5.2.14 FACILITY ACCIDENTS

This section presents a summary of the accident analysis conducted to identify impacts associated with the waste processing alternatives described in Chapter 3. Appendix C.4, Facility Accidents, contains additional details and discussion. This section does not include the following accident analyses, which are found under other subject headings in this EIS or other documents as noted below:

- Industrial accidents and occupational risks due to waste processing operations. These health and safety impacts are evaluated separately in Section 5.2.10.

- Accidents associated with transportation of radioactive or hazardous material, other than transportation within a site as part of facility operations. The impacts of transportation are presented in Section 5.2.9.

- Bounding accidents associated with facility disposition activities. The impacts of facility disposition activities are included in Section 5.3.12

- Facility accidents at Hanford due to the processing of INEEL waste under the Minimum INEEL Processing Alternative, are addressed in the Tank Waste Remediation EIS prepared for processing the liquid HLW stored at that site. If DOE decides to treat INEEL HLW at Hanford, a determination will be made as to whether additional National Environmental Policy Act analysis is necessary.

- Accidents at offsite disposal facilities such as the Waste Isolation Pilot Plant (transuranic waste), the proposed Yucca Mountain geologic repository (HLW), and the Hanford Site or Nevada Test Site (low-level waste and mixed low-level waste), which are evaluated in other National Environmental Policy Act documents.

- Accidents at other INEEL facilities.

Facility accidents are unplanned, unexpected, and undesired events (such as earthquakes, operational errors, or process equipment failures) that can occur during or as a result of implementing a waste processing alternative and that have the potential to impact human health and the environment. Facility accidents with the potential to harm the public include structural failures, fires, and explosions that could result in the release of radioactive and chemical contaminants. Such releases may result in immediate health impacts, for example a lethal chemical exposure. However, they are more likely to have a delayed health impact that occurs over time, such as exposure to ionizing radiation that could eventually result in a cancer fatality.

Implementation of the various projects associated with each of the waste processing alternatives temporarily adds risk to humans and the environment. This implementation risk is illustrated qualitatively in Appendix C.4, Figure C.4-1.

Compliance with DOE Orders and Standards provides the assurance that facility accident risk from implementation of waste processing alternatives is minimized through the incorporation of safety features in the design, construction, and operation of new facilities. Many of the actions under the waste processing alternatives are continuations or modifications of past or present activities at INTEC. As such DOE would continue to control the hazards associated with any of the waste processing alternatives consistent with the operating history at the INEEL. DOE has an ongoing commitment to high levels of safety to assure that the risk of facility accidents is minimized under any of the waste processing alternatives. A thorough review of historical accident experience at the INEEL has been completed.

An analysis has been performed to identify the potential for immediate and long-term environmental impacts, particularly human health impacts, that could occur as a result of implementing the waste processing alternatives and options. The postulated accidents that were analyzed would not necessarily occur but are considered reasonably foreseeable.

5.2.14.1 Methodology for Analysis of Accident Risk to Noninvolved Workers and the Public.

The technical approach and methods used in this accident analysis are intended to be fully compliant with DOE technical guidelines for accident analysis (DOE 1993). These technical guidelines define a bounding facility accident for alternatives as the reasonably foreseeable accident that has the highest potential for environmental impacts, particularly human health and safety impacts, among all identified reasonably foreseeable accidents. An accident scenario that does not require extraordinary initiating events or unrealistic assumptions about the progression of events or the resulting releases is said to be "reasonably foreseeable." For the purposes of this EIS accident analysis, reasonably foreseeable refers to facility accidents for which the frequency is estimated to be greater than once in ten million years. The guidelines also recommend identification of a bounding accident in each of three broad frequency ranges: abnormal, design basis, and beyond design basis. Abnormal events have estimated frequencies of occurrence equal to or greater than once in a thousand years; design basis accidents have frequencies equal to or greater than once in a million years but less than once in a thousand years; and beyond design basis events have frequencies that are less than once in a million years. Within each frequency range, selection of the bounding accident assures that any other reasonably foreseeable accident (in that range) would be expected to have smaller consequences. DOE frequency ranges are compared in Table 5.2-38.

Several general assumptions were used to identify bounding facility accidents in this EIS.

- Facilities are assumed to be designed, constructed, and operated in compliance with DOE Orders, directives, and standards and within regulatory requirements. However, accidents are defined using bounding reasonably foreseeable assumptions regarding initiator severity and facility design response.

- Potential source terms of radioactive or chemically hazardous releases during accidents are evaluated assuming the design features of the facility perform as expected, but no further mitigating actions, including evacuation, are included.

- Potential receptors of postulated air releases are assumed to be directly downwind of the release; as close as the site boundary for a member of the public; and 640 meters for the noninvolved worker.

- Releases to groundwater are assumed to occur immediately, without any holdup as a result of the leak path. Potential receptors are assumed to be directly over the location of the spill, consuming only contaminated groundwater from the aquifer over a 30-year period of exposure, in most cases.

Although this approach overstates the risk of accidents, it provides a level of certainty that the estimated risks reported in this EIS are not likely to be exceeded and it provides a reasonable basis for comparing one waste processing alternative to another.

DOE performed accident analyses of waste processing facilities that are currently operating using safety assurance information from facility safety analysis reports, along with facility operating experience, and probabilistic data from similar facilities and operations. Accident analysis of facilities that have not yet been designed (including most facilities proposed in this EIS to implement waste processing alternatives) uses information primarily from technical feasibility studies performed to ascertain process feasibility and identify process implementation costs. Such information includes preliminary inventories of material at risk, process design data, and some overall design features.

Methods used to assess the potential for facility accidents are based primarily on DOE guidance, experience with similar systems, and understanding of the INTEC site layout. The EIS accident analyses of waste processing facilities incorporates the following three levels of screening analyses.

1. DOE performed a screening evaluation of major facilities and identified various operations needed to implement waste

Table 5.2-38. DOE facility accident frequency categories.

	Accident Frequency Categories	Accident Frequency Category Descriptions	Percent chance of an accident occurring in any given year.	Number of years during which a particular accident could occur. (Accident / Years)
	Accident frequency is a tool used to determine risk to a receptor population. It is not a prediction of when an accident will occur. For example a Design Basis Event with a chance of occurring once in ten thousand years could occur within the first 100 years.		The less probable an accident, the less likely it is to occur in any given year.	The more probable an accident, the shorter the time period in which it could occur.
Reasonably Foreseeable Accidents	Abnormal Event	Accidents that could occur once in a thousand years.	100 %	1/1
			10 %	1/10
			1%	1/100
			0.1%	1/1000
	Design Basis Event	Accidents that could occur once in a million years but not more frequently than once in a thousand years.	0.01%	1/10,000
			0.001%	1/100,000
			0.0001%	1/1,000,000
	Beyond Design Basis Event	Accidents that could occur once in ten million years but not more frequently than once in a million years.	0.00001%	1/10,000,000
Not Reasonably Foreseeable Accidents	Not analyzed in the EIS because of the extreme unlikelihood of these events.	Accidents that could occur less frequently than once in ten million years.	< 0.00001%	< 1/10,000,000

processing alternatives (referred to as process elements) to assess the potential for significant facility accidents. Process elements attributes that infer the existence of significant process hazards include inventories of hazardous or radioactive materials, dispersible physical forms, and the potential for energetic releases during operation.

2. An accident initiating event consists of an occurrence (i.e., natural phenomena, human error, or equipment failure) that can challenge and sometime degrade the safety functions of a facility. An "accident scenario" consists of a set of causal events starting with an initiating event that can lead to a release of radioactive or hazardous materials with the potential to cause injury or death. Therefore, along with the initiator, accident scenarios include events such as the failure of facility safety functions or failure of facility defense in depth features. DOE performed detailed accident analyses beginning with the description of activities, inventories, and conditions pertinent to the accident analysis. DOE compared a standardized set of "accident initiating events" against the described set of activities, inventories, and operating conditions to identify and describe accident scenarios.

3. Finally, DOE grouped accident scenarios into the three major frequency categories. The accident scenario in each frequency range category with the highest potential risk of health and safety impacts to offsite persons or noninvolved onsite workers (the potentially bounding accident scenario) was selected for consequence evaluation. DOE performed detailed consequence (health impact) evaluations for each of these potentially bounding accidents, selecting the reasonably foreseeable accident with the largest impact on human health in each frequency category for each waste processing alternative as bounding.

For purposes of the facility accident analysis, DOE considered six classes of initiating events:

- Fires during facility operations
- Explosions during facility operations
- Spills (of radiological or hazardous material) during facility operations
- Criticality (uncontrolled nuclear chain reaction) during facility operations
- Natural phenomena (for example: flood, lightning, seismic event, high wind) during facility operations
- External events (human-caused events that are external to a facility and may impact the safe operation and integrity of the facility) during facility operations

As noted above, the accident analysis assessed the potential for criticality accidents for each waste processing activity. There have been three criticalities at INTEC (October 16, 1959; January 25, 1961; and October 17, 1978). All three events were a result of a high uranium concentration aqueous solution being placed in a geometrically unsafe storage condition. The sets of conditions leading to the historically recorded criticality events (i.e., sufficient inventory of fissile material in an aqueous environment) are considered reasonably foreseeable only for the Transuranic Separations Option and the Minimum INEEL Processing Alternative. Implementing these alternatives could involve circumstances where a potentially high concentration of transuranic species exists in a stored or handled waste that is not immobilized.

In the aftermath of the tragic events of September 11, DOE is continuing to assess measures that it can take to minimize the risk of potential consequences of radiological sabotage or terrorists attacks against the INEEL site. For this reason, sabotage and terrorist activities are not addressed in the facility accident analysis. The threat of significant health impacts due to sabotage and terrorist activities requires the coexistence of significant radioactive inventories and energy sources capable of causing a substantial release. The defense in depth approach used to design nuclear facilities with significant radiological inventories at the INEEL, combined with limited sources of release energy, precludes a major impact from terrorist action.

The screening process identified a subset of process elements requiring detailed accident analysis to assess the potential for bounding accidents to occur. In some cases, the bounding accident for several alternatives could be identified using a single accident evaluation. The resulting set of required accident analyses used to identify potentially bounding accident scenarios for the waste processing alternatives is shown in Table 5.2-39. From Table 5.2-39, there are 22 separate accident analyses used to identify potentially bounding accident scenarios. Each accident analysis identifies potentially bounding accident scenarios in the three frequency classes, abnormal events, design basis events, and beyond design basis events.

Source Term Identification

Radiological Releases - Most of the accidents analyzed in this EIS result in releases to the atmosphere. This is because air release accidents generally show the highest potential to result in health impacts. For non-criticality radiological releases, the source term is defined as the amount of respirable material released to the atmosphere from a specific location. The radiological source term for non-criticality events is dependent upon several factors including the material at risk, material form, initiator, operating conditions, and material composition. The technical approach described in DOE-STD-3010 (DOE 1994) is modified in the Safety Analysis and Risk Assessment Handbook (Peterson 1997) and was used to estimate source term for radioactive releases. This approach applies a set of release factors to the material at risk constituents to produce an estimated release inventory. The release inventory was combined with the conditions under which the release occurs and other environmental factors to produce the total material released for consequence estimation. Factors applied in the DOE-STD-3010 (DOE 1994) source term method and additional details with respect to source term estimation are contained in Appendix C.4.

Table 5.2-39. Accident evaluations required.

Waste Processing Alternatives / Processing Elements	No Action	Continued Current Operations	Full Separations	Planning Basis	Transuranic Separations	Hot Isostatic Pressed Waste	Direct Cement Waste	Early Vitrification	Steam Reforming	Min. INEEL Processing	Vitrification without Calcine Separations	Vitrification with Calcine Separations
SBW/Newly Generated Liquid Waste Processing[a]		X		X		X	X		X			
New Waste Calcining Facility High Temperature and MACT Modifications		X		X		X	X					
Calcine Retrieval and Onsite Transport[b]	c	c	X	X	X	X	X	X	X	X	X	X
Full Separations[d]			X	X								X
Transuranic Separations					X							
Cesium Separations		X[e]								X		X
Class C Grout					X					X		
Borosilicate Vitrification (cesium, transuranic, strontium)[f]			X	X								X
Borosilicate Vitrification (Calcine and SBW)[g]								X			X	
HLW/SBW Immobilization for Transport (Calcine & Cs IX)										X		
HLW/SBW Immobilization for Transport (HIP)						X						
HLW/SBW Immobilization for Transport (Direct Cement)							X					
HLW/SBW Immobilization for Transport (Calcine & SBW)[h]												
Liquid Waste Stream Evaporation[i,j]		X	X	X	X	X	X		X			X
Additional Offgas Treatment[k]			X	X	X	X	X	X	X	X	X	X
Class C Grout Disposal					X							
HLW Interim Storage for Transport									X	X		
HLW/HAW Stabilization and Preparation for Transport (Calcine and Cs Resin Feedstocks)										X		
HLW/HAW Stabilization and Preparation for Transport (Calcine and SBW Feedstocks)[h]												
Storage of Calcine in Bin Sets[l,m]	X[n]	X[n]	X	X	X	X	X	X	X	X	X	X
Transuranic Waste Stabilization and Preparation for Transport					X					X		

Table 5.2-39. Accident evaluations required (continued).

Waste Processing Alternatives Processing Elements	No Action	Continued Current Operations	Full Separations	Planning Basis	Transuranic Separations	Hot Isostatic Pressed Waste	Direct Cement Waste	Early Vitrification	Steam Reforming	Min. INEEL Processing	Vitrification without Calcine Separations	Vitrification with Calcine Separations
Storage of SBW[o]	X	X	X	X	X	X	X	X	X	X	X	X
SBW Stabilization and Preparation for Transport[p]								X	X		X	X
SBW Retrieval and Transport[q]		X	X	X	X	X	X	X	X	X	X	X

HAW = high-activity waste; SBW = mixed transuranic waste/SBW

a. Title reflects completion of liquid HLW calcining mission. DOE has placed calciner in standby.

b. Process elements associated with calcine retrieval are assumed to be identical to the calcine retrieval process for other waste processing alternatives.

c. Prior engineering assessment indicated bin set 1 to be potentially structurally unstable under static load thus possibly unable to meet requirements of DOE Order 420.1. This condition resulted in an Unresolvd Safety Question, and an assumption that retrieval of calcine from bin set 1 was required to implement any of the waste processing alternatives. Additional structural evaluation since that time resolved this Unresolved Safety Question and calcine retrieval from bin set 1 for the No Action and Continued Current Operations Alternatives is not anticipated.

d. Assumed to be identical to full separations process for Full Separations Option.

e. Requirement for Cs separations for Continued Current Operations Alternative was based on concern that treatment of mixed transuranic waste/SBW, newly generated liquid waste, and tank heels may require additional or alternate processing other than calcination. Currently, DOE has no planned Cs separations facility although Vitrification With Calcine Separations may utilize a partial separations process.

f. Smaller borosilicate vitrification process is analyzed for immobilization of HAW fractions after separation.

g. For Vitrification Without Calcine Separations, process element is assumed to be identical to Borosilicate Vitrification process for Early Vitrification Option.

h. Defined and analyzed based on preliminary descriptions of treatment alternatives and implementing processes. Later information indicated that modeled processes were identical to others or similar to and bounded by other processes (in terms of potential for health impacts) so this accident is not required for analysis.

i. Analyzed liquid waste stream evaporation as post-treatment for separations process. Application to mixed transuranic waste/SBW pretreatment, requires elimination of accidents with no physical basis.

j. Smaller borosilicate vitrification process requires mixed transuranic waste/SBW volume reduction beyond what is currently planned for near term management of mixed transuranic waste/SBW inventories, prior to vitrification.

k. In this EIS, all borosilicate vitrification and separation processes are assumed to require offgas treatment. Continued Current Operations Alternative would rely on current evaporators, which are also analyzed.

l. Identical to equivalent process element for other waste processing alternatives that address calcine waste and includes accidents covering short-term storage of calcine over a 35-year period of vulnerability.

m. Accident analysis process element assumes vulnerability to short term storage accidents over a 35-year period of vulnerability except for the No Action and Continued Current Operations Alternatives, where storage of calcine in the bin sets is permanent.

n. Includes long-term storage accidents that could occur over a 10,000 year period of vulnerability.

o. Evaluation of this process element addresses accidents involving long-term storage and degradation of mixed transuranic waste/SBW storage facilities (10,000 year exposure). However, potentially bounding design basis and beyond design basis accident scenarios could occur at any time. Therefore, the analysis has been expanded to evaluate design basis and beyond period of vulnerability.

p. Process element is assumed to be identical to mixed transuranic waste/SBW stabilization and preparation process for Early Vitrification Option. The radiological source term in a container of vitrified mixed transuranic waste/SBW is about twice the source term in a container of vitrified calcine. Therefore, accident for mixed transuranic waste/SBW provides a bounding analysis.

q. Process element is assumed to be identical to mixed transuranic waste/SBW retrieval process for waste processing alternatives.

The potential for a criticality was assessed in each accident analysis evaluation. Only one reasonably foreseeable criticality accident scenario was identified in the accident analysis evaluations. An inadvertent criticality during transuranic waste shipping container-loading operations results from a vulnerability to loss of control over storage geometry. This scenario is identified under both the Transuranic Separations Option and the Minimum INEEL Processing Alternative. The frequency for this accident is estimated to be between once in a thousand years and once in a million years of facility operations. This event could result in a large dose to a nearby, unshielded maximally exposed worked that is estimated to be 218 rem, representing a 1 in 5 chance of a latent cancer fatality. However, this same analysis estimates a dose to the maximally exposed offsite individual at the site boundary (15,900 meters down wind at the nearest public access) to be only 3 millirem, representing a 2 per million increase in cancer risk to the receptor.

Chemical Releases - Facility accidents may include sets of conditions leading to the release of hazardous chemicals that directly or indirectly threaten involved workers and the public. This EIS facility accident review includes an evaluation of the potential for chemical release accidents. Currently, there is insufficient information on chemical inventories of proposed future waste processing facilities to support a comprehensive and systematic review of chemical release accidents. However, DOE assumed that future requirements for hazardous chemicals during waste processing would be similar to present requirements.

Chemicals that pose the greatest hazard to workers and the public are gases at ambient temperatures and pressures. An example of this type of gas is ammonia, which is stored under pressure as a liquid but quickly flashes to a vapor as it is released. Chemicals such as nitric acid that are liquids at ambient conditions also could pose a toxic hazard to involved workers. However, the potential for these types of chemicals to become airborne and travel to nearby or offsite facilities is low. The facility accident analysis focused on those chemicals that are gases at ambient conditions. Appendix C.4 of this EIS provides additional information on chemical releases.

Receptor Identification

Radiological Releases - For radiological releases, DOE calculated the health impact of the bounding accidents by estimating the dose to human receptors. Human receptors are people who could potentially be exposed to or affected by radioactive releases resulting from accidents associated with the waste processing alternatives.

Four categories of human receptors are considered in this EIS:

- **Involved Worker:** A worker who is associated with a treatment activity or operation of the HLW treatment facility itself;
- **Maximally Exposed Individual:** A hypothetical individual located at the nearest site boundary from the facility location where the release occurs and in the path of an air release.
- **Noninvolved Worker:** An onsite employee not directly involved in the site's HLW management operations.
- **Offsite Population:** The population of persons within a 50-mile radius the INTEC and in the path of an air release.

Doses to individual receptors from a radiological release are estimated in rem. Doses to receptor populations are estimated in person-rem. A person-rem is the product of the number of persons exposed to radiation from a single release and the average dose in rem.

Most bounding accidents evaluated in this EIS impact the receptor population by releasing radioactive particles into the environment, which are then inhaled or settle on individuals or surfaces such that humans are exposed. Such exposures usually result in chronic health impacts that manifest over the long-term and are calculated as latent cancer fatalities. Consequences to receptors impacted by a radiological release are expressed as an increase in the probability of developing a fatal cancer (for an individual) or as an increase in the number of latent cancer fatalities (for a population).

Chemical Releases - To determine the potential health effects to workers and the public that could result from accidents involving releases of chemicals and hazardous materials, the airborne concentrations of such materials released during an accident at varying distances from the point of release were compared to Emergency Response Planning Guideline (ERPG) values. The American Industrial Hygiene Association established ERPG values, which are specific to hazardous chemical substances, to ensure that necessary emergency actions are taken in the event of a release. ERPG severity levels are as follows:

- **ERPG-3.** Exposure to airborne concentrations greater than ERPG-3 values for a period greater than 1 hour results in an unacceptable likelihood that a person would experience or develop life-threatening health effects.

- **ERPG-2.** Exposures to airborne concentrations greater than ERPG-2 but less than ERPG-3 values for a period greater than 1 hour results in an unacceptable likelihood that a person would experience or develop irreversible or other serious health effects or symptoms that could impact a person's ability to take protective action.

- **ERPG-1.** Exposure to airborne concentrations greater than ERPG-1 but less than ERPG-2 values for a period of greater than 1 hour results in an unacceptable likelihood that a person would experience mild transient adverse health effects or perception of a clearly defined objectionable odor.

The facility accident analysis assumes that accident scenarios with the potential for ERPG-2 or ERPG-3 health impacts are bounding scenarios for the waste processing alternatives.

Consequence Assessment

DOE used the "Radiological Safety Analysis Computer Program (RSAC-5)" to estimate human health consequences for radioactive releases. Radiological source terms were used as input to the computer program to determine radiation doses at receptor locations for each potentially bounding facility accident scenario. Meteorological data used in the program are consistent with previous INEEL EIS analyses (i.e., SNF & INEL EIS; DOE 1995) for 95 percent meteorological conditions (i.e. conditions whose severity, from the standpoint of induced consequences to an offsite population, is not exceeded more than 5 percent of the time).

DOE converted radiation doses to various receptors into potential health effects using dose-to-risk conversion factors recommended by the National Council on Radiation Protection and Measurements (NCRP). For conservatism, the NCRP guidelines assume that any additional exposure to radiation carries some incremental additional risk of inducing cancer. In the evaluation of facility accident consequences, DOE adopted the NCRP dose-to-risk conversion factor of 5×10^{-4} latent cancer fatalities for each person-rem of radiation dose to the general public. DOE calculated the expected increase in the number of latent cancer fatalities above those expected for the potentially exposed population. For individual receptors, a dose-to-risk conversion factor of 5×10^{-4} represents the increase in the probability of cancer for an individual member of the general public per rem of additional exposure. For larger doses, where the total exposure during an accident could exceed 20 rem, the increased likelihood of latent cancer fatality is doubled, assuming the body's diminished capability to repair radiation damage.

The consequences from accidental chemical releases were calculated using the computer program "Areal Locations of Hazardous Atmospheres (ALOHA)." Because chemical consequences are based on concentration rather than dose, the computer program calculated air concentrations at receptor locations. Meteorological assumptions used for chemical releases were the same as used for radiological releases.

For each accident evaluation, conservative assumptions were applied to obtain bounding results. For the most part, the assumptions in this EIS are consistent with those applied in other EIS documents prepared at the INEEL, such as the SNF & INEL EIS. However, there were some assumptions that differed.

In this EIS, DOE performed a comprehensive evaluation of accidents that could result in an air release of radioactive or chemically hazardous materials to the environment. The reason for this simplification was that the short time between the occurrence of an air release and the time it would impact human health through respiration would not allow for mitigation measures other than execution of the site emergency plan. Accidents that resulted in a release only to groundwater were not generally evaluated since the time between their occurrence and their impact on the public was assumed to be long enough to take comprehensive mitigation measures. The one exception is that DOE did analyze bounding groundwater release accidents for which effective mitigation might not be feasible.

In this EIS, DOE focused on the human health and safety impacts associated with air release accidents. Other environmental impacts would also result from such events, such as loss of farm production, land usage, and ecological harm. However, these consequences were not evaluated directly in this EIS. Preliminary sensitivity calculations indicate that accidents which bounded the potential for human health impacts also bounded the potential for land contamination and other environmental impacts.

DOE decided not to evaluate impacts from some initiators (i.e., volcanoes) because they determined that such evaluations would not provide new opportunities to identify bounding accidents. Based on evaluations in the accident analysis, volcanic activity impacting INTEC was considered a beyond design basis event. This would place the event with initiators such as external events and beyond design basis earthquakes. This is because the lava flow from the eruption (basaltic volcanism) would likely cover some affected structures, limiting the amount of hazardous and radioactive waste that is released from process vessels and piping. Therefore, the impacts due to a lava flow event are assumed to be bounded by other external events, where the entire inventory would be impacted and available for release. Appendix C.4 contains additional information on volcanism.

5.2.14.2 Methodology for Integrated Analysis of Risk to Involved Workers

Health and safety risk to involved workers (workers associated with the construction, operation, or decontamination and decommissioning of facilities that implement a waste processing alternative) is a potentially significant "cost" of implementing waste processing alternatives, and has been systematically characterized and reported in this EIS. Together with health and safety risk to the public, evaluation of involved worker risk provides a comprehensive basis for comparing waste processing alternatives on the basis of contribution to the implementation risk due to accidents. Unlike health and safety risk to noninvolved workers and the public that results mainly from facility accidents and accidents occurring during transportation, health and safety risk to involved workers results from three sources, industrial accidents, exposure to radioactive materials during normal operations, and facility accidents.

- Industrial accident risk to involved workers results from industrial activities needed to complete major projects that implement an alternative.
- Occupational risk to involved workers results from routine exposure to radioactive materials during industrial activities that implement an alternative.
- Facility accident risk to involved workers results from accidents that release radioactive or chemically hazardous materials, accidents (e.g., criticality) that could result in direct exposure to radiation, or energetic accidents (e.g,. explosions) that can directly harm workers.

Risk to involved workers from facility accidents is evaluated in a manner analogous to evaluation of risk to noninvolved workers and the public. Consequences for involved workers are estimated using information on bounding accidents in three frequency categories with the highest potential consequences to noninvolved workers and the public. Due to limitations on the accuracy of consequence prediction codes at locations near the origin of a release, doses to involved workers are estimated proportionally based on doses to noninvolved workers at 640 meters. On the average, the dose at 100 meters was 9 times greater than the dose at 640 meters. The method used is intended to provide consistency with the definition of facility worker utilized in the SNF & INEL EIS (DOE 1995).

Risk to involved workers from occupational exposures and industrial accidents is appraised in the Health and Safety section of this EIS (5.2.10). In the accident analysis methodology, information used to generate worker risk due to industrial accidents and occupational exposures is integrated with results of the facility accidents evaluation to produce a comprehensive perspective on involved worker risk.

5.2.14.3 Bounding Radiological Impacts to Noninvolved Workers and the Public of Implementing the Alternatives

This EIS analyzes the impacts or consequences of implementing the waste processing alternatives and their options. It describes (1) the major processes of each alternative, (2) the bounding accident scenarios applicable to the major processes, and (3) the resulting impact to INEEL workers and the general public. The systematic accident analysis process employed by DOE identified potentially bounding accidents for each alternative/option. After evaluating the human health consequences associated with these potentially bounding accidents, DOE selected three bounding accidents (one abnormal, one design basis, and one beyond design basis) for each of the risk accruing processes associated with each waste processing alternative.

In general, the process used in selecting the bounding accident scenario was to select the scenario with the highest consequence within each frequency bin. In some cases, one scenario had the highest consequence for the maximally-exposed individual and noninvolved worker, but another scenario had higher consequences for the offsite population and latent cancer fatalities. In these cases, the scenario with the higher consequences for the offsite population/latent cancer fatalities was selected as bounding.

The results for radiological impacts due to releases of radioactive material are expressed in terms of risk. Risk is quantified in terms of the estimated probability of fatality for the maximally exposed individual, involved worker, and noninvolved worker, and the estimated increase in latent cancer fatalities for the INEEL offsite population. A dose-to-risk conversion factor of 5×10^{-4} per person-rem represents the increase in the probability of a fatal cancer for an individual member of the public. For conservatism, this same conversion to dose was used to analyze risk to the noninvolved worker.

Bounding accidents are identified in this EIS based on analysis of those activities, projects, and facility operations that are required to implement the waste processing alternative, and that potentially pose a risk of health impacts to various receptor populations. These bounding accidents are presented in Appendix C.4.

5.2.14.4 Anticipated Radiological Risks of Bounding Facility Accidents

The systematic accident analysis process employed by DOE identified potentially bounding facility accident scenarios for the waste processing alternatives. The potentially bounding accident scenarios were identified for each of the functional activities that implement the various alternatives. After evaluating the human health consequences associated with these potentially bounding accidents, DOE selected three bounding accidents (one abnormal, one design basis, and one beyond design basis) for each alternative. Table 5.2-40 summarizes the bounding facility accidents for each of the alternatives, along with their forecast consequences. Table 5.2-40 contains the following information:

Radiation Dose to Receptors - For each potentially bounding facility accident scenario, this section estimates doses to each receptor given that an accidental release of radioactivity has

Table 5.2-40. Anticipated risk for bounding radiological events for the various waste processing alternatives.[a]

Frequency of occurrence	Abnormal Event (AB) Could occur more than once in a thousand years of facility operation		Design Basis Event (DBE) Could occur more than once in a million years but less than once in a thousand years of facility operation	Beyond Design Basis Event (BDB) Could occur less than once in a million years of facility operation	
Process title	Long Term Storage of Calcine in Bin Sets	Calcine Retrieval Onsite Transport	Short Term Storage of Calcine in Bin Sets	Short Term Storage of Calcine in Bin Sets	Borosilicate Vitrification
Window of exposure (years)	9.5×10^{3}	35	35	35	20
Accident scenario (Event description)	Seismic induced failure of degraded bin set results in failure of the outer containment and a portion of the internal containment in a bin set and the possibility of opening a bin set to the environment. Likelihood of this event increases after 2095 when monitoring and maintenance requirements would no longer be met.	Equipment failure results in release of calcine during retrieval and transport operations.	A short-term flood induced failure of a bin set structure and equipment such that a release occurs with a direct pathway to the environment (No interdiction for 30 days).	An external event results in a bin set release (calcine) during short term storage.	An external event results in release of high activity waste from the borosilicate vitrification facility containment.
Risk to Receptors					
Maximally exposed individual					
Dose (millirem)	8.3×10^{4}	40	880	1.4×10^{4}	1.7×10^{4}
Latent cancer fatality probability	0.042	2.0×10^{-5}	4.4×10^{-4}	7.0×10^{-3}	8.5×10^{-3}
Noninvolved worker					
Dose (millirem)	5.7×10^{6}	2.7×10^{3}	5.9×10^{4}	9.3×10^{5}	1.2×10^{6}
Latent cancer fatality probability	1.0	1.4×10^{-3}	0.059	0.94	1.0
Offsite population					
Dose (person-rem)	5.3×10^{5}	470	5.7×10^{4}	1.2×10^{5}	1.5×10^{5}
Latent cancer fatalities	270	0.23	29	61	76

Table 5.2-40. Anticipated risk for bounding radiological events for the various waste processing alternatives[a] (continued).

Frequency of occurrence	Abnormal Event (AB) Could occur more than once in a thousand years of facility operation		Design Basis Event (DBE) Could occur more than once in a million years but less than once in a thousand years of facility operation	Beyond Design Basis Event (BDB) Could occur less than once in a million years of facility operation	
Process title	Long Term Storage of Calcine in Bin Sets	Calcine Retrieval Onsite Transport	Short Term Storage of Calcine in Bin Sets	Short Term Storage of Calcine in Bin Sets	Borosilicate Vitrification
Accident Analysis included in Alternatives/Options					
No Action Alternative	✔[b]		✔	✔	
Continued Current Operations Alternative	✔		✔	✔	
Separations Alternative					
Full Separations Option		✔	✔		✔
Planning Basis Option		✔	✔		✔
Transuranic Separations Option		✔	✔	✔	
Non-Separations Alternative					
Hot Isostatic Pressed Waste Option		✔	✔	✔	
Direct Cement Waste Option		✔	✔	✔	
Early Vitrification Option		✔	✔	✔	
Steam Reforming Option		✔	✔	✔	
Minimum INEEL Processing Alternative		✔	✔	✔	
Direct Vitrification Alternative					
Vitrification without Calcine Separations Option		✔	✔	✔	
Vitrification with Calcine Separations Option		✔	✔		✔

a. See Table C.4-2 for additional information.

b. Check mark indicates this analyzed accident applies to these EIS alternatives/options occurred. Source terms are evaluated in the accident analysis. Doses are estimated for unit radioactive source terms (i.e. assuming one curie of each radioactive substance is released) using RSAC-5. Dose estimates for accident scenario source terms are then estimated using an Excel spreadsheet to correct for radioactivity content of the released material.

Health Impacts - Conditional risk estimates the probability of health impacts assuming that an accidental release has occurred. For individual receptors, conditional risk is the probability of a fatality given exposure to the release. For the INEEL offsite public, conditional risk is the number of latent cancer fatalities. Consistent with assumptions discussed above regarding dose-to-risk conversion (i.e., a dose-to-risk conversion factor of 5×10^{-4} latent cancer fatalities for each person-rem of radiation received in the accident) the conditional risk of health impacts (fatalities only) is estimated for offsite receptors and is for noninvolved workers.

5.2.14.5 Impacts of Chemical Release Accidents on Noninvolved Workers and the Public of Implementing the Alternatives

DOE has analyzed the consequences of chemical releases from accidents that occur as a result of implementing the waste processing alternatives and their options. This section describes (1) the major processes that contribute chemicals to the atmosphere during an accident and (2) the impacts to INEEL workers and the general public in terms of ERPG values. Potentially bounding chemical release accidents from the accident analysis include mercury and ammonia. Mercury could be released during calcining operations from the carbon bed filter during an exothermic reaction that results from inadequate nitrous oxide reduction. Ammonia could be released during failure of the ammonia storage tanks. Current feasibility studies for several waste processing alternatives identify a need for additional offgas treatment to meet EPA environmental requirements during separation, vitrification, and other functions associated with alternative implementation. These same feasibility studies have identified an ammonia-based treatment process as being most likely to meet the technical requirements of the waste processing alternatives. Thus, ammonia has been identified as a chemical substance posing a potential significant hazard to workers and the public during waste processing alternative implementation.

The major processes or functions that could produce chemical releases from accidents during implementation of waste processing alternatives are the New Waste Calcining Facility High Temperature and Maximum Achievable Control Technology Modifications, and the Additional Offgas Treatment. The analysis of these accidents shows that failures involving ammonia handling and storage equipment represent the bounding abnormal, design basis, and beyond design basis chemical release accidents for all alternatives requiring additional offgas treatment. The beyond design basis accident, which involves an external event and subsequent fire could result in a release from another waste processing facility due to operator incapacitation or evacuation. The impacts due to these bounding accidents are shown in Table 5.2-41.

5.2.14.6 Groundwater Impacts to the Public of Implementing the Alternatives

The bounding accident scenarios described in Appendix C.4 produce human health consequences mainly as a result of inhalation of airborne released contaminants. In this EIS accident analysis, DOE assumed that the inhalation pathway is the predominant source of human health consequences since an air release does not provide an opportunity for intervention and mitigation.

Several potentially bounding accident scenarios identified in the accident analysis produced mainly groundwater releases. In theory, groundwater releases can be mitigated, with little ultimate impact on the public. However, since significant groundwater releases would produce a substantive risk to the environment and the opportunity to mitigate may be limited by time and resource constraints, the impact of accident scenarios resulting in groundwater releases is considered in the facility accidents evaluation.

Environmental risk is presented in the Remedial Investigation/Feasibility Study process in terms of expected exposure to contamination as a func-

Table 5.2-41. Summary of bounding chemical events for the various waste processing alternatives.[a]

Events	Process title	Event description	Contaminant	Peak atmospheric concentration (ERPG)
Abnormal	Additional Offgas Treatment	Failure of ammonia tank connections results in a spill of 150 pounds per minute of liquid ammonia. A fraction of the ammonia would flash to vapor as it escapes the tank. The remainder would settle and form a boiling pool.	Ammonia	Less than ERPG-2 at 3,600 meters
Design Basis	Additional Offgas Treatment	Failure of ammonia tank connections results in a spill of 1,500 pounds per minute of liquid ammonia. A fraction of the ammonia would flash to vapor as it escapes the tank. The remainder would settle and form a boiling pool.	Ammonia	Greater than ERPG-2 at 3,600 meters
Beyond Design Basis	Additional Offgas Treatment	Failure of ammonia tank connections results in a spill of 15,000 pounds per minute of liquid ammonia. A fraction of the ammonia would flash to vapor as it escapes the tank. The remainder would settle and form a boiling pool.	Ammonia	Greater than ERPG-2 at 3,600 meters

a. Results based on modeling assumptions used for CERCLA analyses as reported in Rodriguez et al. (1997).

tion of time. Therefore, the measures of environmental risk such as the EPA drinking water standards or maximum contaminant levels can be used to estimate the potential for future adverse human health impacts. Specifically, expected contamination due to a postulated release can be compared with maximum contaminant level values to assess the severity of environmental risk associated with a release. In this way, accident scenarios resulting in a release to groundwater can be appraised for their potential contribution to environmental risk and the overall potential economic impact of the accident.

Appendix C.4 presents analyses of three major processes or functions that could produce groundwater releases from accidents. These are New Waste Calcining Facility Operations, Long-term Storage of Calcine in Bin Sets, and Storage of Mixed Transuranic Waste/SBW. The predicted impacts to groundwater from accident scenarios resulting in major groundwater releases are described below and the impacts are summarized in Table 5.2-42.

New Waste Calcining Facility Operations

Operation of the New Waste Calcining Facility requires the combustion of kerosene for fluidized bed operation. An accident could leak 15,000 gallons of kerosene (which contains benzene) from storage facilities associated with the New Waste Calcining Facility. This is considered to be an abnormal event with an occurrence equal to or greater than once in 1,000 years. A similar but less probable occurrence, beyond design basis event, would be an external event involving both kerosene storage tanks causing a release of 30,000 gallons of kerosene and a fire. The estimated chance of occurrence for this event is less than one in one million.

For the abnormal and beyond design basis kerosene spill accidents, DOE analyzed the risk to a resident drinking 2 liters per day of the benzene contaminated groundwater from beneath the INTEC Tank Farm. The additional risk of developing cancer over a 30-year lifetime due to these accidents is 1.9×10^{-4} for the abnormal

Table 5.2-42. Groundwater impacts due to accidents.

Process Title	Event	Accident Frequency	Constituent	Peak groundwater concentration (µg/L or pCi/L)	Maximum contaminant level (µg/L or pCi/L)
New Waste Calcining Facility Operations	A leak through failed process connections leaks 15,000 gallons of kerosene.	Abnormal Event	Benzene in kerosene	120	5
New Waste Calcining Facility Operations	An external event results in the failure of both kerosene storage tanks and a subsequent fire.	Beyond Design Basis Event	Benzene in kerosene	180	5
Long-Term Storage of SBW-Single Tank Failure	A seismic event causes the failure of a single full SBW tank and a release of SBW directly to the soil column in the year 2001.	Design Basis Event	I-129 Tc-99 Np-237 Total Pu	0.13[a] 100[a] 0.030[a] 1.1[a]	1 900 15 15
Long-Term Storage of SBW-5 Tank Failure	Degradation and simultaneous failure of 5 full SBW tanks in 2500.	Abnormal Event	I-129 Tc-99 Np-237 Total Pu	0.47[a] 380[a] 0.34[a] 8.6[a]	1 900 15 15

a. Results based on modeling assumptions used for CERCLA analyses as reported in the *Comprehensive RI/FS for the Idaho Chemical Processing Plant OU 3-13 at the INEEL, Part A, RI/BRA Report* (Rodriguez et al. 1997).

MACT = maximum achievable control technology; SBW = mixed transuranic waste/SBW; µg/L = micrograms per liter; pCi/L = picocuries per liter.

event and 2.9×10^{-4} for the beyond design basis event (Jenkins 2001a). Cancer fatalities were not estimated for either event.

Long-Term Storage of Calcine in Bin Sets

This accident assumes that a bin set full of mixed HLW calcine degrades and fails during a seismic event after 500 years. The bin set is assumed to breach releasing the entire inventory of calcine directly to the soil column. Once released, the calcine would partially dissolve under the influence of local precipitation and would release contaminants to the groundwater. Because this event is assumed to occur after 500 years, it is treated as an abnormal event although the seismic initiator is considered a design basis event.

As discussed in Appendix C.4, the radionuclides released from this accident would be a fraction of the radionuclides released from the assumed failure of five full mixed transuranic waste/SBW tanks at 500 years. The 5-tank failure is discussed below. For the bin set failure at 500 years, the percent of the radionuclide inventory released the first year compared to the inventory released from the 5-tank failure is: iodine-129 (1 percent); technetium-99 (11 percent); neptunium-237 (7 percent), and total plutonium (less than 1 percent).

The additional risk for developing cancer for a potential groundwater user after bin set failure at 500 years was not analyzed since groundwater impacts would be easily bounded by the 5-tank failure at 500 years as shown below.

The nonradiological impact of this accident was analyzed by comparing the percentage of the nonradionuclides inventory released during the first year of bin set failure, to the nonradionuclide inventory released for the 5-tank failure in 2500. The analysis (Jenkins 2001b) shows that the most impacting contaminants are beryllium

(8 percent of the 5-tank failure inventory) and molybdenum (4 percent of the 5-tank failure inventory). All other nonradionuclides would be less than 1 percent of the inventory released from the 5-tank failure. Therefore, the impacts from nonradionuclide contaminants released from the failure of a bin set would be bounded by the 5-tank failure at 500 years and the concentrations would be much less than drinking water standards.

Storage of Mixed Transuranic Waste/SBW

Two accidents associated with storage of mixed transuranic waste/SBW in the INTEC Tank Farm were analyzed for this EIS. These are:

- Failure of a full mixed transuranic waste/SBW tank vault with subsequent tank rupture and release of mixed transuranic waste/SBW directly to the soil column due to a seismic event. This event was analyzed to occur in the year 2001 and is considered a design basis event.

- Degradation and eventual simultaneous failure of 5 full mixed transuranic waste/SBW tanks and their vaults after 500 years with a release of mixed transuranic waste/SBW directly to the soil column. This is treated as an abnormal event since it is assumed that the event occurs at 500 years.

Failure of a Full Mixed Transuranic Waste/SBW Tank in the Year 2001 - The rupture of a full mixed transuranic waste/SBW tank in the year 2001 due to a seismic event is assumed to release liquid waste directly to the soil column, where it infiltrates and disperses through the vadose zone and migrates in the groundwater. The impacts for this accident were analyzed using similar modeling assumptions to those considered for CERCLA analyses in the *Comprehensive RI/FS for the Idaho Chemical Processing Plant OU 3-13 at the INEEL, Part A, RI/BRA Report* (Rodriguez et al. 1997). Under these assumptions, the predicted peak groundwater concentration for iodine-129 is 0.13 pCi/L, which is 13 percent of the maximum contaminant level of 1.0 pCi/L. The peak iodine-129 concentration would occur in the year 2075. The predicted groundwater concentration for total plutonium (plutonium-239, plutonium-240, and plutonium-242) is 1.1 pCi/L, which does not exceed the maximum contaminant level of 15 pCi/L for alpha-particle emitters such as plutonium. The peak plutonium concentration would occur in the year 6000. The predicted groundwater concentrations for technetium-99 and neptunium-237 are 110 pCi/L and 0.7 pCi/L, respectively; well below their maximum contaminant levels of 900 pCi/L and 15 pCi/L. The peak concentration for these radionuclides would occur in the years 2095 and 2075, respectively (Bowman 2001a).

The potential nonradionuclide contaminants of concern included those constituents that could reasonably be expected to reach the aquifer in sufficient concentrations to impact the groundwater and pose a threat to the environment. Following screening, the contaminants of concern analyzed were: arsenic, barium, beryllium, cadmium, chromium, fluoride, mercury, molybdenum, nitrates, nickel, lead and uranium. For the single tank failure, the peak concentrations for the 12 species analyzed were all well below the drinking water standards. The peak concentrations for cadmium and nitrate were the closest, but were still more than a factor of 10 below their maximum contaminant levels based on the CERCLA model.

Degradation and Simultaneous Failure of 5 Full Mixed Transuranic Waste/SBW Tanks After 500 Years - For the No Action Alternative, mixed transuranic waste/SBW would be stored in the underground tanks indefinitely. The impact of the tank failures has been analyzed under the assumptions that (a) all five tanks fail simultaneously and (b) prior to failure all other tank contents and tank heels have been pumped into the five tanks. Although five times more mixed transuranic waste/SBW would be released to the soil column (relative to the single tank failure described above), many of the radionuclides would have decayed to very low activities over the 500 years. The impacts for this accident were analyzed using similar modeling assumptions to those considered for the CERCLA analyses in Rodriguez et al. (1997). Under these assumptions, the analysis shows that the impact from the tank failures would result in peak concentrations of iodine-129 at 0.47 pCi/L in the year 2575, technetium-99 at 390 pCi/L in the year 2595, neptunium-237 at 8.1 pCi/L in the year 2575, and total plutonium about 9 pCi/L in the year 6500. Thus, the peak concentrations for these key radionuclides would be less than current drinking water standards (Bowman 2001b).

The risk to an assumed long-term resident drinking the groundwater from beneath the INTEC Tank Farm was analyzed for this accident. Using the concentration-to-dose conversion factor from DOE (1988), and assuming 72 years of water ingestion at 2 liters per day, DOE estimated a lifetime whole-body dose equivalent to 420 millirem due to total plutonium for this accident. This equates to a 210 per million increase in the probability of a fatal cancer. This accident would release at least 5 times more source term to the soil column than considered for the single tank failure. Nevertheless, the concentrations of nonradionuclide contaminants in the aquifer would be less than the drinking water standards.

For nonradionuclide contaminants, the analysis for the 5-tank failure shows the greatest impact would be due to cadmium which would be about 41 percent of its maximum contaminent level. The next most impacting contaminant, uranium, would be about 0.5 percent of its maximum contaminant level based on the CERCLA model.

For purposes of this EIS, DOE calculated the groundwater impacts beneath the mixed transuranic waste/SBW tanks at INTEC. As for the single tank failure, these results could be non-conservative depending on the assumed mass release time for the 5-tank failure. Since doses are directly related to concentrations, a faster release time would be expected to increase concentration and doses accordingly. These impacts are provided for comparison purposes between alternatives under accident conditions and are not meant to fulfill the needs of or replace a performance assessment or INEEL-wide composite analysis as required by DOE Order 435.1. Facilities disposition and closure activities would eventually require such assessments but it is premature to attempt performance assessments until the waste processing technology is selected and the facilities to implement the selected technology are chosen.

5.2.14.7 Consideration of Other Accident Initiators

Each of the process elements associated with the waste processing alternatives were evaluated using a consistent set of accident initiators. During the review of the accident analysis, additional initiators were identified that could potentially result in releases of radioactive or hazardous materials. However, the bounding accidents that describe the potential risk associated with the waste processing alternatives and the accident analyses were not modified as a result of identifying these additional initiators for the following reasons:

Initiator Frequency is Less Than Beyond Design Basis - Very low likelihood events (e.g., meteor strikes) have the potential to cause significant releases. However, accidents that have a frequency of occurrence much less than 1.0×10^{-7} pose a limited risk of occurrence and do not impact the choice of bounding accidents.

Initiator is Encompassed by Another Initiator - The consequences and initiating frequencies of some newly identified initiators are bounded by accidents already identified in the accident analysis. For instance, a release could originate from an aircraft crash (included in analysis) or volcanic activity (identified in review process). The magnitude of the release and the initiating event frequencies for both initiators are similar and for all intents and purposes, the risk is the same. In this case, the volcanic activity initiator is not added into the accident analysis.

Initiator is in Planning/Hypothetical Stage - Some newly identified initiators are associated with potential future activities in and around the INEEL site. However, for activities such as these, their impact on waste processing alternatives would be evaluated as plans for initiation of the project are defined.

5.2.14.8 Sensitivity Analysis

The accident analysis consequence modeling was generally performed using very conservative assumptions to assure bounding results. For the most part, the assumptions in this EIS were consistent with those applied in other EIS documents prepared at the INEEL, such as the SNF & INEL EIS. However, there were some assumptions that differed. Of the assumptions incorporated in consequence modeling for this EIS, exposure pathways, exposure time, breathing rate, meteorology, location (for the population dose), and mass release times for tank failures were some that had significant impact on the results. The approach taken in this EIS ensures a "consequence envelope" is provided. As discussed above, this approach differs in part from the approach taken in other EISs, such as the SNF & INEL EIS. Therefore, the impacts presented in this EIS are generally larger than the impacts that would have been obtained by applying the SNF & INEL EIS assumptions. This EIS provides a likely upper bound to the potential consequences for the accidents associated with the candidate alternatives. In addition, these conservative assumptions were incorporated in a consistent manner. Although adjustments to these assumptions will modify the absolute magnitudes of the predicted consequences, they will not modify the relative ranking of the modeled scenarios. So the set of bounding scenarios are anticipated to remain the same.

5.2.14.9 Risk to Involved Worker

This EIS provides comprehensive and integrated evaluation of involved worker risk (in fatalities over life of the activity) as a result of industrial accidents, occupational exposures, and facility accidents. This EIS developed baseline estimates of involved worker risk using point estimates of risk contributors. Results of the point estimates are presented in Table 5.2-43. The involved worker risks do not include the risks posed by transportation or facility disposition. Appendix C.4, Facility Accidents, provides more information.

From Table 5.2-43 several conclusions can be drawn:

- Involved worker risk for all alternatives are sensitive to parameters such as the number of worker years of exposure, the rate of industrial accident fatalities, and the frequency of radiological release accidents. Consistent with the state of knowledge regarding projects and activities associated with implementation of alternatives, the point estimates provide a means for comparison of alternatives.

- Estimates of involved worker risk due to industrial accidents do not favor options that require the largest amount of manpower during implementation. Thus, waste processing options which rely on separations technology pose the highest risk to involved workers. The separations options encompass the largest requirements for facility construction as well as the longest facility operation campaigns.

- Industrial accidents are the largest contributors to involved worker risk. Therefore, estimates of integrated involved worker risk (including all sources) favor the options that involve less site activity over time.

Table 5.2-43. Point estimates of integrated involved worker risk for the waste processing alternatives.

	Involved worker risk (fatalities)[a]			
	Industrial accidents[b]	Occupational radiation dose[b]	Facility accidents[b]	Integrated worker risk[b]
No Action Alternative	0.44	0.15	21	21
Continued Current Operations Alternative	0.54	0.20	21	21
Separations Alternative				
Full Separations Option	1.8	0.38	2.3×10^{-3}	2.2
Planning Basis Option	1.9	0.47	2.3×10^{-3}	2.4
Transuranic Separations Option	1.2	0.36	2.3×10^{-3}	1.6
Non-Separations Alternative				
Hot Isostatic Pressed Waste Option	1.2	0.44	2.3×10^{-3}	1.6
Direct Cement Waste Option	1.4	0.51	2.3×10^{-3}	1.9
Early Vitrification Option	1.1	0.37	2.3×10^{-3}	1.5
Steam Reforming Option	0.82	0.31	2.3×10^{-3}	1.1
Minimum INEEL Processing Alternative[c]	0.92	0.32	2.3×10^{-3}	1.2
Direct Vitrification Alternative				
Vitrification without Calcine Separations Option	0.90	0.29	2.3×10^{-3}	1.2
Vitrification with Calcine Separations Option	1.6	0.31	2.3×10^{-3}	1.9

a. Does not include risk associated with decontamination and decommissioning (addressed in Section 5.3.12) or transportation (addressed in Section 5.2.9) activities.

b. Fatalities over life of activities.

c. Does not include activities at the Hanford Site.