for the No Action Alternative, the risks are given on an annual basis because the duration of this storage is impossible to determine. The highest accident risks to all three receptors would occur under the No Action Alternative due to the extended storage time.

4.15 IMPACTS OF FINAL TRANSPORTATION AND DISPOSAL/DISPOSITION

4.15.1 Final Transportation

After interim storage at the processing sites, the many of the products and wastes generated from processing the Rocky Flats plutonium residues and scrub alloy would be transported to other sites for disposal or long-term storage. The impacts of this transportation are outside the scope of this EIS, but they are discussed briefly in Appendix E, Section E.6.5 and analyzed in other EISs prepared by DOE.

The environmental impacts of transporting the transuranic waste generated during processing of the plutonium residues are included in the *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement* (DOE 1997g). An approximation of the contribution to these total transportation impacts that may be attributable to the actions addressed in this EIS can be obtained by comparing the quantity of transuranic waste analyzed in the WIPP SEIS II and in this EIS. The quantity of stabilized or repackaged residues and transuranic waste generated in the preferred alternative of this EIS is estimated to be 20,800 drums (4,300 cubic meters). This is about 2.5 percent of the capacity of WIPP for transuranic waste. In the WIPP SEIS II the accident-free population impacts were estimated to be about 3.0 latent cancer fatalities to the public and 0.3 latent cancer fatalities to the truck crews. The highest lifetime accident-free impact to the maximally exposed individual was a 0.0085 probability of a latent cancer fatality. The aggregate potential truck accident impacts to populations along all transportation routes was estimated to be 0.4 latent cancer fatalities.

Low-level and possibly low-level mixed waste would also be generated as a result of processing the residues and scrub alloy. The environmental impacts of transporting these wastes are included in the *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (DOE 1997c).

Table 4–60 Frequencies and Consequences of Accidents During Storage

Alternative	*Accident Scenario*	*Accident Frequency (per year)*	*Offsite Public Maximally Exposed Individual Consequences*		*Offsite Public Population Consequences*		*Noninvolved Onsite Worker Consequences*	
			Dose (mrem)	*Probability of a Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*	*Dose (mrem)*	*Probability of a Latent Cancer Fatality*
Alternative 1 (No Action)								
Storage at Rocky Flats after Processing	Earthquake (Bldg. 371)	0.000094	306	0.00015	4,250	2.1	3,570	0.0014
Alternative 2 (without Plutonium Separation)								
Storage at Rocky Flats after Processing	Earthquake (Butler Bldg.)	0.002	52	0.000026	908	0.5	605	0.00024
Alternative 3 (with Plutonium Separation)								
Storage at Rocky Flats after Processing	Earthquake (Bldg. 371)	0.000094	2,460	0.0012	30,700	15	22,100	0.018
Storage at Rocky Flats after Preprocessing or Offsite Processing	Earthquake (Bldg. 371)	0.000094	1,850	0.00093	22,200	11	15,000	0.0060
Storage at Savannah River Site after Processing in H-Canyon	Earthquake (APSF Vault)	0.00001	100	0.000050	3,990	2.0	33,900	0.027
Storage at Los Alamos National Laboratory after Processing	Earthquake (TA-55 Vault)	0.000019	29,500	0.030	38,800	19	318,000	0.25
Storage at Savannah River Site after Processing at Los Alamos National Laboratory	Earthquake (APSF Vault)	0.00001	435	0.00022	15,500	7.8	109,000	0.087
Alternative 4 (Combination Alternative)								
Storage at Rocky Flats after Processing	Earthquake (Butler Bldg.)	0.002	67	0.000034	1,170	0.6	783	0.00031

APSF = Actinide Packaging and Storage Facility TA = technical area

Table 4–61 Risks of Accidents During Storage

Alternative	*Accident Scenario*	*Offsite Public Maximally Exposed Individual Risk (Probability of a Latent Cancer Fatality per year)*	*Offsite Public Population Risk (Number of Latent Cancer Fatalities per year)*	*Noninvolved Onsite Worker Risk (Probability of a Latent Cancer Fatality per year)*
Alternative 1 (No Action)				
Storage at Rocky Flats after Processing for 20 years	Earthquake (Bldg. 371)	1.4×10^{-8} per yr 2.9×10^{-7} per 20 yrs	0.00020 per yr 0.0040 per 20 yrs	1.3×10^{-7} per yr 2.7×10^{-7} per 20 yrs
	Composite	9.1×10^{-8} per yr 1.8×10^{-6} per 20 yrs	0.0016 per yr 0.031 per 20 yrs	8.5×10^{-7} per yr 0.000017 per 20 yrs
Alternative 2 (without Plutonium Separation)				
Storage at Rocky Flats after Processing	Earthquake (Butler Bldg.)	5.2×10^{-8}	0.00091	4.8×10^{-7}
	Composite	5.2×10^{-8}	0.00091	4.9×10^{-7}
Alternative 3 (with Plutonium Separation)				
Storage at Rocky Flats after Processing	Earthquake (Bldg. 371)	1.2×10^{-7}	0.0014	1.7×10^{-6}
	Composite	2.0×10^{-7}	0.0029	2.5×10^{-6}
Storage at Rocky Flats after Preprocessing for Offsite Processing	Earthquake (Bldg. 371)	8.7×10^{-8}	0.0011	5.6×10^{-7}
	Composite	8.7×10^{-8}	0.0011	5.6×10^{-7}
Storage at Savannah River Site after Processing in H-Canyon	Earthquake (APSF Vault)	5.0×10^{-10}	0.000020	2.7×10^{-7}
	Composite	5.0×10^{-10}	0.000020	2.7×10^{-7}
Storage at Los Alamos National Laboratory after Processing	Earthquake (TA-55 Vault)	5.6×10^{-7}	0.00037	4.8×10^{-6}
	Composite	5.7×10^{-7}	0.00037	4.9×10^{-6}
Storage at Savannah River Site after Processing at Los Alamos National Laboratory	Earthquake (APSF Vault)	2.2×10^{-9}	0.000078	8.7×10^{-7}
	Composite	2.2×10^{-9}	0.000078	8.7×10^{-7}
Alternative 4 (Combination Alternative)				
Storage at Rocky Flats after Processing	Earthquake (Butler Bldg.)	6.7×10^{-8}	0.0012	6.3×10^{-7}
	Composite	6.8×10^{-8}	0.0012	6.3×10^{-7}

APSF = Actinide Packaging and Storage Facility   TA = technical area

Impacts from transportation of plutonium metal and oxides, which would be produced by processing residues and scrub alloy with plutonium separation (Alternative 3), are described in the *Storage and Disposition of Weapons-Usable Fissile Materials Programmatic Environmental Impact Statement* (Storage and Disposition Programmatic EIS) (DOE 1996a). If Alternative 3 (processing with plutonium separation) is implemented at Rocky Flats or Los Alamos National Laboratory for the electrorefining and molten salt extraction salt residues, the resulting plutonium product could have special management requirements. These residues have a high americium content, and most of the non-Purex separation processes bring considered for this category would not remove the americium from the plutonium. Because americium emits gamma radiation, shielded containers would be required for storage and transportation of this mixture of plutonium and americium.

DOE plans to consolidate the storage of weapon-usable plutonium by upgrading existing and planned facilities at the Pantex Plant in Texas and the Savannah River Site in South Carolina. After certain conditions are met, most plutonium now stored at Rocky Flats would be moved to the Pantex Plant and the Savannah River Site (DOE 1997d). The transportation and long-term storage of this plutonium is analyzed in DOE's *Surplus Plutonium Disposition Draft EIS,* which was issued in July 1998 (DOE 1998b).

4.15.2 Disposal/Disposition

The impacts of disposal and/or disposition of the products and wastes generated from processing the Rocky Flats plutonium residues and scrub alloy are outside the scope of this EIS, but they are analyzed in other EISs prepared by DOE.

Products and wastes that result from processing the residues and scrub alloy according to the No Action Alternative would be stored at Rocky Flats until decisions are made concerning their disposition. Accordingly, no disposal impacts can be estimated at this time.

If the residues and scrub alloy are processed according to the Process without Plutonium Separation Alternative, the residual product will be a transuranic waste that meets the WIPP waste acceptance criteria. The environmental impacts of disposing of the transuranic waste from the residues are included in the *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement* (DOE 1997g) and these impacts are estimated to be low. Further NEPA review would be needed before transuranic wastes generated directly from scrub alloy could be disposed of at WIPP.

Secondary wastes classified as low-level or low-level mixed waste may also be generated as a result of the processes to stabilize the residues and scrub alloy. The environmental impacts of disposing of these secondary wastes are included in the *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (DOE 1997c) and these impacts are estimated to be low.

If the residues and scrub alloy are processed according to the Process with Plutonium Separation Alternative, two principal products would result: (1) plutonium metal or plutonium oxide that contains greater than 50 percent plutonium and (2) transuranic waste. In addition, secondary wastes classified as low-level or low-level mixed waste may be generated during the process. High-level waste and saltstone would be generated if processing takes place at the Savannah River Site.

Decisions have not yet been made concerning the disposition of the plutonium metal and plutonium oxide in DOE's inventory. However, current DOE policy will ensure that any plutonium separated and/or stabilized under this EIS will not be used for nuclear explosive purposes (DOE 1994b). The environmental impacts of further stabilization of this material are analyzed in the *Surplus Plutonium Disposition Draft EIS* issued in July

1998 (DOE 1998b). No environmental impact statement has yet been published on the disposal of stabilized plutonium in a monitored geologic repository.

Two additional waste streams would be generated at the Savannah River Site if the residues or scrub alloy are processed there. These processes would produce a liquid waste that would be sent to the high-level waste tank farm and mixed with high-level wastes. When this waste is processed, part of it would be sent to the Defense Waste Processing Facility to be vitrified as high-level waste and another fraction would be sent to the Saltstone Manufacturing and Disposal Facility to be solidified as low-level waste. The high-level waste fraction of this waste would be processed in the Defense Waste Processing Facility. The product of this processing would be canisters filled with high-level waste glass, which would be stored in the Glass Waste Storage Building at the Savannah River Site. The environmental impacts of these processing and storage activities are addressed in the *Final Supplemental Environmental Impact Statement, Defense Waste Processing Facility* (DOE 1994c) and these impacts are estimated to be low.

The high-level waste fraction of this waste would be disposed of in the monitored geologic repository for defense high-level waste and spent nuclear fuel. The environmental impacts of disposing of the high-level waste fraction of this material will be addressed with other high-level waste. The impacts of disposing of saltstone at the Savannah River Site are also addressed in the *Final Supplemental Environmental Impact Statement, Defense Waste Processing Facility* (DOE 1994c) and these impacts are estimated to be low.

4.16 Environmental Justice

As discussed in Appendix F, Executive Order 12898 directs Federal agencies to address disproportionately high and adverse health or environmental effects of alternatives on minority populations and low-income populations.

Chapter 3 and Appendix F describe the distributions of minority and low-income populations in the vicinity of the three candidate processing sites and potential intersite transportation routes. Analyses described elsewhere in this chapter predict only minimal risks to health and safety from the management of plutonium residues and scrub alloy currently stored at Rocky Flats. Analyses of risks from incident-free operations and from accidents under all alternatives yield estimates that are much less than 1 latent cancer fatality in the public population. Because none of the alternatives would cause high and adverse consequences to the population at large, no minority or low-income populations would be expected to experience disproportionately high and adverse consequences.

4.17 Costs, Processing Durations, and Uncertainties

This section summarizes costs, processing durations, and uncertainties for the Minimum Cost Management Approach, the Preferred Alternative, the No Action Alternative, and the Minimum Duration Management Approach. Detailed supporting data and calculations for the individual processing technologies are presented in Appendix G. All costs are presented in undiscounted 1997 dollars.

4.17.1 Cost Estimation Procedures

All costs for individual alternatives and management approaches are rolled-up totals from six individual cost categories:

- Facilities and equipment
- Labor and site overheads

- Transuranic waste, including variable costs of disposal at WIPP
- Low-level waste at Rocky Flats and Los Alamos National Laboratory
- Other materials storage, shipping, and disposal costs, including costs at the Savannah River Site, and
- Costs related to interim storage of stabilized residues and transuranic waste at Rocky Flats (No Action Alternative).

Facilities and equipment costs are divided into two groups: (1) costs that have been incurred, are being incurred, or will be incurred in support of the plutonium residues clean-up independent of the Records of Decision in the present EIS, and (2) costs that will be incurred pursuant to the Records of Decision in the present EIS. The former group includes costs to bring the facilities into compliance with DOE regulations and Defense Nuclear Facilities Safety Board recommendations, to upgrade the facilities for their missions, to install facility-specific equipment, and to complete operational readiness reviews and startup tests. These costs, plus ongoing research and development costs, are allocable to the plutonium residues program, but are not incremental (i.e., decisional) in the present EIS. Allocable costs in most alternatives are $180 million for facilities and equipment (i.e., an average of six facilities at $30 million per facility) and $10 million for research and development. Costs for expensive, specialized pieces of equipment used in a small number of processing technologies are directly assigned to these technologies and are decisional in this EIS. Processing costs are based on facilities and equipment that are (or would be) up-and-running for this program rather than on developmental technologies. Decommissioning costs at all three sites are considered part of site-wide programs outside the scope of this EIS.

Labor costs and site overheads are estimated as a function of the number of hours that operations and support personnel are exposed to radiation (not the amount of radiation they are exposed to). These exposure-hours are then multiplied by a factor that relates allocable labor hours at the site to exposure-hours. The more allocable labor-hours per exposure-hour, the greater the multiplier. The multiplier captures the hours spent by: (1) exposed individuals in non-exposed activities (e.g., preparing for operations, down-time during maintenance, and administrative matters), (2) non-exposed individuals in direct support of the operations, and (3) indirect site support personnel. The relationships between exposure-hours and allocable labor costs are based on empirical observations from a sample of recent residues management activities at Rocky Flats.

Transuranic waste costs are based on unit costs for packaging, characterizing, and shipping drums of transuranic waste and stabilized residues to WIPP. Variable costs for disposing of transuranic waste at WIPP are included for each processing technology. Other waste treatment and disposal costs, including low-level waste, are allocated on a similar unit cost basis, including costs for disposal of high-level waste in a monitored geologic repository.

Other materials storage, shipping, and disposal costs include shipping materials from Rocky Flats to the Los Alamos National Laboratory or the Savannah River Site for processing, storing 3013 canisters of refined plutonium, disposing of saltstone at the Savannah River Site, producing vitrified high-level waste at the Savannah River Site Defense Waste Processing Facility, disposing of vitrified high-level waste at the monitored geologic repository, and disposing of refined plutonium in later DOE programs.

Assuming Records of Decision in 1998 selecting the No Action Alternative, processing activities would continue until about 2006. Stabilized residues and transuranic waste generated during the stabilization processes are assumed to remain on site for an additional twenty years. For cost purposes, all stabilized residues are assumed to be qualified for shipment to WIPP at the same level of characterization as other transuranic wastes before being shipped to WIPP in 2025.

4.17.2 Cost Factors

Five factors explain most of the costs and cost relationships described in this EIS. These cost factors can be summarized as follows:

- **Labor and Labor Multipliers** — Labor-related costs are based on the number of hours operators are exposed and a multiplier to account for non-exposure hours, indirect hours, site labor, etc. The multipliers range from 1.1 for repackaging and similar non-processing activities, to 3.1 for pyro-oxidation, distillation, and processes with similar requirements, 4.2 for vitrification, blend down, and similar processes, and 5.8 for "wet processes" such as sonic washing, water leaching, mediated electrochemical oxidation, and Purex processing at the Savannah River Site. Multiplied labor costs may overstate the *incremental* out-of-pocket costs to DOE since many site and indirect costs are fixed or semi-fixed.

- **Duration --** In general, the shorter the duration of processing, the lower the costs. As a practical matter, the only processing technologies for which the differences in *incremental* labor costs to DOE are likely to be significant are those with much higher durations of exposure-hours among the direct workers.

- **Capital Expenditures --** Processing technologies that require the acquisition of highly specific large-scale equipment (e.g., equipment for mediated electrochemical oxidation at Rocky Flats or the Savannah River Site or distillation at the Los Alamos National Laboratory) are never among the least costly technologies. There are no processing technologies for which savings on operations can offset the costs for new, large-scale equipment.

- **Transuranic Waste --** Processing technologies that create large numbers of drums of transuranic waste or stabilized residues generate large costs for waste packaging, characterization, and shipping. Variable costs for disposal at WIPP are a minor cost factor.

High Assay Materials— Processing technologies that ship the materials with the highest plutonium assays to the Savannah River Site for Purex processing tend to be among the least expensive options. This is because (1) Purex processing costs at the Savannah River Site vary according to total residue mass while processing costs at Rocky Flats and the Los Alamos National Laboratory vary according to plutonium mass, and (2) Purex processing at the Savannah River Site F-Canyon requires no large capital additions while many of the processes for high assay residues at either of the other sites require expensive capital additions.

4.17.3 Cost of the Minimum Cost Management Approach

DOE estimates that the Minimum Cost Management Approach has an allocable cost of about $428 million. About $180 million of this cost has been or will be incurred at Rocky Flats in support of the plutonium residues program independent of the present EIS. Another $10 million will be incurred at Rocky Flats or Los Alamos National Laboratory in fiscal year 1998 for development and testing of the processing technologies independent of the present EIS. Of the remaining $238 million, about $185 million is attributable to labor, waste processing, site overheads, etc. at the individual sites. About $47 million is attributable to disposition of separated plutonium outside of this EIS. Itemized equipment (i.e., distillation apparatus at Rocky Flats) is estimated to cost about $4 million. Variable costs for disposal at WIPP are about $1 million. The Minimum Cost Management Approach would require an estimated 3.2 years of calendar time at Rocky Flats, with Building 707, Module A requiring the most processing time. **Table 4-62** shows the individually allocable costs for each processing technology and the totals for the various categories.

Among the major residue categories, the least costly processing technology for the ash residues is some form of repackaging at Rocky Flats under Alternative 4. With the exception of Purex processing at the Savannah River Site for sand, slag, and crucible, the least costly technologies for managing the ash residues are the same as the preferred processing technologies. For the salt residues, the only category where the least costly technology is the same as the preferred processing technology is repackaging and shipment to WIPP for other direct oxide reduction salts under Alternative 4. The least costly processing technology for both categories of electrorefining and molten salt extraction salts is distillation at Rocky Flats. This technology requires about $4 million in itemized equipment costs at Rocky Flats. The least costly processing technology for the high assay direct oxide reduction salts is salt scrub at Rocky Flats followed by Purex processing at the Savannah River Site F-Canyon.

Table 4–62 Individually Allocable Costs of the Minimum Cost Processing Technologies [a]

Material Category	*Minimum Cost Processing Technology*	*Approximate Cost ($M)*	*Preferred Processing Technology?*
Incinerator Ash	Repackage at Rocky Flats under Alternative 4	58	Yes
Sand, Slag, and Crucible	Repackage at Rocky Flats under Alternative 4	11	No
Graphite Fines	Repackage at Rocky Flats under Alternative 4	4	Yes
Inorganic Ash	Repackage at Rocky Flats under Alternative 4	8	Yes
Molten Salt Extraction and Electrorefining Salts IDC 409	Distillation at Rocky Flats	18[b]	No
Other Electrorefining and Molten Salt Extraction Salts	Distillation at Rocky Flats	45[b]	No
Direct Oxide Reduction Salts, IDCs 365, 413, 427	Salt scrub at Rocky Flats and Purex Process at the Savannah River Site F-Canyon	13	No
Other Direct Oxide Reduction Salts	Repackage at Rocky Flats under Alternative 4	8	Yes
Aqueous-contaminated Combustibles	Blend Down at Rocky Flats	2	No
Organic-contaminated Combustibles	Blend Down at Rocky Flats	1	No
Dry Combustibles	Blend Down at Rocky Flats	1	No
Plutonium Fluorides	Repackage at Rocky Flats and Purex Process at the Savannah River Site F-Canyon	18	Yes
Ful Flo Filter Media	Blend Down at Rocky Flats	4	Yes
HEPA IDC 338 Filter Media	Blend Down at Rocky Flats	10	No
Other HEPA Filter Media	Vitrify at Rocky Flats	1	No
Sludge (IDC 089, 099, 332)	Vitrify at Rocky Flats	1	No
Other Sludge	Blend Down at Rocky Flats	3	No
Glass	Neutralize/Dry at Rocky Flats under Alternative 4	1	Yes
Graphite	Repackage at Rocky Flats under Alternative 4	8	Yes
Inorganic	Repackage at Rocky Flats under Alternative 4	2	Yes
Scrub Alloy	Repackage at Rocky Flats and Purex Process at the Savannah River Site F-Canyon	20	Yes
Labor, site, processing, & disposal costs[b,c,d]		~234	

Material Category	***Minimum Cost Processing Technology***	***Approximate Cost ($M)***	***Preferred Processing Technology?***
Of which, materials disposition costs[d]		~47	
Plus, itemized equipment costs[d]		~4	
Subtotal - decisional costs[d]		~238	
Common facilities costs at Rocky Flats[e]		~180	
R&D at Rocky Flats and Los Alamos National Laboratory[e]		~10	
Total		~428	

[a] Excluding the no action processing technologies, which would generate stabilized residues without variances for disposal in WIPP.
[b] Excluding $2 million of $4 million in itemized distillation equipment costs.
[c] Because costs for many of the minor residues are significantly less than $1 million but are shown as $1 million, the sum of the individual costs on the table exceeds the actual total.
[d] Costs that DOE would incur by selecting the specified processing technologies.
[e] Costs that DOE expects to incur regardless of the processing technologies selected.

4.17.4 Cost of the Preferred Alternative

The Preferred Alternative adds an estimated $96 million in decisional costs to the Minimum Cost Management Approach (**Table 4-63**). This additional cost is attributable to the processing technologies for sand, slag, and crucible; electrorefining and molten salt extraction salts; high assay direct oxide reduction salts; combustibles; filters; and sludges. DOE prefers to incur the higher costs of the preferred processing technologies rather than accept the technical and schedule uncertainties associated with the less costly processing technologies. The Preferred Alternative requires about 5.5 years at Rocky Flats, with operations at Building 707, Module E taking the longest. The major cost/uncertainty tradeoffs are as follows:

Sand, Slag, and Crucible—The preferred processing technology of repackaging at Rocky Flats for Purex processing at the Savannah River Site is about $25 million more expensive than repackaging under Alternative 4. DOE prefers Purex processing at the Savannah River Site because there is a high degree of technical and schedule uncertainty related to characterizing the sand, slag, and crucible under Alternative 4. While DOE believes that the material could be qualified for shipment to WIPP, the characterization process would be lengthy and would create very large cost and scheduling concerns at the Savannah River Site if qualification issues could not be resolved and the material were ultimately required to be shipped to the Savannah River Site.

IDC 409 Electrorefining and Molten Salt Extraction Salts—The preferred processing technology of pyro-oxidation followed by repackaging under Alternative 4 for the high assay electrorefining and molten salt extraction salts is virtually the same cost as the minimum cost processing technology of distillation at Rocky Flats. DOE prefers repackaging under Alternative 4 because it has much less technical and schedule uncertainty.

Other Electrorefining and Molten Salt Extraction Salts—The preferred processing technology of pyro-oxidation followed by repackaging under Alternative 4 for the other electrorefining and molten salt extraction salts is about $21 million more expensive than the minimum cost processing technology of distillation at Rocky Flats. DOE prefers repackaging under Alternative 4 because it has much less technical and schedule uncertainty.

IDC 365, 413, and 427 Direct Oxide Reduction Salts—The preferred processing technology is to ship the high assay direct oxide reduction salts (most of which are IDCs 365, 413, and 427) to the Los Alamos National Laboratory for acid dissolution and to repackage the remaining [IDC 365, 413, and 427] direct oxide reduction salts under Alternative 4. Because DOE needs to retain the flexibility to ship all the high assay direct oxide reduction salts to the Los Alamos National Laboratory in the event repackaging under Alternative 4 is not feasible, the cost summary for the preferred alternative shows the costs for the more costly of the two processing options, i.e., shipping all 727 kg to the Los Alamos National Laboratory for acid dissolution. These costs are about $5 million higher than either repackaging all the high assay direct oxide reduction salts under Alternative 4 or repackaging and Purex processing the salts at the Savannah River Site. The "hybrid" is about $3 million more expensive than either repackaging all the high assay direct oxide reduction salts under Alternative 4 or repackaging and Purex processing the salts at the Savannah River Site. Shipment of the salts to the Los Alamos National Laboratory rather than repackaging under Alternative 4 reduces the duration of activities at Rocky Flats' Building 707, Module E by about 1-2 months.

Other Direct Oxide Reduction Salts—The preferred processing technology of pyro-oxidation followed by repackaging under Alternative 4 for the other direct oxide reduction salts is the least costly technology. DOE recognizes the possibility that some of the other direct oxide reduction salts may not meet the requirements for repackaging under Alternative 4. In this case, DOE prefers to ship the salts to the Los Alamos National Laboratory for acid dissolution. DOE cannot determine how much other direct oxide reduction salt could be shipped to the Los Alamos National Laboratory until each can of material is examined. In the event all of the other direct oxide reduction salts are shipped to the Los Alamos National Laboratory, the additional cost to DOE for processing is estimated at about $12 million. Shipment of the salts to the Los Alamos National Laboratory rather than repackaging under Alternative 4 reduces the duration of activities at Rocky Flats' Building 707, Module E by a few months.

Combustibles—The preferred processing technologies of neutralize/dry, thermal desorption/steam passivation, and repackaging, (all under Alternative 4) for aqueous-contaminated, organic-contaminated, and dry combustibles, respectively, are about $10 million more expensive than blending down the residues. Blend-down generates fewer drums for disposal at WIPP (220 compared to 1,008) and requires 1/2 year less time at Rocky Flats. However, blend down has a high technical uncertainty for addressing the safety issues related to nitric acid-contaminated and organic-contaminated combustibles and radiolysis. It is not known if the dilution of the nitrates would address the potentially explosive formation of nitrate cellulose or if the dilution of the combustible organic material in the combustibles would prevent the potential generation of hydrogen gas from radiolysis. The time needed to verify that blend down would eliminate the safety issues would adversely affect the schedule for shutting down Rocky Flats.

IDC 338 High Efficiency Particulate Air Filters—The preferred processing technology of neutralize/dry under Alternative 4 is about $29 million more expensive than vitrification or blend down. Vitrification generates fewer drums for disposal at WIPP (656 compared with 3,361) and requires almost one year less processing time at Rocky Flats. However, HEPA filters have never been vitrified and thus present a high technical uncertainty. Blend down could be substituted for vitrification with fewer drums (572), slightly more processing time at Rocky Flats, and essentially no change in costs. However, blend down has a high technical uncertainty for addressing the safety issues related to nitric acid-contaminated filters. It is not known if the dilution of the nitrates would address the potentially explosive formation of nitrate cellulose or if the dilution of the organic material in the HEPA filters would prevent the potential generation of hydrogen gas from radiolysis. The time needed to verify that blend down would eliminate the safety issues or to prove that vitrification works for HEPA filters would adversely affect the schedule for shutting down Rocky Flats.

Other Sludge—The preferred processing technology of filter/dry under Alternative 4 is about $9 million more expensive than vitrification or blend down. Vitrification generates fewer drums for disposal at WIPP (216 compared with 1,095) and requires about two months less processing time at Rocky Flats. However, vitrification has tested unsuccessfully on sludges and more testing would be needed to develop the process. Blend down could be substituted for vitrification with fewer drums (212), slightly more processing time at Rocky Flats, and essentially no change in costs. However, blend down has a high technical uncertainty for addressing the safety issues related to nitric acid-contaminated and solvent-contaminated sludges. It is not known if the dilution of the nitrates would address the potentially explosive formation of nitrate cellulose or if the dilution of the organic material in the sludges would prevent the potential generation of hydrogen gas from radiolysis. The time needed to verify that blend down would eliminate the safety issues or to prove that vitrification works for sludges would adversely affect the schedule for shutting down Rocky Flats.

For repackaged combustibles and filter media, DOE is severely limited in the amount of plutonium per drum it may ship to WIPP. This limitation (23.2 fissile gram-equivalent) is due to the amount of organic material that may interact with radionuclides to generate explosive conditions. Once the combustibles and filter media are changed from their original state by processes such as vitrification, pipe components can be used to pack the plutonium at up to 200 fissile gram-equivalent. This reduces the number of drums shipped to WIPP by more than a factor of eight. In the case of blending, the reduced drum count is due to the shredding process that precedes the blending process. Subject to the uncertainties described above, shredded combustibles and filters can be blended and placed in pipe components. Whole combustibles and filters, even if chemically neutralized, are too bulky for insertion in pipe components. The reduction in drum counts more than offsets the costs of the processing and the costs of the pipe components, thus making ostensibly more complicated processing technologies less expensive than the simple technology of stabilization through neutralization and repackaging.

Table 4–63 Costs of the Preferred Processing Technologies

Material Category	*Preferred Processing Technology*	*Approximate Cost, ($M)*	*Premium over Minimum Cost Processing Technology ($M)*
Incinerator Ash	Repackage at Rocky Flats under Alternative 4	58	--
Sand, Slag, and Crucible	Repackage at Rocky Flats and Purex Process at the Savannah River Site F-Canyon	36	25
Graphite Fines	Repackage at Rocky Flats under Alternative 4	4	--
Inorganic Ash	Repackage at Rocky Flats under Alternative 4	8	--
Molten Salt Extraction and Electrorefining Salts IDC 409	Pyro-oxidize, blend and repackage at Rocky Flats under Alternative 4	20	--[b]
Other Electrorefining and Molten Salt Extraction Salts	Pyro-oxidize and repackage at Rocky Flats under Alternative 4	68	21[b]
Direct Oxide Reduction Salts, IDCs 365, 413, 427	Ship some of the residue to the Los Alamos National Laboratory; pyro-oxidize, blend, and repackage the remaining residue at Rocky Flats under Alternative 4[f]	17	4

Material Category	***Preferred Processing Technology***	***Approximate Cost, ($M)***	***Premium over Minimum Cost Processing Technology ($M)***
Other Direct Oxide Reduction Salts	Pyro-oxidize and repackage at Rocky Flats under Alternative 4	8	--
Aqueous-contaminated Combustibles	Neutralize/Dry at Rocky Flats under Alternative 4	5	4
Organic-contaminated Combustibles	Thermal Desorption / Steam Passivation at Rocky Flats under Alternative 4	6	5
Dry Combustibles	Repackage at Rocky Flats under Alternative 4	2	1
Plutonium Fluorides	Repackage at Rocky Flats and Purex Process at the Savannah River Site F-Canyon	18	--
Ful Flo Filter Media	Blend Down at Rocky Flats	4	--
HEPA IDC 338 Filter Media	Neutralize/Dry at Rocky Flats under Alternative 4	39	29
Other HEPA Filter Media	Blend Down and repackage at Rocky Flats under Alternative 4	1	--
Sludge (IDC 089, 099, 332)	Blend Down and repackage at Rocky Flats under Alternative 4	1	--
Other Sludge	Filter/Dry at Rocky Flats under Alternative 4	12	9
Glass	Neutralize/Dry at Rocky Flats under Alternative 4	1	--
Graphite	Repackage at Rocky Flats under Alternative 4	8	--
Inorganic	Repackage at Rocky Flats under Alternative 4	2	--
Scrub Alloy	Repackage at Rocky Flats and Purex Process at the Savannah River Site F-Canyon	20	--
Labor, site, processing, & disposal costs[b,c,d]		~334	~96
Of which, materials disposition costs[d]		~22	-25
Plus, itemized equipment costs[d]		0[b]	0[b]
Subtotal - Decisional Costs[d]		~334	~96
Common facilities costs at Rocky Flats[e]		~180	--
R&D Costs at Rocky Flats and Los Alamos National Laboratory[e]		~10	--
Total[b]		~524	~96

[a] Excluding the no action processing technologies, which would generate stabilized residues without variances for disposal in WIPP.

[b] If $2 million of the $4 million total for distillation equipment is allocated to this processing technology.

[c] Because costs for many of the minor residues are significantly less than $1 million but are shown as $1 million, the sum of the individual costs on the table exceeds the actual total.

[d] Costs that DOE would incur by selecting the specified processing technologies.

[e] Costs that DOE expects to incur regardless of the processing technologies selected

[f] Based on shipment of all 727 kg to the Los Alamos National Laboratory for acid dissolution. Costs would be lower if some portion of this residue is repackaged at Rocky Flats under Alternative 4.