APPENDIX D
EVALUATION OF HUMAN HEALTH EFFECTS FROM ROUTINE PROCESSING/STORAGE OPERATIONS AND ACCIDENTS

This appendix presents detailed information on the potential impacts and risks to humans associated with releases of radioactivity and hazardous chemicals from the proposed processing and storage technologies during normal operations and from postulated accidents. This information is intended to support the public and occupational health and safety assessments described in Chapter 4 of this Environmental Impact Statement (EIS). Section D.1 provides general background information on radiation and associated health effects, as well as methods and general assumptions used in the assessment of normal and accident radiological impacts; Section D.2 provides information on releases associated with normal operational activities, as well as ranges of potential radiological impacts associated with these normal operational activities at each site; Section D.3 provides indepth information on postulated accidents; and Section D.4 provides information on hazardous chemical impacts. Information regarding potential radiological impacts resulting from intersite transportation is presented in Appendix E of this EIS.

This appendix presents numerical information using engineering and/or scientific notation. For example, the number 100,000 can also be expressed as 1×10^5. The fraction 0.00001 can also be expressed as 1×10^{-5}. The following chart defines the equivalent numerical notations that may be used in this appendix.

FRACTIONS AND MULTIPLES OF UNITS

Multiple	*Decimal Equivalent*	*Prefix*	*Symbol*
1×10^6	1,000,000	mega-	M
1×10^3	1,000	kilo-	k
1×10^2	100	hecto-	h
1×10	10	deka-	da
1×10^{-1}	0.1	deci-	d
1×10^{-2}	0.01	centi-	c
1×10^{-3}	0.001	milli-	m
1×10^{-6}	0.000001	micro-	μ
1×10^{-9}	0.000000001	nano-	n
1×10^{-12}	0.000000000001	pico-	p
1×10^{-15}	0.000000000000001	femto-	f
1×10^{-18}	0.000000000000000001	atto-	a

D.1 RADIOLOGICAL IMPACTS TO HUMAN HEALTH

This section presents supporting information on the potential radiological impacts to humans from normal operations and postulated accidents. It provides the reader with background information on the nature of radiation (Section D.1.1), the methodology used to calculate radiological impacts (Section D.1.2), the input data for the various processing assessments at each site (Section D.1.3), and sample process flow diagrams/ tables that are coordinated with the discussions presented in Appendix C (Section D.1.4).

D.1.1 Background

D.1.1.1 Nature of Radiation and Its Effects on Humans

❒ **What Is Radiation?—**Radiation is energy transferred in the form of particles or waves. Humans are exposed constantly to radiation from the solar system and from the earth's rocks and soil. This radiation contributes to the natural background radiation that has always surrounded us. Manmade sources of radiation also exist, including medical and dental x-rays, household smoke detectors, and materials released from nuclear and coal-fired power plants.

Radiation comes from the activity of atoms, which form the substance of all matter in the universe. Atoms are composed of even smaller particles (protons, neutrons, electrons), whose number and arrangement distinguish one atom from another. Atoms of different types are known as elements. There are more than 100 natural and manmade elements. Some of these elements, such as uranium, radium, plutonium, and thorium, share a very important quality: they are unstable (i.e., they decay). As they change into more stable forms, invisible waves of energy or particles, known as ionizing radiation, are released. Radioactivity is the emitting of this radiation.

Ionizing radiation refers to the fact that this energy force can ionize, or electrically charge, atoms by stripping off electrons. Ionizing radiation can cause a change in the chemical composition of many things, including living tissue (organs), which can affect the way they function.

Radiation Type	Typical Speed km/sec	Typical Travel Distance in Air (m)	Barrier
α	16,000	< 1	Sheet of paper or skin's surface
β	160,000	3	Thin sheet of aluminum foil or glass
γ	300,000	Very Large [a]	Thick wall of concrete, lead, or steel
n	39,000	Very Large	Water, Paraffin, Graphite

[a] *Would be infinite in a vacuum*

- Alpha (á) particles are the heaviest type of ionizing radiation; despite a speed of approximately 16,000 kilometers/second (km/sec) (9,940 miles [mi]/sec), they can travel only several centimeters in air. Alpha particles lose their energy almost as soon as they collide with anything. They can be stopped easily by a sheet of paper or by the skin's surface.

- Beta particles (â) are much lighter than alpha particles. They can travel at a speed up to 160,000 km/sec (99,400 mi/sec) and can travel in the air for a distance of approximately 3 meters (m) (9.8 feet [ft]). Beta particles can pass through a sheet of paper but may be stopped by a thin sheet of aluminum foil or glass.

- Gamma rays (ã) and x-rays, unlike alpha or beta particles, are waves of pure energy. Gamma rays travel at the speed of light (300,000 km/sec [186,000 mi/sec]). Gamma radiation is very penetrating and requires a thick wall of concrete, lead, or steel to stop it.

- The neutron (n) is another particle that contributes to radiation exposure, both directly and indirectly. The latter is associated with the gamma rays and alpha particles that are emitted following neutron capture in matter. A neutron has about one quarter the weight of an alpha particle and can travel at speeds of up to 39,000 km/sec (24,200 mi/sec). Neutrons are more penetrating than beta particles but less penetrating than gamma rays.

The effects on people of radiation emitted during the disintegration (decay) of a radioactive substance depend on the type of radiation (alpha and beta particles and gamma and x-rays) and the total amount of radiation energy absorbed by the body. The total energy absorbed per unit quantity of tissue is referred to as absorbed dose. The absorbed dose, when multiplied by certain quality factors and factors that take into account different sensitivities of various tissues, is referred to as effective dose equivalent or, where the context is clear, simply dose. The common unit of effective dose equivalent is the roentgen equivalent man (rem); 1 rem equals 1,000 millirem (mrem).

The radioactivity of an isotope decreases with time. The time it takes an isotope to lose half of its original radioactivity is designated its half-life. For example, a quantity of iodine-131, an isotope that has a half-life of 8 days, will lose one-half of its radioactivity in that amount of time. In 8 more days, one-half of the remaining radioactivity will be lost, and so on. Eventually, the radioactivity will essentially disappear. Each radioactive element has a characteristic half-life. The half-lives of various radioactive elements may vary from millionths of a second to millions of years.

When a radioactive element emits a particle or gamma-ray, it often changes to an entirely different element, one that may or may not be radioactive. Eventually, a stable element is formed. This transformation, which may take several steps, is known as a decay chain. Radium, for example, is a naturally occurring radioactive element with a half-life of 1,622 years. It emits an alpha particle and becomes radon, a radioactive gas with a half-life of only 3.8 days. Radon decays first to polonium, then through a series of steps to bismuth, and ultimately to lead.

❒ **Units of Radiation Measure—**Scientists and engineers use a variety of units to measure radiation. These different units can be used to determine the amount, type, and intensity of radiation. Just as heat can be measured in terms of its intensity or effects using units of calories or degrees, amounts of radiation can be measured in curies (Ci), radiation absorbed dose (rad), or rem.

- *Curie*—The curie, named after the French scientists Marie and Pierre Curie, describes the "intensity" of a sample of radioactive material. The rate of decay of 1 gram (g) of radium is the basis of this unit of measure. It is equal to 3.7×10^{10} disintegrations (decays)/sec.

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

Radiation Units and Conversions

1 Ci = 3.7×10^{10} sec^{-1} = 3.7×10^{10} Becquerel
1 rad = 100 erg/g = 0.01 Gray
1 erg = 10^{-7} joule
1 Gray = 1 joule/kg = 100 rad
1 rem = 0.01 Sievert

- *Rem*—A rem is a measurement of the dose from radiation based on its biological effects. The rem is used in measuring the effects of radiation on the body as degrees Centigrade are used in measuring the effects of sunlight heating pavement. Thus, 1 rem of one type of radiation is presumed to have the same biological effects as 1 rem of any other kind of radiation. This allows comparison of the biological effects of radionuclides that emit different types of radiation.

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

The three types of doses calculated in this EIS are external dose, internal dose, and combined external and internal dose. Each type of dose is discussed separately in the following paragraphs:

- *External Dose*—The external dose can result from several different pathways, all having in common the fact that the radiation causing the exposure is external to the body. In this EIS, these pathways include exposure to a cloud of radiation passing over the receptor, standing on ground that is contaminated with radioactivity, swimming in contaminated water, and boating in contaminated water. The appropriate measure of dose is called the effective dose equivalent. If the receptor departs from the source of radiation exposure, the dose rate will be reduced. It is assumed that external exposure occurs uniformly during the year.

- *Internal Dose*—The internal dose results from a radiation source entering the human body through either ingestion of contaminated food and water or inhalation of contaminated air. In this EIS, pathways for internal exposure include: (1) ingestion of crops contaminated either by airborne radiation deposits or by irrigation using contaminated water sources, (2) ingestion of animal products from animals that ingested contaminated food, (3) ingestion of contaminated water, and (4) inhalation of contaminated air. In contrast to external exposure, once radiation from internal exposure enters the body, it remains there for a period of time that varies depending on decay and biological elimination rates. The unit of measure for internal doses is the committed dose equivalent. It is the internal dose that each body organ receives from 1 "year intake" (ingestion plus inhalation). Normally, a 50- or 70-year dose-commitment period is used (i.e., the 1-year intake period plus 49 or 69 years). The dose rate increases during the 1 year intake. The dose rate after the first year intake declines slowly as the radioactivity in the body continues to produce a dose. The integral of the dose rate over the 50 or 70 years gives the committed dose equivalent. In this EIS, a 50-year dose-commitment period was used.

  The various organs of the body have different susceptibilities to harm from radiation. The quantity that takes these different susceptibilities into account to provide a broad indicator of the risk to the health of an individual from radiation is called the committed effective dose equivalent. It is obtained by multiplying the committed dose equivalent in each major organ or tissue by a weighting factor associated with the risk susceptibility of the tissue or organ, then summing the totals. It is possible for the committed dose equivalent to an organ to be larger than the committed effective dose equivalent if that organ has a small weighting factor. The concept of committed effective dose equivalent applies only to internal pathways.

- *Combined External and Internal Dose*—For convenience, the sum of the committed effective dose equivalent from internal pathways and the effective dose equivalent from external pathways is also called the committed effective dose equivalent in this EIS. The U.S. Department of Energy (DOE), in DOE Order 5400.1, calls this quantity the effective dose equivalent (DOE 1990).

The units used in this EIS for committed dose equivalent, effective dose equivalent, and committed effective dose equivalent to an individual are the rem and mrem (1/1000 of 1 rem). The corresponding unit for the collective dose to a population (the sum of the doses to members of the population, or the product of the number of exposed individuals and their average dose) is the person-rem.

❐ **Sources of Radiation—**The average American receives a total of approximately 350 mrem/year (yr) from all sources of radiation, both natural and manmade. The sources of radiation can be divided into six different categories: (1) cosmic radiation, (2) terrestrial radiation, (3) internal radiation, (4) consumer products, (5) medical diagnosis and therapy, and (6) other sources (NCRP 1987). These categories are discussed in the following paragraphs:

- *Cosmic Radiation*—Cosmic radiation is ionizing radiation resulting from energetic charged particles from space continuously hitting the earth's atmosphere. These particles, and the secondary particles and photons they create, are cosmic radiation. Because the atmosphere provides some shielding against cosmic radiation, the intensity of this radiation increases with altitude above sea level. For the sites considered in this EIS, the cosmic radiation ranges from 27 to 51 mrem/yr. The average dose to the people in the United States is approximately 27 mrem/yr.

- *External Terrestrial Radiation*—External terrestrial radiation is the radiation emitted from the radioactive materials in the earth's rocks and soils. The external terrestrial radiation for the sites in this EIS ranges from 28 to 63 mrem/yr. The average dose from external terrestrial radiation is approximately 28 mrem/yr.

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

- *Consumer Products*—Consumer products also contain sources of ionizing radiation. In some products, such as smoke detectors and airport x-ray machines, the radiation source is essential to the products' operation. In other products, such as televisions and tobacco, the radiation occurs incidentally to the product function. The average dose from consumer products is approximately 10 mrem/yr.

- *Medical Diagnosis and Therapy*—Radiation is an important diagnostic medical tool and cancer treatment. Diagnostic x-rays result in an average exposure of 39 mrem/yr. Nuclear medical procedures result in an average exposure of 14 mrem/yr.

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

The collective (or population) dose to an exposed population is calculated by summing the estimated doses received by each member of the exposed population. This total dose received by the exposed population is measured in person-rem. For example, if 1,000 people each receive a dose of 1 mrem (0.001 rem), the collective dose is 1,000 persons × 0.001 rem = 1.0 person-rem. Alternatively, the same collective dose (1.0 person-rem) results if 500 people each receive a dose of 2 mrem (500 persons × 2 mrem = 1 person-rem).

❒ **Limits of Radiation Exposure—**The amount of manmade radiation that the public may be exposed to is limited by Federal regulations. Although most scientists believe that radiation absorbed in small doses over several years is not harmful, U.S. Government regulations assume that the effects of all radiation exposures are cumulative.

Under the Clean Air Act, the exposure to a member of the general public from DOE facility releases into the atmosphere is limited by the U.S. Environmental Protection Agency (EPA) to a dose of 10 mrem/yr in addition to the natural background and medical radiation normally received (EPA 1995a). DOE also limits to 10 mrem the dose annually received from material released to the atmosphere (DOE 1993e). EPA and DOE also limit the annual dose to a member of the general public from radioactive releases to drinking water to 4 mrem, as required under the Safe Drinking Water Act (EPA 1992a; DOE 1993e). The DOE annual limit of radiation dose from all pathways to a member of the general public is 100 mrem. (DOE 1993e).

Each of the three sites covered by this EIS operates below all of these limits. The average individual in the United States receives a dose of approximately 0.3 rem (300 mrem) per year from natural sources of radiation. For perspective, a modern chest x-ray results in an approximate dose of 0.006 rem (6 mrem) and a diagnostic pelvis and hip x-ray results in an approximate dose of 0.065 rem (65 mrem) (NCRP 1987). An acute dose of about 450 rem (450,000 mrem) would result in a 50 percent chance of death.

For people working in an occupation that involves radiation, the Nuclear Regulatory Commission and DOE limit doses to 5 rem (5,000 mrem) in any 1 year (NRC 1993; DOE 1993a). DOE also conventionally imposes a 2 rem/yr Administrative Control Limit amongst its sites in the interest of complying with As Low As Reasonably Achievable initiatives (DOE 1996a).

D.1.1.2 Health Effects

Radiation exposure and its consequences are topics of interest to the general public. For this reason, this EIS places much emphasis on the consequences of exposure to radiation, even though the effects of radiation exposure under most circumstances evaluated in this EIS are small. To provide the background for discussions of impacts, this section explains the basic concepts used in the evaluation of radiation effects.

Radiation can cause a variety of ill-health effects in people. The most significant ill-health effect to depict the consequences of environmental and occupational radiation exposure is induction of cancer fatalities. This effect is referred to as “latent” cancer fatalities because the cancer may take many years to develop and for death to occur and may not actually be the cause of death. In the discussions that follow, all fatal cancers are considered latent and the term “latent” is not used.

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

For a uniform irradiation of the body, the incidence of cancer varies among organs and tissues; the thyroid and skin demonstrate a greater sensitivity than other organs. Such cancers, however, also produce relatively low mortality rates because they are relatively amenable to medical treatment. Because of the readily available data for cancer mortality rates and the relative scarcity of prospective epidemiologic studies, somatic effects leading to cancer fatalities rather than cancer incidence are presented in this EIS. The numbers of cancer fatalities can be used to compare the risks among the various alternatives.

The National Research Council's Committee on the Biological Effects of Ionizing Radiation has prepared a series of reports to advise the U.S. Government on the health consequences of radiation exposures. The latest of these reports, *Health Effects of Exposure to Low Levels of Ionizing Radiation BEIR V* (NAS 1990), provides the most current estimates for excess mortality from leukemia and cancers other than leukemia expected to result from exposure to ionizing radiation. This report updates the models and risk estimates provided in an earlier report of the Committee, *The Effects on Populations of Exposure to Low Levels of Ionizing Radiation*. The BEIR V models were developed for application to the U.S. population.

BEIR V provides estimates that are consistently higher than those in its predecessor BEIR III. This increase is attributed to several factors, including the use of a linear dose response model for cancers other than leukemia, revised dosimetry for the Japanese atomic bomb survivors, and additional follow-up studies of the atomic bomb survivors and other cohorts. BEIR III employs constant relative and absolute risk models, with separate coefficients for each of several sex and age-at-exposure groups; BEIR V develops models in which the excess relative risk is expressed as a function of age at exposure, time after exposure, and sex for each of several cancer categories. The BEIR III models were based on the assumption that absolute risks are comparable between the atomic bomb survivors and the U.S. population; BEIR V models were based on the assumption that the relative risks are comparable. For a disease such as lung cancer, where baseline risks in the United States are much larger than those in Japan, the BEIR V approach leads to larger risk estimates than the BEIR III approach.

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

❒ **Risk Estimates for Doses Equal to or Greater than 20 Rem—**BEIR V includes risk estimates for a single exposure to a high level of radiation to all people in a large population group. The estimates are given in terms of lifetime risks per 1.0×10^6 person-rem. Fatality estimates for leukemia, breast cancer, respiratory cancer, digestive cancer, and other cancers are given for both sexes and nine age-at-exposure groups. These estimates, based on the linear model, are summarized in **Table D–1**. The average risk estimate from all ages and both sexes is 885 excess cancer fatalities per million person-rem. This value has been conservatively rounded up to 1,000 excess cancer fatalities per million person-rem.

Table D–1 Lifetime Risks per 100,000 Persons Exposed to a Single Exposure of 10 Rem[a]

Gender	*Type of Fatal Cancer*		
	Leukemia [b]	*Cancers Other Than Leukemia*	*Total Cancers*
Male	220	660	880
Female	160	730	890
Average	190	695	885[c]

[a] The risk values in this table are applied to situations in which the dose received by an individual is greater than 10 rem per hour. The accident analyses in this EIS assumes that the rate of exposure is greater than this value if the dose received during the accident is greater than 20 rem. For those accidents, the risk values in Table D-1 are applied.

[b] These are the linear estimates, which are double the linear-quadratic estimates provided in BEIR V for leukemia at low doses and dose-rates.

[c] This value has been rounded up to 1,000 excess cancer fatalities per million person-rem.

Source: NAS 1990.

Although values for other health effects are not presented in this EIS, the risk estimators for nonfatal cancers and for genetic disorders to future generations are estimated to be approximately 200 and 260 per million person-rem, respectively. These values are based on information presented in the *1990 Recommendations of the International Commission on Radiological Protection* (ICRP 1991) and are seen to be 20 percent and 26 percent, respectively, of the fatal cancer estimator. Thus, if the number of excess fatal cancers is projected to be "X," the number of excess genetic disorders would be 0.26 times "X."

❒ **Risk Estimates for Doses Less than 20 Rem—**For doses lower than 20 rem, a linear-quadratic model provides a significantly better fit to the data for leukemia than a linear model, and leukemia risks were based on a linear-quadratic function, which reduces the effects by a factor of two over estimates that are obtained from a linear model. For other cancers, linear models were found to provide an adequate fit to the data and were used for extrapolation to low doses. The BEIR V Committee, however, recommended reducing these linear estimates by a factor between 2 and 10 for doses received at low dose rates. For this EIS, a risk reduction factor of two was adopted for conservatism.

Based on the preceding discussion, the resulting risk estimator would be equal to half the value observed for high-dose situations or approximately 500 excess fatal cancers per million person-rem (0.0005 excess fatal cancer per person-rem). This is the risk value used in this EIS to calculate fatal cancers to the general public during normal operations and also for accidents in which individual doses are less than 20 rem. For workers, a value of 400 excess fatal cancers per million person-rem (0.0004 excess fatal cancer per person-rem) is used in this EIS. This lower value reflects the absence of children (who are more radiosensitive than adults) in the workforce. Again, based on information provided in the *1990 Recommendations of the International Commission on Radiological Protection* (ICRP 1991), the health risk estimators for nonfatal cancer and genetic disorders among the public are 20 percent and 26 percent, respectively, of the fatal cancer risk estimator. For workers, the health risk estimators are both 20 percent of the fatal cancer risk estimator. For this EIS, only fatal cancers are presented.

The risk estimates may be applied to calculate the effects of exposing a population to radiation. For example, in a population of 100,000 people exposed only to natural background radiation (0.3 rem/yr), 15 latent cancer fatalities per year would result from this radiation (100,000 persons × 0.3 rem/yr × 0.0005 latent cancer fatalities per person-rem = 15 latent cancer fatalities/yr).

Calculations of the number of excess cancer fatalities associated with radiation exposure do not always yield whole numbers; calculations may yield numbers less than 1.0, especially in environmental applications. For example, if a population of 100,000 were exposed as described in the previous paragraph but to a total dose of only 0.001 rem, the collective dose would be 100 person-rem, and the corresponding estimated number of latent cancer fatalities would be 0.05 (100,000 persons × 0.001 rem × 0.0005 latent cancer fatalities/person-rem = 0.05 latent cancer fatalities).

For latent cancer fatalities less than 1.0, the estimated 0.05 latent cancer fatalities is a statistical estimate—0.05 is the *average* number of deaths that would result if the same exposure situation were applied to many different groups of 100,000 people. In most groups, no person (0 people) would incur a latent cancer fatality from the 0.001 rem dose each member would have received. In a small fraction of the groups, 1 latent cancer fatality would result; in exceptionally few groups, 2 or more latent cancer fatalities would occur. The *average* number of deaths over all the groups would be 0.05 latent cancer fatalities (just as the average of 0, 0, 0, and 1 is 1/4, or 0.25). The most likely outcome is 0 latent cancer fatalities.

These same concepts apply to estimating the effects of radiation exposure on a single individual. Consider the effects, for example, of exposure to background radiation over a lifetime. The "number of latent cancer fatalities" corresponding to a single individual's exposure over a (presumed) 72-year lifetime to 0.3 rem/yr is the following:

1 person × 0.3 rem/yr × 72 yr × 0.0005 latent cancer fatalities/person-rem = 0.011 latent cancer fatalities.

Again, this is a statistical estimate; that is, the estimated effect of background radiation exposure on the exposed individual would produce a 1.1 percent chance that the individual might incur a latent cancer fatality caused by the exposure over his full lifetime. Presented another way, this method estimates that approximately 1.1 percent of the population might die of cancers induced by background radiation (DOE 1996a).

D.1.2 Methodology for Estimating Radiological Impacts

The radiological impacts of normal operations and postulated accidents of processing/storage facilities were calculated using Version 1.485 of the GENII computer code, which will remain the latest version of the code available until the 1998–1999 timeframe (PNNL 1997). Site-specific and technology-specific input data were used, including location, meteorology, population, food production and consumption, and source terms. Section D.1.2.1 briefly describes GENII and outlines the approach used for normal operations. The approach used for design basis accidents is discussed later in Section D.3.

D.1.2.1 GENII Computer Code

The GENII computer model, developed by Pacific Northwest Laboratory, is an integrated system of various computer modules that analyze environmental contamination resulting from acute or chronic releases to, or initial contamination in, air, water, or soil. The model calculates radiation doses to individuals and populations. The GENII computer model is well documented for assumptions, technical approach, methodology, and quality assurance issues (PNL 1988). The GENII computer model has gone through extensive quality assurance and quality control steps, including comparing results from model computations with those from hand calculations and performing internal and external peer reviews. Recommendations given in these reports were incorporated into the final GENII computer model, as deemed appropriate.

For this EIS, only the ENVIN, ENV, and DOSE computer modules were used. The codes are connected through data transfer files. The output of one code is stored in a file that can be used by the next code in the system.

- **ENVIN—**The ENVIN module of the GENII code controls the reading of input files and organizes the input for optimal use in the environmental transport and exposure module, ENV. The ENVIN code interprets the basic input, reads the basic GENII data libraries and other optional input files, and organizes the input into sequential segments based on radionuclide decay chains.

  A standardized file that contains scenario, control, and inventory parameters is used as input to ENVIN. Radionuclide inventories can be entered as functions of releases to air or water, concentrations in basic environmental media (air, soil, or water), or concentrations in foods. If certain atmospheric dispersion options have been selected, this module can generate tables of atmospheric dispersion parameters that will be used in later calculations. If the finite plume air submersion option is requested in addition to the atmospheric dispersion calculations, preliminary energy-dependent finite plume dose factors are prepared as well. The ENVIN module prepares the data transfer files that are used as input by the ENV module; ENVIN generates the first portion of the calculation documentation—the run input parameters report.

- **ENV—**The ENV module calculates the environmental transfer, uptake, and human exposure to radionuclides that result from the chosen scenario for the user-specified source term. The code reads the input files from ENVIN and then, for each radionuclide chain, sequentially performs the precalculations to establish the conditions at the start of the exposure scenario. Environmental concentrations of radionuclides are established at the beginning of the scenario by assuming decay of preexisting sources, considering biotic transport of existing subsurface contamination, and defining soil contamination from continuing atmospheric or irrigation depositions. For each year of postulated exposure, the code then estimates the air, surface soil, deep soil, groundwater, and surface water concentrations of each radionuclide in the chain. Human exposures and intakes of each radionuclide are calculated for (1) pathways of external exposure from finite atmospheric plumes; (2) inhalation; (3) external exposure from contaminated soil, sediments, and water; (4) external exposure from special geometries; and (5) internal exposures from consumption of terrestrial foods, aquatic foods, drinking water, animal products, and inadvertent intake of soil. The intermediate information on annual media concentrations and intake rates are written to data transfer files. Although these may be accessed directly, they are usually used as input to the DOSE module of GENII.

- **DOSE—**The DOSE module reads the intake and exposure rates defined by the ENV module and converts the data to radiation dose.

D.1.2.2 Data and General Assumptions for Normal Operations and Postulated Accidents

To perform the dose assessments for this EIS, different types of data were collected and/or generated. In addition, calculational assumptions were made. This section discusses both the data collected and/or generated for use in performing the dose assessments and the assumptions made for this EIS.

- **Meteorological Data—**The meteorological data used for all sites discussed in this EIS were in the form of joint frequency data files. A joint frequency data file is a table listing the fractions of time the wind blows in a certain direction, at a certain speed, and within a certain stability class. The joint frequency data files were based on measurements taken over a period of several years at different locations and heights on each of the sites. Average annual meteorological conditions (averaged over the measurement period) were used for normal operations.

- **Population Data—**Population distributions were based on site-provided information and on the *1990 Census of Population and Housing* data (DOC 1992). Projections were determined for the year 2000 (approximate midlife of operations) for areas within 80 km (50 mi) of the proposed facilities at each candidate site. The site population in 2000, assumed to be representative of the population over the operational period evaluated, was used in the impact assessments. The population was spatially distributed on a circular grid with 16 directions and 10 radial distances up to 80 km (50 mi). The grid was centered on the facility from which the radionuclides were assumed to be released.

- **Source Term Data—**The source terms (quantities of radionuclides released to the environment over a given period) for each alternative were estimated based on experience with similar facility operations and safety analysis assessments. The source terms used to generate the estimated impacts of normal operations are provided in Section D.2 for the processing/storage processes examined in this EIS.

- **Food Production and Consumption Data—**Data from the *1987* and *1992 Censuses of Agriculture* (DOC 1988; DOC 1993) were used to generate site-specific data for food production. Food production was spatially distributed on the same circular grid used for the population distributions. The consumption rates used in GENII were those for the maximum individual and average individual. People living within the 80-km (50-mi) assessment area were assumed to consume only food grown in that area.

- **Calculational Assumptions—**Dose assessments were performed for both members of the general public and workers for each site examined in this EIS. These assessments were made to determine the *incremental* doses that would be associated with the alternatives addressed in this EIS. Doses for members of the public were calculated for two different types of receptors: the maximally exposed offsite individual and the general population living within 80 km (50 mi) of the facility. The maximally exposed individual associated with the alternatives addressed in this EIS was assumed to be located at a position on the site boundary that would receive the highest dose during normal operations or during a postulated accident of a given alternative. Similarly, an 80-km (50-mi) population dose was calculated for each operating processing/storage facility at the sites.

  To estimate the radiological impacts from incident-free (normal) operations of processing/storage facilities, the following additional assumptions and factors were considered in using GENII:

  - Ground surfaces were assumed to have no previous deposition of radionuclides.
  - The annual external exposure time to the plume and to soil contamination was 0.7 year for the maximally exposed offsite individual (NRC 1977).
  - The annual external exposure time to the plume and to soil contamination was 0.5 year for the population (NRC 1977).
  - The annual inhalation exposure time to the plume was 1.0 year for the maximally exposed individual and general population (NRC 1977).
  - The exposed individual or population was assumed to have the characteristics and habits (e.g., inhalation and ingestion rates) of the adult human.
  - A semi-infinite/finite plume model was used for air immersion doses. Other pathways evaluated were ground exposure, inhalation, ingestion of food crops, and ingestion of contaminated animal products. Drinking water, aquatic food ingestion, and any other pathways that may involve liquid exposure are not examined because all releases are to the air.
  - Reported stack heights were used for atmospheric releases. The resultant doses were conservative, as use of the actual stack height instead of the effective stack height negates plume rise.
  - The calculated doses were 50-year committed doses from 1 year of intake.

  To estimate the radiological impacts from postulated accident scenarios, the following assumptions and factors were considered in using GENII (an extensive discussion of these assumptions is presented in Section D.3.3.1):

- Ground surfaces were assumed to have no previous deposition of radionuclides.

- The external exposure time to soil contamination was 0.7 year for the maximally exposed offsite individual and the general population.

- The exposed individual or population was assumed to have the characteristics and habits (e.g., inhalation and ingestion rates) of the adult human.

- Drinking water, aquatic food ingestion, and any other pathways that may involve liquid exposure are not examined because all releases are to the air.

- A semi-infinite plume model was used for air immersion doses.

- Reported stack heights were used for atmospheric releases and were assumed to be the effective stack height. The resultant doses were conservative, as use of the actual stack height negates plume rise.

The exposure, uptake, and usage parameters used in the GENII model for normal operations are provided in **Table D–2** through **Table D–4**. The parameters used for postulated accidents are presented in **Table D–5** through **Table D–7**.

Table D–2 GENII Exposure Parameters to Plumes and Soil Contamination (Normal Operations)

Maximum Individual				*General Population*			
External Exposure		*Inhalation of Plume*		*External Exposure*		*Inhalation of Plume*	
Plume (hours)	*Soil Contamination (hours)*	*Exposure Time (hours)*	*Breathing Rate (cm^3/sec)*	*Plume (hours)*	*Soil Contamination (hours)*	*Exposure Time (hours)*	*Breathing Rate (cm^3/sec)*
6,136	6,136	8,766	270	4,383	4,383	8,766	270

cm^3/sec = cubic centimeter per second
Source: PNL 1988, NRC 1977.

Table D–3 GENII Usage Parameters for Consumption of Terrestrial Food (Normal Operations)

	Maximum Individual				*General Population*			
Food Type	*Growing Time (days)*	*Yield (kg/m^2)*	*Holdup Time (days)*	*Consumption Rate (kg/yr)*	*Growing Time (days)*	*Yield (kg/m^2)*	*Holdup Time (days)*	*Consumption Rate (kg/yr)*
Leafy Vegetables	90.0	1.5	1.0	30.0	90.0	1.5	14.0	15.0
Root Vegetables	90.0	4.0	5.0	220.0	90.0	4.0	14.0	140.0
Fruit	90.0	2.0	5.0	330.0	90.0	2.0	14.0	64.0
Grains/Cereals	90.0	0.8	180.0	80.0	90.0	0.8	180.0	72.0

kg/m^2 = kilogram per square meter kg/yr = kilogram per year
Source: PNL 1988.

Table D–4 GENII Usage Parameters for Consumption of Animal Products (Normal Operations)

			Stored Feed				*Fresh Forage*			
Food Type	*Consumption Rate (kg/yr)*	*Holdup Time (days)*	*Diet Fractio n*	*Growing Time (days)*	*Yield (kg/m^2)*	*Storage Time (days)*	*Diet Fraction*	*Growing Time (days)*	*Yield (kg/m^2)*	*Storage Time (days)*

Maximum Individual										
Beef	80.0	15.0	0.25	90.0	0.80	180.0	0.75	45.0	2.00	100.0
Poultry	18.0	1.0	1.00	90.0	0.80	180.0	--	--	--	--
Milk	270.0	1.0	0.25	45.0	2.00	100.0	0.75	30.0	1.50	0.00
Eggs	30.0	1.0	1.00	90.0	0.80	180.0	--	--	--	--
General Population										
Beef	70.0	34.0	0.25	90.0	0.80	180.0	0.75	45.0	2.00	100.0
Poultry	8.5	34.0	1.0	90.0	0.80	180.0	--	--	--	--
Milk	230.0	3.0	0.25	45.0	2.00	100.0	0.75	30.0	1.50	0.00
Eggs	20.0	18.0	1.0	90.0	0.80	180.0	--	--	--	--

kg/yr = kilogram per year kg/m^2 = kilogram per square meter
Source: PNL 1988.

Table D–5 GENII Exposure Parameters to Plumes and Soil Contamination (Postulated Accidents)

Maximum Individual				***General Population***			
External Exposure		***Inhalation of Plume***		***External Exposure***		***Inhalation of Plume***	
Plume (hours)	***Soil Contamination (hours)***	***Exposure Time (hours)***	***Breathing Rate (cm^3/sec)***	***Plume (hours)***	***Soil Contaminatio n (hours)***	***Exposure Time (hours)***	***Breathing Rate (cm^3/sec)***
0.00	6,136	100% of Release Time	330	0.00	6,136	100% of Release Time	330

cm^3/sec = cubic centimeter per second
Source: PNL 1988, NRC 1977.

Table D–6 GENII Usage Parameters for Consumption of Terrestrial Food (Postulated Accidents)

	Maximum Individual				***General Population***			
Food Type	***Growing Time (days)***	***Yield (kg/m^2)***	***Holdup Time (days)***	***Consumption Rate (kg/yr)***	***Growing Time (days)***	***Yield (kg/m^2)***	***Holdup Time (days)***	***Consumption Rate (kg/yr)***
Leafy Vegetables	90.0	1.5	1.0	30.0	90.0	1.5	14.0	15.0
Root Vegetables	90.0	4.0	5.0	220.0	90.0	4.0	14.0	140.0
Fruit	90.0	2.0	5.0	330.0	90.0	2.0	14.0	64.0
Grains/Cereals	90.0	0.8	180.0	80.0	90.0	0.8	180.0	72.0

kg/m^2 = kilogram per square meter kg/yr = kilogram per year
Source: PNL 1988.

Table D–7 GENII Usage Parameters for Consumption of Animal Products (Postulated Accidents)

			Stored Feed				***Fresh Forage***			
Food Type	***Consumption Rate (kg/yr)***	***Holdup Time (days)***	***Diet Fraction***	***Growing Time (days)***	***Yield (kg/m^2)***	***Storage Time (days)***	***Diet Fraction***	***Growing Time (days)***	***Yield (kg/m^2)***	***Storage Time (days)***
Maximum Individual										
Beef	80.0	15.0	0.25	90.0	0.80	180.0	0.75	45.0	2.00	100.0
Poultry	18.0	1.0	1.00	90.0	0.80	180.0	--	--	--	--

			Stored Feed				***Fresh Forage***			
Food Type	***Consumption Rate (kg/yr)***	***Holdup Time (days)***	***Diet Fraction***	***Growing Time (days)***	***Yield (kg/m²)***	***Storage Time (days)***	***Diet Fraction***	***Growing Time (days)***	***Yield (kg/m²)***	***Storage Time (days)***
Milk	270.0	1.0	0.25	45.0	2.00	100.0	0.75	30.0	1.50	0.00
Eggs	30.0	1.0	1.00	90.0	0.80	180.0	--	--	--	--
General Population										
Beef	70.0	34.0	0.25	90.0	0.80	180.0	0.75	45.0	2.00	100.0
Poultry	8.5	34.0	1.0	90.0	0.80	180.0	--	--	--	--
Milk	230.0	3.0	0.25	45.0	2.00	100.0	0.75	30.0	1.50	0.00
Eggs	20.0	18.0	1.0	90.0	0.80	180.0	--	--	--	--

kg/yr = kilogram per year kg/m^2 = kilogram per square meter
Source: PNL 1988.

Workforce doses (on a weekly basis) directly associated with processing/storage normal operations were taken from reports prepared by Rocky Flats, the Savannah River Site, and Los Alamos National Laboratory. To obtain the total workforce dose associated with a particular processing/storage process over its operational interim, the reported weekly dose is multiplied by the estimated number of weeks the particular process is to be in effect.

Radiological impacts to workers from postulated accident scenarios were evaluated at onsite locations where a given incident would cause the highest dose. For conservatism, the maximally exposed onsite worker was assumed to have an inhalation exposure time of 5 minutes and an external exposure time to soil contamination of 20 minutes. For a ground-level release accident, a maximally exposed onsite worker was assumed to be 100 meters from a given release point; for an elevated release, the worker was situated between 200 and 500 meters, depending on the given site's atmospheric dispersion characteristics. All doses to workers include a component associated with the intake of radioactivity into the body and another component resulting from external exposure to direct radiation.

D.1.2.3 Health Effects Calculations

In this EIS, the collective combined effective dose equivalent is the sum of the collective committed effective dose equivalent (internal dose) and the collective effective dose equivalent (external dose), as explained in Section D.1.1.1. Doses calculated by GENII were used to estimate health effects using the risk estimators presented in Section D.1.1.2. The incremental cancer fatalities in the general population and in groups of workers caused by radiation exposure were, therefore, estimated by multiplying the collective combined effective dose equivalent by 0.0005 and 0.0004 fatal cancers/person-rem, respectively, for normal operations and also for accidents in which doses to members of the population were less than 20 rem. For situations in which the dose was greater than 20 rem, these factors were doubled. Although health risk factors are statistical factors and not strictly applicable to individuals, they have been used in the past to estimate the incremental risk to an individual from exposure to radiation. Therefore, the factor of 0.0005 and 0.0004 per rem of individual committed effective dose equivalent for a member of the public and for a worker, respectively (or double these values for individual doses greater than 20 rem), have also been used in this EIS to calculate the individual's incremental fatal cancer risk from exposure to radiation.

For the public, the health effects expressed in this EIS are the risk of fatal cancers to the maximally exposed individual and the number of fatal cancers to the 80-km (50-mi) population from exposure to radioactivity released from any site over the full operational period. For workers, the health effects expressed are the risk to the average worker at a site and the number of fatal cancers to all workers at that site over the full period of site operations.

D.1.2.4 Uncertainties

The sequence of analyses performed to generate the radiological impact estimates from normal operation include: (1) selection of normal operational modes, (2) estimation of source terms, (3) estimation of environmental transport and uptake of radionuclides, (4) calculation of radiation doses to exposed individuals, and (5) estimation of health effects. There are uncertainties associated with each of these steps. Uncertainties exist in the way the physical systems being analyzed are represented by the computational models and in the data required to exercise the models (due to measurement errors, sampling errors, or natural variability).

In principle, one can estimate the uncertainty associated with each source and predict the remaining uncertainty in the results of each set of calculations. Thus, one can propagate the uncertainties from one set of calculations to the next and estimate the uncertainty in the final results. However, conducting such a full-scale quantitative uncertainty analysis is neither practical nor a standard practice for a study of this type. Instead, the analysis is designed to ensure—through judicious selection of release scenarios, models, and parameters—that the results represent the potential risks. This is accomplished by making conservative assumptions in the calculations at each step. The models, parameters, and release scenarios used in the calculations are selected in such a way that most intermediate results and, consequently, the final estimates of impacts are greater than what would be expected. As a result, even though the range of uncertainty in a quantity might be large, the value calculated for the quantity is close to one of the extremes in the range of possible values, so that the chance of the actual quantity being greater than the calculated value is low (or the chance of the quantity being less than the calculated value if the criteria are such that the quantity has to be maximized). This has been the goal of the radiological assessment for normal operations in this study (i.e., to produce results that are conservative).

The degree of conservatism in the calculated results is closely related to the range of possible values the quantity can have. This range is determined by what can be expected to realistically occur. Thus, the only processes considered are those credible for the conditions under which the physical system being modeled operates. This consideration has been employed for normal operation analyses.

Uncertainties are also derived from the lack of engineering design data for facilities that are only conceptual. Although the radionuclide composition of source terms are reasonable estimates, there are uncertainties in the radionuclide inventory and release reactions that affect estimated impacts.

D.1.3 Radiological Impact Assessment Data

This section presents the various site-dependent GENII input data required for quantifying the potential radiological impacts associated with the processing/storage alternatives discussed in this EIS. Agricultural data, population data, meteorological data, and atmospheric dispersion characteristics are presented for Rocky Flats, the Savannah River Site, and Los Alamos National Laboratory.

- **Agricultural Data—**Agricultural food production data (wheels) were generated based on the results of the 1987 and 1992 U.S. Censuses of Agriculture (DOC 1988; DOC 1993). The wheel was generated by combining the fraction of a county in each segment (e.g., south, southwest, north-northeast) and the county production of the eight food categories analyzed by GENII (leafy vegetables, root vegetables, fruits, grains, beef, poultry, milk, and eggs). Each county's food production (in kilograms) was assumed to be distributed uniformly over the given county's land area. These categorized food wheels are fed into

GENII as an input file and are used in the assessment of doses to a given general population from the ingestion pathway. For further discussion, see Section D.1.2.2.

- **Population Data—**Population data (wheels) were generated based on the 1990 U.S. Census of Population and Housing (DOC 1992). For each block in the 1990 census, the population was assigned a distance and direction from the release point; then the block's population was projected based on state estimates of county growth rates through the year 2000. The population in each segment (e.g., south, southwest, north-northeast) was cumulated over all the blocks in the census. These population wheels are fed into GENII as an input file and are used in the assessment of a total dose incurred to a given general population. For further discussion, see Section D.1.2.2.

- **Meteorological Data—**Meteorological data (i.e., Joint Frequency Distributions) were based on measurements of the fractions of time (given as percentages) the wind blows in a certain direction, at a certain speed, and within a certain stability class for each site examined within this EIS. These data are fed into GENII as an input file and are used in the evaluation of ÷/Q or E/Q values (these values represent radioisotope concentrations divided by the rates at which they are emitted to the environment), which are used to determine the total dose incurred to a given general population, an offsite maximally exposed individual, or an onsite worker.

D.1.3.1 Radiological Impact Assessments at Rocky Flats

This section presents the radiological impact input data used in the assessment of the various processing/storage alternatives at Rocky Flats. For purposes of radiological impact modeling, the Rocky Flats analyses assumed that Buildings 707 and 371 would be the locations from which radioactive effluents would be released. **Table D–8** presents the characteristics of both these release points, including location, release height, minimum distance, and annual average dispersion to the site boundary in each of 16 directions.

Table D–8 Release Point Characteristics, Direction, Distance, and Atmospheric Dispersion at the Rocky Flats Site Boundary

Release Location	*Building 707*	*Building 371*
Latitude [a]	39.89°	39.89°
Longitude [a]	-105.20°	-105.20°
Release Height	12.4 m	44.2 m

Distance and Atmospheric Dispersion at Site Boundary				
	Building 707		*Building 371*	
Direction	*Distance (m)*	*÷/Q (sec/m³)*	*Distance (m)*	*÷/Q (sec/m³)*
N	2,350	1.0×10^{-7}	2,310	2.5×10^{-7}
NNE	2,540	7.6×10^{-8}	2,340	2.0×10^{-7}
NE	2,730	5.3×10^{-8}	2,720	1.1×10^{-7}
ENE	3,120	3.9×10^{-8}	3,270	8.1×10^{-8}
E	3,060	3.0×10^{-8}	3,620	5.6×10^{-8}
ESE	3,120	3.2×10^{-8}	3,720	6.0×10^{-8}
SE	2,880	5.0×10^{-8}	3,220	1.0×10^{-7}
SSE	2,440	7.5×10^{-8}	2,670	1.7×10^{-7}
S	2,380	8.9×10^{-8}	2,610	2.2×10^{-7}
SSW	2,440	1.0×10^{-7}	2,460	2.5×10^{-7}
SW	2,140	1.3×10^{-7}	1,610	6.0×10^{-7}
WSW	1,940	2.1×10^{-7}	1,740	7.1×10^{-7}
W	2,980	1.3×10^{-7}	2,560	3.8×10^{-7}
WNW	3,030	1.3×10^{-7}	2,620	3.6×10^{-7}
NW	2,930	8.9×10^{-8}	2,360	3.1×10^{-7}

Distance and Atmospheric Dispersion at Site Boundary				
	Building 707		Building 371	
Direction	Distance (m)	÷/Q (sec/m³)	Distance (m)	÷/Q (sec/m³)
NNW	2,410	1.1×10^{-7}	2,360	2.7×10^{-7}

÷/Q = Radioisotope concentrations divided by the rates at which they are emitted to the environment
sec/m³ = seconds per cubic meter
[a] The distance between Buildings 707 and 371 is approximately 500 meters. Because of this small distance, the coordinates are the same to the accuracy given.
Source: DOE 1995b, DOE 1996e, PNL 1988.

Descriptions of population and foodstuff distributions centered on Rocky Flats are provided in **Table D–9** and **Table D–10**, respectively. The joint frequency distribution used for the dose assessment (presented in **Table D–11**) was based on the meteorological measurements for 1994 and 1996 taken from the meteorological tower at Rocky Flats at the 10-m (33-ft) height.

Table D–9 Rocky Flats Population Data Out to 80 km (50 mi) for Year 2000

	Distance (miles)										
Direction	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50	Total
S	0	0	164	466	519	10,777	41,364	18,942	4,306	3,544	**80,082**
SSW	0	0	164	308	229	438	12,822	8,927	2,551	1,945	**27,384**
SW	0	0	90	56	61	499	3,682	1,227	1,054	1,281	**7,950**
WSW	0	0	21	55	58	500	1,623	2,765	1,890	8,392	**15,304**
W	0	0	53	68	58	496	3,898	1,343	1,112	893	**7,921**
WNW	0	0	21	53	66	418	1,497	1,604	388	1,833	**5,880**
NW	0	0	38	35	144	970	1,490	3,322	5	2,599	**8,603**
NNW	0	0	73	81	211	58,878	29,949	4,208	7,627	5,545	**106,572**
N	0	0	46	94	493	8,207	21,684	17,222	50,176	115,674	**213,596**
NNE	0	0	77	143	595	21,060	22,519	34,494	8,747	11,876	**99,511**
NE	0	0	107	410	200	15,797	3,852	3,772	2,631	85,090	**111,859**
ENE	0	0	5	100	11	28,481	21,467	25,953	3,255	2,106	**81,378**
E	0	0	6	1,315	5,954	41,207	98,629	4,323	3,253	3,031	**157,718**
ESE	0	0	21	223	192	65,014	103,130	137,283	4,034	1,124	**311,021**
SE	0	0	10	500	3,675	58,471	308,362	316,464	53,246	7,366	**748,094**
SSE	0	0	171	857	1,742	25,320	211,024	179,144	17,158	16,678	**452,094**
Total	**0**	**0**	**1,067**	**4,764**	**14,208**	**336,533**	**886,992**	**760,993**	**161,433**	**268,977**	**2,434,967**

Source: KHC 1997c.

Table D–10 Rocky Flats Agricultural Data (kg/yr)

	Distance (miles)										
Food Type	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50	Direction
Leafy Veg.	0	0	0	0	0	0	0	0	0	0	S
	0	0	0	0	0	0	0	0	0	0	SSW
	0	0	0	0	0	0	0	0	0	0	SW
	0	0	0	0	0	0	0	0	0	0	WSW
	0	0	0	0	0	0	0	0	0	0	W
	0	0	0	0	0	0	0	0	0	0	WNW
	0	0	0	0	0	0	0	0	0	0	NW

Food Type	***Distance (miles)***										***Direction***
	0-1	***1-2***	***2-3***	***3-4***	***4-5***	***5-10***	***10-20***	***20-30***	***30-40***	***40-50***	
	0	0	0	0	0	0	0	0	0	0	NNW
	0	0	0	0	0	0	0	0	0	0	N
	0	0	0	0	0	0	0	0	0	0	NNE
	0	0	0	0	0	0	0	0	0	0	NE
	0	0	0	0	0	0	0	0	0	0	ENE
	0	0	0	0	0	0	0	0	0	0	E
	0	0	0	0	0	0	0	0	0	0	ESE
	0	0	0	0	0	0	0	0	0	0	SE
	0	0	0	0	0	0	0	0	0	0	SSE
Root Veg.	0	0	0	0	0	0	0	0	0	0	S
	0	0	0	0	0	0	0	0	0	0	SSW
	0	0	0	0	0	0	0	0	0	0	SW
	0	0	0	0	0	0	0	0	0	0	WSW
	0	0	0	0	0	0	0	0	0	0	W
	0	0	4,900	19,000	32,000	360,000	1.30×10^{6}	1.50×10^{6}	0	0	WNW
	0	0	34,000	38,000	48,000	400,000	1.60×10^{6}	2.40×10^{6}	980,000	400,000	NW
	0	14,000	27,000	38,000	48,000	400,000	160×10^{6}	2.60×10^{6}	3.00×10^{6}	3.80×10^{6}	NNW
	0	16,000	27,000	38,000	48,000	400,000	1.60×10^{6}	2.40×10^{6}	3.00×10^{6}	3.80×10^{6}	N
	0	15,000	27,000	38,000	48,000	400,000	1.90×10^{6}	7.10×10^{6}	8.60×10^{6}	1.30×10^{7}	NNE
	0	11,000	27,000	38,000	48,000	400,000	6.30×10^{6}	1.30×10^{7}	1.80×10^{7}	2.30×10^{7}	NE
	0	0	19,000	36,000	48,000	380,000	4.30×10^{6}	1.20×10^{7}	1.80×10^{7}	2.30×10^{7}	ENE
	0	0	0	680	7,400	190,000	990,000	2.10×10^{6}	5.60×10^{6}	9.50×10^{6}	E
	0	0	0	0	0	86,000	890,000	1.40×10^{6}	1.30×10^{6}	1.10×10^{6}	ESE
	0	0	0	0	0	7,600	120,000	45,000	0	0	SE
	0	0	0	0	0	0	0	0	0	0	SSE
Fruits	0	0	0	0	0	0	0	0	0	0	S
	0	0	0	0	0	0	0	0	0	0	SSW
	0	0	0	0	0	0	0	0	0	0	SW
	0	0	0	0	0	0	0	0	0	0	WSW
Fruits (continued)	0	0	0	0	0	0	0	0	0	0	W
	0	0	0.360	1.40	2.40	27.0	99.0	110	0	0	WNW
	0	0	2.50	2.80	3.60	30.0	120	180	50.0	0	NW
	0	1.00	2.00	2.80	3.60	30.0	120	160	8.40	0	NNW
	0	1.20	2.00	2.80	3.60	30.0	120	110	0	0	N
	0	1.10	2.00	2.80	3.60	30.0	110	85.0	18.0	28.0	NNE
	0	0.850	2.00	2.80	3.60	30.0	42.0	33.0	46.0	60.0	NE
	0	0	1.40	2.70	3.60	25.0	10.0	32.0	46.0	60.0	ENE
	0	0	0	0	0	6.20	0	1.30	10.0	20.0	E
	0	0	0	0	0	0	0	0	0	0	ESE
	0	0	0	0	0	0	0	0	0	0	SE
	0	0	0	0	0	0	0	0	0	0	SSE
Grains	0	390	480	680	870	7,300	29,000	66,000	220,000	390,000	S
	0	390	480	680	870	7,300	29,000	39,000	33,000	28,000	SSW
	0	390	480	680	870	7,300	16,000	260	0	0	SW
	0	390	480	680	870	7,300	3,200	0	0	0	WSW
	0	0	870	680	870	7,100	210	0	0	0	W
	0	0	11,000	40,000	68,000	760,000	2.80×10^{6}	3.10×10^{6}	0	0	WNW
	0	0	70,000	79,000	100,000	850,000	3.40×10^{6}	5.00×10^{6}	1.90×10^{6}	670,000	NW
	0	29.000	57,000	79,000	100,000	850,000	3.40×10^{6}	5.30×10^{6}	5.10×10^{6}	6.40×10^{6}	NNW
	0	33,000	57,000	79,000	100,000	850,000	3.40×10^{6}	4.70×10^{6}	5.00×10^{6}	6.40×10^{6}	N
	0	32,000	57,000	79,000	100,000	850,000	3.80×10^{6}	1.10×10^{7}	1.30×10^{7}	1.90×10^{7}	NNE
	0	24,000	57,000	79,000	100,000	850,000	9.70×10^{6}	1.90×10^{7}	2.70×10^{7}	3.40×10^{7}	NE

	Distance (miles)										
Food Type	***0-1***	***1-2***	***2-3***	***3-4***	***4-5***	***5-10***	***10-20***	***20-30***	***30-40***	***40-50***	***Direction***
	0	0	40,000	76,000	100,000	1.20×10^{6}	1.10×10^{7}	1.90×10^{7}	2.70×10^{7}	3.40×10^{7}	ENE
	0	0	870	2,100	16.000	1.40×10^{6}	1.10×10^{7}	1.80×10^{7}	2.60×10^{7}	3.40×10^{7}	E
	0	0	870	680	870	960,000	9.90×10^{6}	1.60×10^{7}	1.80×10^{7}	1.80×10^{7}	ESE
	0	0	870	680	870	92,000	1.40×10^{6}	4.20×10^{6}	4.60×10^{6}	3.80×10^{6}	SE
	0	390	480	680	870	7,300	62,000	2.60×10^{6}	360,000	550,000	SSE
Meats	0	0	0	0	0	0	0	75,000	660,000	1.30×10^{6}	S
	0	0	0	0	0	0	0	63,000	320,000	550,000	SSW
	0	0	0	0	0	0	12,000	59,000	540,000	800,000	SW
	0	0	0	0	0	0	130,000	16,000	54,000	170,000	WSW
	0	0	0	0	0	1,100	180,000	440,000	1.10×10^{6}	1.30×10^{6}	W
	0	0	3,200	12,000	21,000	230,000	900,000	1.30×10^{6}	1.30×10^{6}	1.60×10^{6}	WNW
	0	0	21,000	24,000	31,000	260,000	1.00×10^{6}	1.60×10^{6}	1.50×10^{6}	1.60×10^{6}	NW
	0	0	26,000	24,000	31,000	260,000	1.00×10^{6}	1.60×10^{6}	1.30×10^{6}	1.60×10^{6}	NNW
	0	10,000	17,000	24,000	31,000	260,000	1.00×10^{6}	1.40×10^{6}	1.30×10^{6}	1.60×10^{6}	N
	0	9,800	17,000	24,000	31,000	260,000	1.10×10^{6}	1.70×10^{6}	1.90×10^{6}	2.60×10^{6}	NNE
	0	7,500	17,000	24,000	31,000	260,000	1.20×10^{6}	2.10×10^{6}	2.90×10^{6}	3.80×10^{6}	NE
	0	0	11,000	24,000	31,000	240,000	860,000	2.10×10^{6}	2.90×10^{6}	3.80×10^{6}	ENE
	0	0	0	440	4,800	100,000	470,000	840,000	1.50×10^{6}	2.20×10^{6}	E
	0	0	0	0	0	41,000	420,000	650,000	620,000	530,000	ESE
	0	0	0	0	0	3,600	58,000	21,000	540,000	3.00×10^{6}	SE
	0	0	0	0	0	0	0.000190	320,000	1.30×10^{6}	1.70×10^{6}	SSE
Poultry	0	0	0	0	0	0	0	0	0	0	S
	0	0	0	0	0	0	0	0	0	0	SSW
	0	0	0	0	0	0	0	0	0	0	SW
	0	0	0	0	0	0	0	0	0	0	WSW
	0	0	0	0	0	0	0	0	0	0	W
	0	0	0	0	0	0	0	0	0	0	WNW
	0	0	0	0	0	0	0	0	36.0	46.0	NW
Poultry (continued)	0	0	0	0	0	0	0	44.0	330	440	NNW
	0	0	0	0	0	0	0	110	340	440	N
	0	0	0	0	0	0	3.80	100	270	330	NNE
	0	0	0	0	0	0	54.0	110	160	210	NE
	0	0	0	0	0	1.10	47.0	110	160	210	ENE
	0	0	0	0	0	2.70	25.0	45.0	81.0	120	E
	0	0	0	0	0	2.20	23.0	49.0	110	180	ESE
	0	0	0	0	0	0.190	3.10	100	120	34.0	SE
	0	0	0	0	0	0	1.10	68.0	0.0750	0	SSE
Milk	0	0	0	0	0	0	0	820	7,200	15,000	S
	0	0	0	0	0	0	0	190	980	1,700	SSW
	0	0	0	0	0	0	0	140	1,700	2,500	SW
	0	0	0	0	0	0	0	0	150	740	WSW
	0	0	0	0	0	0	0	1,600	5,300	6,700	W
	0	0	9,600	37,000	64,000	710,000	2.70×10^{6}	2.90×10^{6}	6,300	8,100	WNW
	0	0	66,000	75,000	96,000	800,000	3.20×10^{6}	4.70×10^{6}	1.70×10^{6}	490,000	NW
	0	28,000	53,000	75,000	96,000	800,000	3.20×10^{6}	4.80×10^{6}	3.70×10^{6}	4.60×10^{6}	NNW
	0	31,000	53,000	75,000	96,000	800,000	3.20×10^{6}	4.00×10^{6}	3.60×10^{6}	4.60×10^{6}	N
	0	30,000	53,000	75,000	96,000	800,000	3.20×10^{6}	5.30×10^{6}	5.70×10^{6}	8.00×10^{6}	NNE
	0	23,000	53,000	75,000	96,000	800,000	3.80×10^{6}	6.60×10^{6}	9.20×10^{6}	1.20×10^{7}	NE
	0	0	38,000	72,000	96,000	710,000	2.50×10^{6}	6.40×10^{6}	9.20×10^{6}	1.20×10^{7}	ENE
	0	0	0	1,400	15,000	280,000	1.10×10^{6}	2.10×10^{6}	4.00×10^{6}	6.10×10^{6}	E
	0	0	0	0	0	97,000	1.00×10^{6}	1.60×10^{6}	1.50×10^{6}	1.30×10^{6}	ESE
	0	0	0	0	0	8,600	140,000	51,000	21,000	380,000	SE

Food Type	Distance (miles)										Direction
	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50	
	0	0	0	0	0	0	0	3,500	14,000	33,000	SSE
Eggs	0	25	31	44	56	470	1,900	3,000	2,800	2,500	S
	0	25	31	44	56	470	1,900	2,500	2,200	1,900	SSW
	0	25	31	44	56	470	1,100	26.0	110	170	SW
	0	25	31	44	56	470	200	0	12.0	65.0	WSW
	0	0	56.0	44	56	460	13.0	130	430	540	W
	0	0	51.0	22.0	19.0	44.0	0	160	510	650	WNW
	0	0	19.0	0	0	0	0	44.0	580	870	NW
	0	8.80	0	0	0	0	0	270	2,000	2,700	NNW
	0	6.90	0	0	0	0	0	700	2,100	2,700	N
	0	7.50	0	0	0	0	0	300	1,300	1,400	NNE
	0	12.0	0	0	0	0	0	0	0	0	NE
	0	0	34.0	1.70	0	0	0	0	0	0	ENE
	0	0	56.0	43.0	48.0	170	0	0	0	0	E
	0	0	56.0	44.0	56.0	310	0	0	0	0	ESE
	0	0	56.0	44.0	56.0	450	110	0	450	170	SE
	0	25.0	31.0	44.0	56.0	470	1,200	680	1,400	1,700	SSE

kg/yr = kilogram per year
Source: DOC 1993.

Table D–11 Rocky Flats 1994-1996 Joint Frequency Distributions at 10-m (33-ft) Height

Wind Speed (m/sec)	***Stability Class***	***Wind Blows Toward***															
		S	***SSW***	***SW***	***WSW***	***W***	***WNW***	***NW***	***NNW***	***N***	***NNE***	***NE***	***ENE***	***E***	***ESE***	***SE***	***SSE***
1.4	A	0.11	0.15	0.13	0.09	0.07	0.11	0.08	0.1	0.15	0.17	0.14	0.24	0.17	0.16	0.22	0.15
	B	0.03	0.01	0.02	0.02	0.06	0.02	0	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02
	C	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.03
	D	0.02	0.07	0.11	0.22	0.11	0.07	0.02	0.02	0.02	0.03	0.05	0.09	0	0.01	0.02	0.03
	E	0.05	0.09	0.09	0.2	0.07	0.07	0.02	0.06	0.05	0.06	0.05	0.02	0.02	0.03	0.03	0.01
	F	0.24	0.24	0.34	0.38	0.38	0.28	0.23	0.16	0.16	0.13	0.06	0.1	0.11	0.1	0.16	0.17
2.6	A	0.25	0.17	0.2	0.15	0.14	0.16	0.14	0.28	0.55	0.69	0.72	0.9	1.06	1.05	0.87	0.43
	B	0.11	0.06	0.1	0.07	0.05	0.05	0.06	0.08	0.36	0.36	0.22	0.2	0.22	0.31	0.36	0.18
	C	0.17	0.06	0.06	0.05	0.06	0.07	0.13	0.16	0.18	0.24	0.11	0.07	0.08	0.11	0.23	0.25
	D	0.44	0.67	0.71	0.87	0.92	0.56	0.31	0.33	0.33	0.34	0.31	0.3	0.18	0.11	0.31	0.37
	E	0.31	0.45	0.54	0.94	0.54	0.38	0.26	0.22	0.2	0.13	0.18	0.08	0.08	0.08	0.15	0.15
	F	0.43	0.51	0.45	0.47	0.55	0.64	0.59	0.51	0.47	0.33	0.24	0.26	0.22	0.34	0.33	0.45
4.4	A	0.01	0	0.01	0.01	0	0.02	0.01	0.03	0.01	0.01	0	0	0	0	0.01	0
	B	0.13	0.13	0.07	0.09	0.11	0.11	0.21	0.25	0.43	0.67	0.56	0.41	0.47	0.64	0.64	0.33
	C	0.17	0.09	0.14	0.09	0.17	0.17	0.29	0.41	0.91	0.52	0.39	0.29	0.24	0.45	0.6	0.57
	D	0.93	0.94	0.93	1.22	1.14	1.18	1.46	1.72	1.06	0.83	0.59	0.4	0.32	0.28	0.37	0.78
	E	0.43	0.49	0.56	0.74	0.37	0.51	0.65	0.37	0.15	0.17	0.14	0.13	0.08	0.02	0.05	0.13
	F	0.02	0.01	0.02	0.02	0.01	0.01	0.02	0.03	0.01	0	0.01	0	0	0	0	0
7	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0
	C	0.09	0.07	0.07	0.11	0.21	0.21	0.2	0.24	0.39	0.15	0.1	0.07	0.03	0.05	0.07	0.1
	D	0.67	0.55	0.84	1.34	1.84	2.7	1.41	1.18	1.02	0.6	0.23	0.11	0.08	0.08	0.11	0.53
	E	0.08	0.05	0.05	0.05	0.02	0.07	0.06	0.09	0	0.01	0.01	0	0	0	0	0.01
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9.8	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	0.13	0.15	0.18	0.62	1.26	2.22	0.44	0.17	0.16	0.14	0.02	0.01	0	0.01	0	0.11
	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	0.02	0.05	0.07	0.49	2.4	2.24	0.2	0.02	0.02	0.01	0	0	0	0	0	0.06
	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Source: KHC 1997b.

D.1.3.2 Radiological Impact Assessments at the Savannah River Site

This section presents the radiological impact input data used in the assessment of the various processing/ storage alternatives at the Savannah River Site. For purposes of radiological impact modeling, the Savannah River Site analyses used the assumption that either F-Area or H-Area could be the locations from which radioactive effluents would be released. **Table D–12** presents the characteristics of the release point, including location, release height, minimum distance, and annual average dispersion to the site boundary in each of 16 directions.

Table D–12 F-Area and H-Area Release Point Characteristics, Direction, Distance, and Atmospheric Dispersion at the Savannah River Site Boundary

Release Point	***F-Area***		***H-Area***	
Latitude	33.286°		33.286°	
Longitude	-81.676°		-81.640°	
Release Height	61 m		61 m	
Distance and Atmospheric Dispersion at Site Boundary				
Direction	***F-Area Distance (m)***	***÷/Q (sec/m³)***	***H-Area Distance (m)***	***÷/Q (sec/m³)***
N	10,898	1.6×10^{-8}	12,288	1.4×10^{-8}
NNE	12,665	1.1×10^{-8}	12,852	1.1×10^{-8}
NE	14,770	9.6×10^{-9}	14,883	9.5×10^{-9}
ENE	18,525	6.9×10^{-9}	15,959	8.4×10^{-9}
E	17,118	6.2×10^{-9}	14,047	8.0×10^{-9}
ESE	16,943	5.4×10^{-9}	13,688	7.1×10^{-9}
SE	19,771	3.0×10^{-9}	17,629	3.5×10^{-9}
SSE	18,933	2.6×10^{-9}	17,662	2.9×10^{-9}
S	18,516	1.7×10^{-9}	18,109	1.7×10^{-9}
SSW	15,467	5.9×10^{-9}	18,481	4.8×10^{-9}
SW	11,525	1.5×10^{-8}	14,355	1.1×10^{-8}
WSW	9,645	1.5×10^{-8}	14,212	8.8×10^{-9}
W	9,416	1.1×10^{-8}	12,763	7.2×10^{-9}
WNW	9,847	9.6×10^{-9}	12,643	7.1×10^{-9}
NW	9,448	1.3×10^{-8}	11,889	9.4×10^{-9}
NNW	9,972	1.6×10^{-8}	11,749	1.3×10^{-8}

÷/Q = Radioisotope concentrations divided by the rates at which they are emitted to the environment
sec/m^3 = second per cubic meter
Source: HNUS 1996, WSRC 1996a, PNL 1988.

Descriptions of population and foodstuff distributions centered on the F-Area are provided in **Table D–13** and **Table D–14**, respectively. Descriptions of population and foodstuff distributions centered on the H-Area are provided in **Tables D–15** and **D–16**, respectively. The joint frequency distribution used for the dose assessment (presented in **Table D–17**) was based on the meteorological measurements for 1987 through 1991 from the meteorological tower at the Savannah River Site at the 61-m (201-ft) height.

Table D–13 Savannah River Site (F-Area) Population Data Out to 80 km (50 mi) for Year 2000

Direction	*Distance (miles)*										*Total*
	0-1	*1-2*	*2-3*	*3-4*	*4-5*	*5-10*	*10-20*	*20-30*	*30-40*	*40-50*	
S	0	0	0	0	0	0	570	1,980	3,289	5,995	**11,834**
SSW	0	0	0	0	0	36	864	1,742	4,721	3,726	**11,089**
SW	0	0	0	0	0	80	1,170	7,477	1,818	6,516	**17,061**
WSW	0	0	0	0	0	183	3,242	3,465	3,510	8,317	**18,717**
W	0	0	0	0	0	297	7,168	39,152	18,993	22,459	**88,069**
WNW	0	0	0	0	0	2,020	9,675	186,036	47,704	7,923	**253,358**
NW	0	0	0	0	0	1,216	15,680	35,012	2,627	4,589	**59,124**
NNW	0	0	0	0	0	2,668	32,691	19,807	8,828	9,247	**73,241**
N	0	0	0	0	0	945	6,680	5,442	5,159	22,630	**40,856**
NNE	0	0	0	0	0	103	1,653	2,487	5,712	25,161	**35,116**
NE	0	0	0	0	0	0	2,922	3,516	5,486	12,551	**24,475**
ENE	0	0	0	0	0	0	2,811	5,675	7,700	38,820	**55,006**
E	0	0	0	0	0	0	5,776	5,167	7,094	6,563	**24,600**
ESE	0	0	0	0	0	0	917	3,896	4,870	8,845	**18,528**
SE	0	0	0	0	0	0	544	1,896	3,798	8,461	**14,699**
SSE	0	0	0	0	0	0	369	667	4,352	4,215	**9,603**
Total	**0**	**0**	**0**	**0**	**0**	**7,548**	**92,732**	**323,417**	**135,661**	**196,018**	**755,376**

Source: DOC 1992.

Table D–14 Savannah River Site (F-Area) Agricultural Data (kg/yr)

Food Type	*Distance (miles)*										*Direction*
	0-1	*1-2*	*2-3*	*3-4*	*4-5*	*5-10*	*10-20*	*20-30*	*30-40*	*40-50*	
Leafy Veg.	0	0	0	0	0	0	0	0	0	0	S
	0	0	0	0	0	0	0	0	0	0	SSW
	0	0	0	0	0	340,000	0	0	0	1,100	SW
	0	0	0	0	0	370	33.0	0	1,600	8,800	WSW
	0	0	0	0	0	1,300	130	0	2,800	4,100	W
	0	0	0	0	0	1,400	3,400	0	0	0	WNW
	0	0	0	0	0	1,400	6,300	4,700	0	0	NW
	0	0	0	0	0	1,300	6,900	8,700	8.60	2,400	NNW
	0	0	0	0	0	1,100	6,900	12,000	11,000	48,000	N
	0	0	0	0	0	590	6,900	12,000	310,000	960,000	NNE
	0	0	0	0	0	46.0	6,000	31,000	250,000	770,000	NE
	0	0	0	0	0	0	7.60	32,000	160,000	210,000	ENE
	0	0	0	0	0	0	0	0	23,000	130,000	E
	0	0	0	0	0	0	0	0	0	0	ESE
	0	0	0	0	0	0	0	0	0	0	SE
	0	0	0	0	0	0	0	0	0	0	SSE
Root Veg.	0	0	0	0	0	0	1.80×10^{6}	3.10×10^{6}	4.10×10^{6}	6.30×10^{6}	S
	0	0	0	0	0	3,100	2.10×10^{6}	3.40×10^{6}	4.30×10^{6}	6.70×10^{6}	SSW
	0	0	0	0	0	9.70×10^{7}	2.20×10^{6}	3.60×10^{6}	4.80×10^{6}	5.80×10^{6}	SW
	0	0	0	0	0	110,000	2.10×10^{6}	3.60×10^{6}	5.30×10^{6}	8.00×10^{6}	WSW
	0	0	0	0	0	180,000	230,000	1.30×10^{6}	3.40×10^{6}	4.40×10^{6}	W
	0	0	0	0	0	190,000	500,000	110,000	54,000	320,000	WNW
	0	0	0	0	0	200,000	880,000	820,000	400,000	140,000	NW
	0	0	0	0	0	190,000	960,000	1.30×10^{6}	730,000	1.20×10^{6}	NNW

	Distance (miles)										
Food Type	***0-1***	***1-2***	***2-3***	***3-4***	***4-5***	***5-10***	***10-20***	***20-30***	***30-40***	***40-50***	***Direction***
Root Veg. (continued)	0	0	0	0	0	150,000	960,000	1.60×10^{6}	1.70×10^{6}	2.40×10^{6}	N
	0	0	0	0	0	81,000	960,000	1.60×10^{6}	2.50×10^{6}	3.80×10^{6}	NNE
	0	0	0	0	0	6,300	1.20×10^{6}	2.60×10^{6}	4.20×10^{6}	5.10×10^{6}	NE
	0	0	0	0	0	0	3.40×10^{6}	6.30×10^{6}	7.80×10^{6}	9.90×10^{6}	ENE
	0	0	0	0	0	0	3.60×10^{6}	6.30×10^{6}	7.90×10^{6}	1.00×10^{7}	E
	0	0	0	0	0	0	3.30×10^{6}	6.60×10^{6}	8.40×10^{6}	5.30×10^{6}	ESE
	0	0	0	0	0	0	6.40×10^{7}	6.80×10^{6}	8.80×10^{6}	9.20×10^{6}	SE
	0	0	0	0	0	0	3.80×10^{7}	3.00×10^{7}	6.70×10^{6}	7.80×10^{6}	SSE
Fruits	0	0	0	0	0	0	390,000	1.10×10^{6}	1.70×10^{6}	2.50×10^{6}	S
	0	0	0	0	0	690	450,000	870,000	1.40×10^{6}	2.30×10^{6}	SSW
	0	0	0	0	0	3.30×10^{7}	480,000	790,000	1.20×10^{6}	1.20×10^{6}	SW
	0	0	0	0	0	44,000	470,000	790,000	1.00×10^{6}	880,000	WSW
	0	0	0	0	0	110,000	45,000	270,000	440,000	390,000	W
	0	0	0	0	0	120,000	280,000	1,100	230	1,300	WNW
	0	0	0	0	0	120,000	530,000	2.80×10^{6}	6.60×10^{6}	2.20×10^{6}	NW
	0	0	0	0	0	110,000	580,000	2.80×10^{6}	1.20×10^{7}	1.40×10^{7}	NNW
	0	0	0	0	0	90,000	580,000	970,000	5.10×10^{6}	4.80×10^{6}	N
	0	0	0	0	0	49,000	580,000	970,000	1.00×10^{6}	740,000	NNE
	0	0	0	0	0	3,900	530,000	890,000	1.00×10^{6}	750,000	NE
	0	0	0	0	0	0	250,000	490,000	850,000	1.10×10^{6}	ENE
	0	0	0	0	0	0	260,000	340,000	160,000	700,000	E
	0	0	0	0	0	0	240,000	400,000	180,000	56,000	ESE
	0	0	0	0	0	0	4.30×10^{6}	310,000	370,000	310,000	SE
	0	0	0	0	0	0	2.60×10^{6}	2.00×10^{6}	1.10×10^{6}	1.00×10^{6}	SSE
Grains	0	0	0	0	0	0	2.60×10^{6}	7.40×10^{6}	1.10×10^{7}	1.50×10^{7}	S
	0	0	0	0	0	4,500	2.90×10^{6}	6.00×10^{6}	1.10×10^{7}	1.40×10^{7}	SSW
	0	0	0	0	0	1.10×10^{8}	3.10×10^{6}	5.10×10^{6}	8.20×10^{6}	1.00×10^{7}	SW
	0	0	0	0	0	140,000	3.00×10^{6}	5.10×10^{6}	8.10×10^{6}	1.50×10^{7}	WSW
	0	0	0	0	0	210,000	640,000	2.20×10^{6}	6.10×10^{6}	7.90×10^{6}	W
	0	0	0	0	0	220,000	760,000	720,000	260,000	650,000	WNW
	0	0	0	0	0	220,000	1.00×10^{6}	1.20×10^{6}	750,000	330,000	NW
	0	0	0	0	0	210,000	1.10×10^{6}	1.60×10^{6}	1.30×10^{6}	2.00×10^{6}	NNW
	0	0	0	0	0	170,000	1.10×10^{6}	1.80×10^{6}	2.30×10^{6}	4.10×10^{6}	N
	0	0	0	0	0	93,000	1.10×10^{6}	1.80×10^{6}	2.70×10^{6}	3.60×10^{6}	NNE
	0	0	0	0	0	7,300	1.30×10^{6}	3.60×10^{6}	6.10×10^{6}	6.90×10^{6}	NE
	0	0	0	0	0	0	4.00×10^{6}	8.70×10^{6}	1.40×10^{7}	1.80×10^{7}	ENE
	0	0	0	0	0	0	4.20×10^{6}	9.00×10^{6}	1.60×10^{7}	1.90×10^{7}	E
	0	0	0	0	0	0	3.90×10^{6}	8.90×10^{6}	1.60×10^{7}	1.20×10^{7}	ESE
	0	0	0	0	0	0	8.20×10^{7}	1.10×10^{7}	1.50×10^{7}	1.70×10^{7}	SE
	0	0	0	0	0	0	5.20×10^{7}	5.20×10^{7}	1.30×10^{7}	1.60×10^{7}	SSE
Beef	0	0	0	0	0	0	120,000	460,000	730,000	990,000	S
	0	0	0	0	0	220	150,000	340,000	690,000	930,000	SSW
	0	0	0	0	0	6.00×10^{6}	150,000	250,000	460,000	610,000	SW
	0	0	0	0	0	10,000	150,000	250,000	410,000	790,000	WSW
	0	0	0	0	0	21,000	40,000	120,000	340,000	510,000	W
	0	0	0	0	0	22,000	70,000	50,000	95,000	180,000	WNW
	0	0	0	0	0	23,000	110,000	140,000	160,000	210,000	NW
	0	0	0	0	0	22,000	110,000	180,000	230,000	350,000	NNW
	0	0	0	0	0	17,000	110,000	190,000	310,000	650,000	N
	0	0	0	0	0	9,600	110,000	190,000	250,000	290,000	NNE

	Distance (miles)										
Food Type	***0-1***	***1-2***	***2-3***	***3-4***	***4-5***	***5-10***	***10-20***	***20-30***	***30-40***	***40-50***	***Direction***
Beef (continued)	0	0	0	0	0	750	100,000	260,000	430,000	500,000	NE
	0	0	0	0	0	0	24,000	220,000	820,000	1.10×10^6	ENE
	0	0	0	0	0	0	26,000	140,000	520,000	880,000	E
	0	0	0	0	0	0	24,000	82,000	340,000	450,000	ESE
	0	0	0	0	0	0	480,000	64,000	200,000	520,000	SE
	0	0	0	0	0	0	360,000	580,000	430,000	670,000	SSE
Poultry	0	0	0	0	0	0	0	0	0	54,000	S
	0	0	0	0	0	0	0	0	0	67,000	SSW
	0	0	0	0	0	4.70×10^7	0	0	0	45.0	SW
	0	0	0	0	0	51,000	4,500	0	61.0	350	WSW
	0	0	0	0	0	170,000	18,000	0	110	160	W
	0	0	0	0	0	190,000	460,000	0	0	5,100	WNW
	0	0	0	0	0	190,000	860,000	640,000	0	300,000	NW
	0	0	0	0	0	180,000	940,000	1.20×10^6	1,200	540,000	NNW
	0	0	0	0	0	150,000	940,000	1.60×10^6	1.70×10^6	3.60×10^6	N
	0	0	0	0	0	80,000	940,000	1.60×10^6	1.30×10^6	5,400	NNE
	0	0	0	0	0	6,300	820,000	1.20×10^6	970,000	0	NE
	0	0	0	0	0	0	1,100	0	0	0	ENE
	0	0	0	0	0	0	0	0	0	0	E
	0	0	0	0	0	0	0	0	0	0	ESE
	0	0	0	0	0	0	0	0	0	0	SE
	0	0	0	0	0	0	0	0	0	0	SSE
Milk	0	0	0	0	0	0	550,000	620,000	650,000	760,000	S
	0	0	0	0	0	970	640,000	2.90×10^6	7.90×10^6	8.10×10^6	SSW
	0	0	0	0	0	3.20×10^6	670,000	1.10×10^6	3.80×10^6	2.90×10^6	SW
	0	0	0	0	0	22,000	660,000	1.10×10^6	2.00×10^6	4.40×10^6	WSW
	0	0	0	0	0	12,000	49,000	380,000	1.80×10^6	3.50×10^6	W
	0	0	0	0	0	13,000	31,000	0	47,000	1.20×10^6	WNW
	0	0	0	0	0	13,000	58,000	440,000	1.10×10^6	790,000	NW
	0	0	0	0	0	12,000	64,000	430,000	2.00×10^6	3.30×10^6	NNW
	0	0	0	0	0	9,900	64,000	110,000	1.90×10^6	7.40×10^6	N
	0	0	0	0	0	5,400	64,000	110,000	390,000	970,000	NNE
	0	0	0	0	0	420	55,000	690,000	1.70×10^6	1.80×10^6	NE
	0	0	0	0	0	0	70.0	1.10×10^6	4.60×10^6	5.60×10^6	ENE
	0	0	0	0	0	0	0	960,000	4.20×10^6	5.70×10^6	E
	0	0	0	0	0	0	0	320,000	2.60×10^6	1.60×10^6	ESE
	0	0	0	0	0	0	24,000	12,000	42,000	120,000	SE
	0	0	0	0	0	0	200,000	320,000	350,000	390,000	SSE
Eggs	0	0	0	0	0	0	630	0	0	83,000	S
	0	0	0	0	0	0	0	0	0	100,000	SSW
	0	0	0	0	0	620,000	0	0	0	91.0	SW
	0	0	0	0	0	0	0	0	120	700	WSW
	0	0	0	0	0	0	0	0	220	330	W
	0	0	0	0	0	0	0	0	0	0	WNW
	0	0	0	0	0	0	0	120,000	320,000	110,000	NW
	0	0	0	0	0	0	0	100,000	590,000	640,000	NNW
	0	0	0	0	0	0	0	0	170,000	29.0	N
	0	0	0	0	0	0	0	0	0	0	NNE
	0	0	0	0	0	0	4,100	4,000	160	120	NE
Eggs (continued)	0	0	0	0	0	0	43,000	55,000	500	630	ENE
	0	0	0	0	0	0	45,000	56,000	71.0	400	E

Food Type	*Distance (miles)*										Direction
	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50	
	0	0	0	0	0	0	42,000	58,000	120	0	ESE
	0	0	0	0	0	0	630,000	1,200	0	0	SE
	0	0	0	0	0	0	310,000	0	0	0	SSE

kg/yr = kilogram per year
Source: HNUS 1996.

Table D–15 Savannah River Site (H-Area) Population Data Out to 80 km (50 mi) for Year 2000

Direction	*Distance (miles)*										Total
	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50	
S	0	0	0	0	0	0	480	1,800	5,200	3,500	**10,980**
SSW	0	0	0	0	0	0	620	1,900	5,100	2,400	**10,020**
SW	0	0	0	0	0	25	880	7,500	1,900	2,900	**13,205**
WSW	0	0	0	0	0	66	2,300	4,400	3,300	8,200	**18,266**
W	0	0	0	0	0	630	4,300	52,000	21,000	13,000	**90,930**
WNW	0	0	0	0	0	1,300	7,300	160,000	72,000	6,500	**247,100**
NW	0	0	0	0	0	950	13,000	32,000	3,900	3,500	**53,350**
NNW	0	0	0	0	0	2,500	28,000	22,000	8,000	6,100	**66,600**
N	0	0	0	0	0	330	3,700	3,500	4,500	19,000	**31,030**
NNE	0	0	0	0	0	82	1,600	2,800	6,000	20,000	**30,482**
NE	0	0	0	0	0	14	3,600	3,500	6,000	9,400	**22,514**
ENE	0	0	0	0	0	9	3,600	6,100	6,900	42,000	**58,609**
E	0	0	0	0	0	110	7,400	3,800	6,800	4,000	**22,110**
ESE	0	0	0	0	0	3	1,300	2,500	3,500	5,700	**13,003**
SE	0	0	0	0	0	0	540	4,800	4,800	8,100	**18,240**
SSE	0	0	0	0	0	0	370	590	1,900	2,700	**5,560**
Total	**0**	**0**	**0**	**0**	**0**	**6,019**	**78,990**	**309,190**	**160,800**	**157,000**	**711,999**

Source: DOC 1992.

Table D–16 Savannah River Site (H-Area) Agricultural Data (kg/yr)

Food Type	*Distance (miles)*										Direction
	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50	
Leafy Veg.	0	0	0	0	0	0	0	0	0	0	S
	0	0	0	0	0	0	0	0	0	0	SSW
	0	0	0	0	0	120,000	0	0	0	430	SW
	0	0	0	0	0	110,000	110,000	0	560	7,900	WSW
	0	0	0	0	0	750	1,100	0	1,800	4,800	W
	0	0	0	0	0	730	5,200	0	0	0	WNW
	0	0	0	0	0	990	6,800	7,100	0	0	NW
	0	0	0	0	0	1,000	6,900	10,000	450	4,000	NNW
	0	0	0	0	0	850	6,900	12,000	30,000	150,000	N
	0	0	0	0	0	610	6,900	12,000	410,000	960,000	NNE

	Distance (miles)										
Food Type	***0-1***	***1-2***	***2-3***	***3-4***	***4-5***	***5-10***	***10-20***	***20-30***	***30-40***	***40-50***	***Direction***
Leafy Veg. (continued)	0	0	0	0	0	110	4,700	47,000	290,000	700,000	NE
	0	0	0	0	0	0	0	44,000	170,000	200,000	ENE
	0	0	0	0	0	0	0	0	35,000	150,000	E
	0	0	0	0	0	0	0	0	0	0	ESE
	0	0	0	0	0	0	0	0	0	0	SE
	0	0	0	0	0	0	0	0	0	0	SSE
Root Veg.	0	0	0	0	0	0	1.4×10^{7}	3.0×10^{6}	4.1×10^{6}	5.8×10^{6}	S
	0	0	0	0	0	0	1.8×10^{6}	3.4×10^{6}	4.3×10^{6}	6.9×10^{6}	SSW
	0	0	0	0	0	4.2×10^{7}	2.7×10^{7}	3.6×10^{6}	4.8×10^{6}	5.8×10^{6}	SW
	0	0	0	0	0	1.5×10^{7}	1.8×10^{7}	3.6×10^{6}	5.1×10^{6}	7.9×10^{6}	WSW
	0	0	0	0	0	100,000	420,000	950,000	3.1×10^{6}	4.8×10^{6}	W
	0	0	0	0	0	100,000	740,000	110,000	58,000	220,000	WNW
	0	0	0	0	0	140,000	950,000	1.1×10^{6}	490,000	280,000	NW
	0	0	0	0	0	140,000	960,000	1.5×10^{6}	770,000	1.3×10^{6}	NNW
	0	0	0	0	0	120,000	960,000	1.6×10^{6}	1.9×10^{6}	2.6×10^{6}	N
	0	0	0	0	0	85,000	960,000	1.6×10^{6}	2.6×10^{6}	3.8×10^{6}	NNE
	0	0	0	0	0	16,000	1.9×10^{6}	3.2×10^{6}	4.8×10^{6}	5.3×10^{6}	NE
	0	0	0	0	0	3,300	4.0×10^{6}	6.1×10^{6}	7.8×10^{6}	9.8×10^{6}	ENE
	0	0	0	0	0	170,000	4.0×10^{6}	6.1×10^{6}	7.9×10^{6}	1.0×10^{7}	E
	0	0	0	0	0	130,000	3.9×10^{6}	6.5×10^{6}	7.9×10^{6}	4.1×10^{6}	ESE
	0	0	0	0	0	0	3.4×10^{7}	6.8×10^{6}	8.3×10^{6}	9.0×10^{6}	SE
	0	0	0	0	0	0	8.3×10^{7}	5.4×10^{6}	7.4×10^{6}	8.2×10^{6}	SSE
Fruits	0	0	0	0	0	0	1.3×10^{6}	1.1×10^{6}	1.7×10^{6}	2.3×10^{6}	S
	0	0	0	0	0	0	410,000	880,000	1.4×10^{6}	2.4×10^{6}	SSW
	0	0	0	0	0	1.2×10^{7}	2.3×10^{6}	790,000	1.2×10^{6}	1.3×10^{6}	SW
	0	0	0	0	0	8.9×10^{6}	1.0×10^{7}	790,000	1.1×10^{6}	930,000	WSW
	0	0	0	0	0	63,000	140,000	190,000	480,000	460,000	W
	0	0	0	0	0	62,000	440,000	1,100	360	840	WNW
	0	0	0	0	0	83,000	580,000	2.4×10^{6}	8.2×10^{6}	4.6×10^{6}	NW
	0	0	0	0	0	84,000	580,000	1.8×10^{6}	1.2×10^{7}	1.3×10^{7}	NNW
	0	0	0	0	0	71,000	580,000	970,000	3.6×10^{6}	4.4×10^{6}	N
	0	0	0	0	0	52,000	580,000	970,000	930,000	730,000	NNE
	0	0	0	0	0	9,100	490,000	830,000	940,000	690,000	NE
	0	0	0	0	0	240	290,000	470,000	880,000	1.0×10^{6}	ENE
	0	0	0	0	0	13,000	290,000	240,000	220,000	810,000	E
	0	0	0	0	0	9,800	290,000	340,000	130,000	28,000	ESE
	0	0	0	0	0	0	2.3×10^{6}	310,000	330,000	300,000	SE
	0	0	0	0	0	0	4.9×10^{6}	640,000	890,000	790,000	SSE
Grains	0	0	0	0	0	0	1.7×10^{7}	7.7×10^{6}	1.1×10^{7}	1.5×10^{7}	S
	0	0	0	0	0	0	2.6×10^{6}	6.0×10^{6}	1.1×10^{7}	1.5×10^{7}	SSW
	0	0	0	0	0	4.9×10^{7}	3.2×10^{7}	5.1×10^{6}	8.4×10^{6}	1.0×10^{7}	SW
	0	0	0	0	0	1.7×10^{7}	2.1×10^{7}	5.1×10^{6}	7.5×10^{6}	1.4×10^{7}	WSW
	0	0	0	0	0	120,000	820,000	1.8×10^{6}	5.4×10^{6}	8.7×10^{6}	W
	0	0	0	0	0	120,000	930,000	740,000	350,000	490,000	WNW
	0	0	0	0	0	160,000	1.1×10^{6}	1.5×10^{6}	910,000	560,000	NW
	0	0	0	0	0	160,000	1.1×10^{6}	1.7×10^{6}	1.4×10^{6}	2.3×10^{6}	NNW

Food Type	***Distance (miles)***										**Direction**
	0-1	***1-2***	***2-3***	***3-4***	***4-5***	***5-10***	***10-20***	***20-30***	***30-40***	***40-50***	
Grains (continued)	0	0	0	0	0	130,000	1.1×10^{6}	1.8×10^{6}	2.5×10^{6}	4.1×10^{6}	N
	0	0	0	0	0	98,000	1.1×10^{6}	1.8×10^{6}	2.7×10^{6}	3.6×10^{6}	NNE
	0	0	0	0	0	18,000	2.2×10^{6}	4.8×10^{6}	7.2×10^{6}	7.8×10^{6}	NE
	0	0	0	0	0	3,900	4.7×10^{6}	9.1×10^{6}	1.4×10^{7}	1.8×10^{7}	ENE
	0	0	0	0	0	200,000	4.7×10^{6}	9.8×10^{6}	1.6×10^{7}	1.8×10^{7}	E
	0	0	0	0	0	160,000	4.6×10^{6}	9.5×10^{6}	1.5×10^{7}	1.0×10^{7}	ESE
	0	0	0	0	0	0	4.4×10^{7}	1.1×10^{7}	1.4×10^{7}	1.7×10^{7}	SE
	0	0	0	0	0	0	1.2×10^{8}	1.0×10^{7}	1.4×10^{7}	1.6×10^{7}	SSE
Beef	0	0	0	0	0	0	210,000	490,000	730,000	960,000	S
	0	0	0	0	0	0	130,000	340,000	700,000	960,000	SSW
	0	0	0	0	0	2.2×10^{7}	320,000	250,000	480,000	620,000	SW
	0	0	0	0	0	1.7×10^{7}	2.0×10^{6}	250,000	380,000	760,000	WSW
	0	0	0	0	0	100,000	55,000	98,000	290,000	540,000	W
	0	0	0	0	0	100,000	92,000	49,000	90,000	160,000	WNW
	0	0	0	0	0	140,000	110,000	160,000	180,000	210,000	NW
	0	0	0	0	0	140,000	110,000	190,000	230,000	390,000	NNW
	0	0	0	0	0	120,000	110,000	190,000	300,000	610,000	N
	0	0	0	0	0	84,000	110,000	190,000	240,000	290,000	NNE
	0	0	0	0	0	1,800	86,000	310,000	490,000	570,000	NE
	0	0	0	0	0	23	28,000	290,000	830,000	1.1×10^{6}	ENE
	0	0	0	0	0	1,200	28,000	210,000	540,000	920,000	E
	0	0	0	0	0	950	28,000	120,000	380,000	410,000	ESE
	0	0	0	0	0	0	260,000	64,000	260,000	510,000	SE
	0	0	0	0	0	0	730,000	240,000	350,000	630,000	SSE
Poultry	0	0	0	0	0	0	0	0	0	26,000	S
	0	0	0	0	0	0	0	0	0	76,000	SSW
	0	0	0	0	0	1.7×10^{7}	0	0	0	17	SW
	0	0	0	0	0	1.4×10^{7}	1.6×10^{7}	0	22	310	WSW
	0	0	0	0	0	100,000	150,000	0	71	190	W
	0	0	0	0	0	100,000	710,000	0	0	300	WNW
	0	0	0	0	0	140,000	940,000	980,000	0	180,000	NW
	0	0	0	0	0	140,000	940,000	1.4×10^{6}	66,000	890,000	NNW
	0	0	0	0	0	120,000	940,000	1.6×10^{6}	1.9×10^{6}	3.1×10^{6}	N
	0	0	0	0	0	84,000	940,000	1.6×10^{6}	1.0×10^{6}	0	NNE
	0	0	0	0	0	15,000	640,000	970,000	660,000	0	NE
	0	0	0	0	0	0	0	0	0	0	ENE
	0	0	0	0	0	0	0	0	0	0	E
	0	0	0	0	0	0	0	0	0	0	ESE
	0	0	0	0	0	0	0	0	0	0	SE
	0	0	0	0	0	0	0	0	0	0	SSE
Milk	0	0	0	0	0	0	480,000	540,000	650,000	800,000	S
	0	0	0	0	0	0	580,000	2.5×10^{6}	6.7×10^{6}	7.7×10^{6}	SSW
	0	0	0	0	0	1.1×10^{6}	640,000	1.1×10^{6}	4.3×10^{6}	4.0×10^{6}	SW
	0	0	0	0	0	980,000	1.7×10^{6}	1.1×10^{6}	1.7×10^{6}	4.2×10^{6}	WSW
	0	0	0	0	0	6,900	80,000	270,000	1.4×10^{6}	3.7×10^{6}	W
	0	0	0	0	0	6,700	48,000	0	0	810,000	WNW

Food Type	***Distance (miles)***										***Direction***
	0-1	***1-2***	***2-3***	***3-4***	***4-5***	***5-10***	***10-20***	***20-30***	***30-40***	***40-50***	
Milk (continued)	0	0	0	0	0	9,100	63,000	370,000	1.4×10^6	1.0×10^6	NW
	0	0	0	0	0	9,200	64,000	250,000	2.0×10^6	3.8×10^6	NNW
	0	0	0	0	0	7,800	64,000	110,000	1.6×10^6	6.6×10^6	N
	0	0	0	0	0	5,700	64,000	110,000	470,000	960,000	NNE
	0	0	0	0	0	990	43,000	1.2×10^6	2.2×10^6	1.7×10^6	NE
	0	0	0	0	0	0	0	1.6×10^6	4.7×10^6	5.4×10^6	ENE
	0	0	0	0	0	0	0	1.6×10^6	4.2×10^6	5.7×10^6	E
	0	0	0	0	0	0	0	740,000	2.8×10^6	1.1×10^6	ESE
	0	0	0	0	0	0	14,000	12,000	56,000	110,000	SE
	0	0	0	0	0	0	150,000	180,000	260,000	310,000	SSE
Eggs	0	0	0	0	0	0	150,000	0	0	40,000	S
	0	0	0	0	0	0	0	0	0	120,000	SSW
	0	0	0	0	0	310,000	310,000	0	0	35	SW
	0	0	0	0	0	0	0	0	45	630	WSW
	0	0	0	0	0	0	0	0	140	380	W
	0	0	0	0	0	0	0	0	0	0	WNW
	0	0	0	0	0	0	0	87,000	390,000	220,000	NW
	0	0	0	0	0	0	0	44,000	570,000	570,000	NNW
	0	0	0	0	0	0	0	0	98,000	0	N
	0	0	0	0	0	0	0	0	0	0	NNE
	0	0	0	0	0	9.4	16,000	4,600	220	110	NE
	0	0	0	0	0	41	50,000	41,000	520	600	ENE
	0	0	0	0	0	2,200	50,000	38,000	110	470	E
	0	0	0	0	0	1,700	49,000	44,000	0	0	ESE
	0	0	0	0	0	0	330,000	1,900	0	0	SE
	0	0	0	0	0	0	480,000	0	0	0	SSE

kg/yr = kilogram per year
Source: HNUS 1996

Table D–17 Savannah River Site Meteorological Data (Joint Frequency Distributions) 1987-1991 at 61-m (201-ft) Height

Wind Speed (m/sec)	*Stability Class*	*Wind Blows Toward*															
		S	***SSW***	***SW***	***WSW***	***W***	***WNW***	***NW***	***NNW***	***N***	***NNE***	***NE***	***ENE***	***E***	***ESE***	***SE***	***SSE***
2	A	0.37	0.41	0.37	0.42	0.4	0.37	0.4	0.36	0.36	0.35	0.45	0.39	0.45	0.43	0.37	0.41
	B	0.08	0.08	0.09	0.1	0.05	0.06	0.06	0.05	0.08	0.07	0.05	0.05	0.05	0.08	0.05	0.07
	C	0.03	0.06	0.09	0.07	0.06	0.05	0.06	0.05	0.07	0.05	0.06	0.05	0.08	0.05	0.05	0.05
	D	0.02	0.05	0.06	0.04	0.06	0.03	0.06	0.07	0.06	0.03	0.07	0.05	0.04	0.03	0.05	0.04
	E	0.01	0.02	0.04	0.01	0.01	0.03	0.03	0.03	0.02	0.02	0.01	0.01	0.02	0.01	0.02	0.02
	F	0	0.01	0.01	0.01	0.01	0.01	0	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01
4	A	0.87	0.74	0.88	1	0.94	0.94	0.65	0.62	0.74	0.72	1	1.28	1.29	0.94	0.53	0.6
	B	0.27	0.41	0.58	0.62	0.43	0.34	0.24	0.22	0.32	0.33	0.48	0.67	0.56	0.37	0.25	0.21
	C	0.17	0.57	1.13	1.03	0.6	0.41	0.41	0.37	0.48	0.52	0.59	0.79	0.53	0.45	0.3	0.24
	D	0.1	0.44	1.07	0.89	0.55	0.5	0.71	0.69	0.92	0.91	0.8	0.81	0.72	0.57	0.43	0.27
	E	0.06	0.27	0.69	0.48	0.3	0.33	0.46	0.7	0.67	0.57	0.54	0.47	0.43	0.43	0.33	0.3
	F	0.02	0.05	0.09	0.04	0.02	0.08	0.09	0.09	0.11	0.08	0.12	0.09	0.03	0.05	0.05	0.07
6	A	0.57	0.26	0.16	0.19	0.15	0.07	0.07	0.09	0.14	0.14	0.21	0.24	0.27	0.24	0.14	0.24
	B	0.14	0.39	0.38	0.31	0.16	0.11	0.07	0.08	0.19	0.21	0.32	0.51	0.51	0.36	0.13	0.09
	C	0.12	0.54	1.3	0.74	0.35	0.19	0.22	0.25	0.47	0.46	0.56	0.69	0.64	0.56	0.21	0.12
	D	0.12	0.43	0.85	0.58	0.4	0.44	0.65	1.16	1.45	0.78	0.9	0.77	0.78	0.65	0.32	0.09
	E	0.07	0.53	0.69	0.71	0.6	0.45	0.65	1.01	1.18	0.94	0.91	0.89	0.48	0.4	0.19	0.14
	F	0.01	0.26	0.21	0.14	0.14	0.19	0.13	0.16	0.22	0.21	0.24	0.23	0.07	0.04	0.02	0.04
8	A	0.09	0.05	0.01	0.01	0.01	0	0.01	0.01	0.02	0.02	0.02	0.04	0.03	0.02	0.01	0.06
	B	0.01	0.08	0.03	0.01	0.01	0.01	0	0.01	0.05	0.04	0.05	0.1	0.17	0.21	0.06	0.01
	C	0.01	0.1	0.2	0.08	0.02	0.03	0.03	0.06	0.16	0.16	0.21	0.26	0.45	0.43	0.1	0.02
	D	0.01	0.05	0.1	0.02	0.01	0.01	0.05	0.18	0.22	0.15	0.1	0.09	0.03	0.05	0.03	0
	E	0	0.05	0.03	0.04	0.01	0.01	0	0.03	0.04	0.02	0.04	0.01	0.01	0	0	0
	F	0	0.03	0.02	0.02	0	0.01	0	0.01	0.02	0.01	0.02	0.01	0	0	0	0
12	A	0.01	0	0	0	0	0	0	0	0	0.01	0.01	0.01	0	0.01	0	0.01
	B	0	0.01	0	0	0	0	0	0	0	0	0.01	0.01	0.06	0.06	0.01	0
	C	0	0.01	0	0	0	0.01	0	0.03	0.04	0.04	0.05	0.06	0.16	0.17	0.02	0.01
	D	0	0.02	0.02	0	0	0	0	0.01	0.02	0.04	0	0	0.01	0	0	0
	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14.1	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Source: WSRC 1996a.

D.1.3.3 Radiological Impact Assessments at Los Alamos National Laboratory

This section presents the radiological impact input data used in the assessment of the processing/storage alternatives at Los Alamos National Laboratory. For purposes of radiological impact modeling, Los Alamos National Laboratory analyses used the assumption that Technical Area 55 would be the location from which radioactive effluents would be released. **Table D–18** presents the characteristics of the release point, including location, release height, minimum distance, and annual average dispersion to the site boundary in each of 16 directions.

Table D–18 Release Point Characteristics, Direction, Distance, and Atmospheric Dispersion at the Los Alamos National Laboratory Site Boundary

Release Location	***Technical Area 55***	
Latitude	35.876°	
Longitude	-106.292°	
Release Height	11.2 m	
Distance and Atmospheric Dispersion at Site Boundary		
Direction	***Distance (m)***	***÷/Q (sec/m³)***
N	1,000 [a]	2.5×10^{-6}
NNE	1,390	1.9×10^{-6}
NE	1,760	1.2×10^{-6}
ENE	2,800	4.8×10^{-7}
E	2,680	5.3×10^{-7}
ESE	1,680	9.6×10^{-7}
SE	6,420	1.1×10^{-7}
SSE	4,980	1.8×10^{-7}
S	3,350	3.7×10^{-7}
SSW	3,050	3.8×10^{-7}
SW	3,280	2.8×10^{-7}
WSW	3,430	2.0×10^{-7}
W	3,220	2.0×10^{-7}
WNW	2,600	2.1×10^{-7}
NW	2,000	3.4×10^{-7}
NNW	1,460	8.4×10^{-7}

÷/Q = Radioisotope concentrations divided by the rates at which they are emitted to the environment
sec/m^3 = second per cubic meter
[a] Nearest resident is present at this location (trailer court); this location is on private property that is surrounded by the site.
Source: LANL 1994, PNL 1988.

Descriptions of population and foodstuff distributions centered on Technical Area 55 are provided in **Table D–19** and **Table D–20**, respectively. The joint frequency distribution used for the dose assessment (presented in **Table D–21**) was based on the meteorological measurements for 1993 through 1996 from the meteorological tower at Los Alamos National Laboratory at the 11-m (36-ft) height.

Table D–19 Los Alamos National Laboratory Site Population Data Out to 80 km (50 mi) for Year 2000

	Distance (miles)										
Direction	***0-1***	***1-2***	***2-3***	***3-4***	***4-5***	***5-10***	***10-20***	***20-30***	***30-40***	***40-50***	***Total***
S	0	0	26	20	29	143	711	1,940	1,121	2,422	**6,412**
SSW	0	0	26	24	77	41	884	3,681	3,505	50,614	**58,852**
SW	0	0	26	22	76	114	51	1,237	856	10,074	**12,456**
WSW	0	0	26	32	96	317	256	1,065	1,784	43	**3,619**
W	0	0	47	78	117	163	201	682	85	531	**1,904**
WNW	0	507	65	89	116	195	63	123	2,293	393	**3,844**
NW	0	1,485	1,327	79	103	372	95	186	236	241	**4,124**
NNW	0	1,428	102	79	101	175	127	161	166	216	**2,555**
N	500	545	73	96	127	308	388	611	480	250	**3,378**
NNE	0	419	76	106	136	481	684	709	573	138	**3,322**
NE	0	521	76	95	66	419	5,769	3,046	1,348	2,425	**13,765**
ENE	0	717	142	24	20	275	17,189	3,811	3,049	2,436	**27,663**
E	0	543	415	15	20	444	4,970	774	764	1,105	**9,050**
ESE	0	119	31	15	20	171	1,045	3,520	396	659	**5,976**
SE	0	0	0	0	54	5,524	1,028	76,189	4,297	2,125	**89,217**
SSE	0	0	0	45	26	397	594	10,278	2,402	481	**14,223**
Total	**500**	**6,284**	**2,458**	**819**	**1,184**	**9,539**	**34,055**	**108,013**	**23,355**	**74,153**	**260,360**

Source: DOC 1992.

Table D–20 Los Alamos National Laboratory Site Agricultural Data (kg/yr)

	Distance/Miles										
Food Type	***0-1***	***1-2***	***2-3***	***3-4***	***4-5***	***5-10***	***10-20***	***20-30***	***30-40***	***40-50***	***Direction***
Leafy Veg.	0	0	0	0	0	0	0	0	0	0	S
	0	0	0	0	0	0	0	0	0	0	SSW
	0	0	0	0	0	0	0	0	0	0	SW
	0	0	0	0	0	0	0	0	0	0	WSW
	0	0	0	0	0	0	0	0	0	0	W
	0	0	0	0	0	0	0	0	0	0	WNW
	0	0	0	0	0	0	0	0	0	0	NW
	0	0	0	0	0	0	0	0	0	0	NNW
	0	0	0	0	0	0	0	0	0	0	N
	0	0	0	0	0	0	0	0	0	0	NNE
	0	0	0	0	0	0	0	0	0	0	NE
	0	0	0	0	0	0	0	0	0	0	ENE
	0	0	0	0	0	0	0	0	0	0	E
	0	0	0	0	0	0	0	0	0	0	ESE
	0	0	0	0	0	0	0	0	0	0	SE
	0	0	0	0	0	0	0	0	0	0	SSE
Root Veg.	0	0	0	0	0	0	0	0	0	0	S
	0	0	0	0	0	0	0	0	0	0	SSW
	0	0	0	0	0	0	0	0	0	0	SW
	0	0	0	0	0	0	0	0	0	0	WSW
	0	0	0	0	0	0	0	0	0	0	W
	0	0	0	0	0	0	0	0	0	0	WNW
	0	0	0	0	0	0	0	0	0	0	NW
	0	0	0	0	0	0	0	0	0	0	NNW
	0	0	0	0	0	0	0	0	0	0	N
	0	0	0	0	0	0	0	0	0	0	NNE

Food Type	*Distance/Miles*										*Direction*
	0-1	***1-2***	***2-3***	***3-4***	***4-5***	***5-10***	***10-20***	***20-30***	***30-40***	***40-50***	
Root Veg. (continued)	0	0	0	0	0	0	0	0	0	0	NE
	0	0	0	0	0	0	0	0	0	0	ENE
	0	0	0	0	0	0	0	0	0	0	E
	0	0	0	0	0	0	0	0	0	0	ESE
	0	0	0	0	0	0	0	0	0	0	SE
	0	0	0	0	0	0	0	0	0	0	SSE
Fruits	0	0	0	110	290	3,100	9,.600	12,000	15,000	17,000	S
	0	0	55.0	290	380	3,100	13,000	21,000	29,000	35,000	SSW
	0	0	39.0	290	360	3,100	13,000	21,000	29,000	38,000	SW
	0	0	0	50.0	45.0	2,300	13,000	21,000	29,000	38,000	WSW
	0	0	0	0	0	2,700	13,000	21,000	29,000	38,000	W
	0	0	0	0	0	2,600	13,000	22,000	31,000	38,000	WNW
	0	0	0	0	0	1,700	14,000	24,000	34,000	43,000	NW
	0	0	0	0	0	2,000	15,000	24,000	34,000	44,000	NNW
	0	0	0	0	0	2,100	15,000	24,000	34,000	44,000	N
	0	0	0	0	0	2,300	15,000	24,000	33,000	41,000	NNE
	0	0	0	7.70	38.0	3,200	15,000	24,000	15,000	680	NE
	0	0	4.50	42.0	57.0	1,200	9,900	21,000	23,000	1,100	ENE
	0	0	16.0	44.0	57.0	470	1,900	3,200	8,000	5,400	E
	0	0	13.0	44.0	57.0	440	1,900	3,200	2,000	290	ESE
	0	0	0	0	17.0	280	1,900	3,200	4,200	2,000	SE
	0	0	0	0	0	470	1,900	3,200	4,400	5,700	SSE
Grains	0	0	0	84.0	210	2,300	8,700	14,000	19,000	30,000	S
	0	0	40.0	220	280	2,300	9,200	15,000	22,000	35,000	SSW
	0	0	29.0	210	270	2,300	9,200	15,000	22,000	28,000	SW
	0	0	0	37.0	33.0	1,700	9,200	15,000	22,000	28,000	WSW
	0	0	0	0	0	2,000	9,200	15,000	22,000	28,000	W
	0	0	0	0	0	1,900	9,200	13,000	18,000	28,000	WNW
	0	0	0	0	0	1,200	5,900	5,100	8,000	13,000	NW
	0	0	0	0	0	1,500	3,400	5,100	7,100	9,200	NNW
	0	0	0	0	0	1,300	3,100	5,100	7,100	9,200	N
	0	0	0	0	0	880	3,100	5,100	6,900	8,700	NNE
	0	0	0	30.0	150	900	3,100	5,100	4,400	3,000	NE
	0	0	18.0	170	220	1,600	4,700	6,400	5,500	3,100	ENE
	0	0	61.0	170	220	1,900	7,500	12,000	9,400	7,400	E
	0	0	50.0	170	220	1,700	7,500	12,000	17,000	22,000	ESE
	0	0	0	0	69.0	1,100	7,500	12,000	17,000	22,000	SE
	0	0	0	0	0	1,200	7,500	12,000	17,000	22,000	SSE
Beef	0	0	0	0	0	38.0	58,000	170,000	280,000	510,000	S
	0	0	0	0	0	0	0	0	0	190,000	SSW
	0	0	0	0	0	0	0	0	0	0	SW
	0	0	0	0	0	0	0	0	0	0	WSW
	0	0	0	0	0	0	0	0	0	0	W
	0	0	0	0	0	0	0	85,000	110,000	0	WNW
	0	0	0	0	0	0	110,000	330,000	430,000	460,000	NW
	0	0	0	0	0	270	190,000	330,000	460,000	590,000	NNW
	0	0	0	0	0	7,100	200,000	330,000	460,000	590,000	N
	0	0	0	0	0	20,000	200,000	330,000	450,000	570,000	NNE
	0	0	0	850	4,200	49,000	200,000	330,000	360,000	370,000	NE
	0	0	500	4,700	6,300	52,000	200,000	330,000	400,000	370,000	ENE
	0	0	1,700	4,900	6,300	52,000	210,000	350,000	690,000	970,000	E
	0	0	1,400	4,900	6,300	48,000	210,000	350,000	740,000	1.20×10^6	ESE
	0	0	0	0	1,900	31,000	210,000	350,000	510,000	1.00×10^6	SE
	0	0	0	0	0	30,000	210,000	350,000	490,000	630,000	SSE

	Distance/Miles										
Food Type	***0-1***	***1-2***	***2-3***	***3-4***	***4-5***	***5-10***	***10-20***	***20-30***	***30-40***	***40-50***	***Direction***
Poultry	0	0	0	0	0	0	0	0	0	0	S
	0	0	0	0	0	0	0	0	0	0	SSW
	0	0	0	0	0	0	0	0	0	0	SW
	0	0	0	0	0	0	0	0	0	0	WSW
	0	0	0	0	0	0	0	0	0	0	W
	0	0	0	0	0	0	0	0	0	0	WNW
	0	0	0	0	0	0	0	0	0	0	NW
	0	0	0	0	0	0	0	0	0	0	NNW
	0	0	0	0	0	0	0	0	0	0	N
	0	0	0	0	0	0	0	0	0	0	NNE
	0	0	0	0	0	0	0	0	0	0	NE
	0	0	0	0	0	0	0	0	0	0	ENE
	0	0	0	0	0	0	0	0	0	0	E
	0	0	0	0	0	0	0	0	0	0	ESE
	0	0	0	0	0	0	0	0	0	0	SE
	0	0	0	0	0	0	0	0	0	0	SSE
Milk	0	0	0	0	0	4.1	6,100	18,000	29,000	1.20×10^{6}	S
	0	0	0	0	0	0	0	0	0	1.50×10^{6}	SSW
	0	0	0	0	0	0	0	0	0	0	SW
	0	0	0	0	0	0	0	0	0	0	WSW
	0	0	0	0	0	0	0	0	0	0	W
	0	0	0	0	0	0	0	3,100	4,000	0	WNW
	0	0	0	0	0	0	3,900	12,000	16,000	16,000	NW
	0	0	0	0	0	9.80	6,700	12,000	17,000	21,000	NNW
	0	0	0	0	0	260	7,100	12,000	17,000	21,000	N
	0	0	0	0	0	720	7,100	12,000	16,000	21,000	NNE
	0	0	0	90.0	440	2,300	7,100	12,000	13,000	13,000	NE
	0	0	53.0	490	670	4,700	13,000	16,000	14,000	13,000	ENE
	0	0	180	520	670	5,.600	22,000	37,000	37,000	43,000	E
	0	0	150	520	670	5,100	22,000	37,000	35,000	28,000	ESE
	0	0	0	0	200	3,300	22,000	37,000	50,000	41,000	SE
	0	0	0	0	0	3,200	22,000	37,000	52,000	67,000	SSE
Eggs	0	0	0	0	0	0.0770	120	340	550	750	S
	0	0	0	0	0	0	0	0	0	0	SSW
	0	0	0	0	0	0	0	0	0	0	SW
	0	0	0	0	0	0	0	0	0	0	WSW
	0	0	0	0	0	0	0	0	0	0	W
	0	0	0	0	0	0	0	70.0	91.0	0	WNW
	0	0	0	0	0	0	89.0	270	360	380	NW
	0	0	0	0	0	22.0	150	270	380	490	NNW
	0	0	0	0	0	5.90	160	270	380	490	N
	0	0	0	0	0	17.0	160	270	360	450	NNE
	0	0	0	1.70	8.40	49.0	160	270	160	57.0	NE
	0	0	1.00	9.40	13.0	91.0	260	350	250	5.40	ENE
	0	0	3.50	9.90	13.0	110	420	700	430	240	E
	0	0	2.80	9.90	13.0	97.0	420	700	720	680	ESE
	0	0	0	0	3.80	63.0	420	700	960	860	SE
	0	0	0	0	0	60.0	420	700	990	1,300	SSE

kg/yr = kilogram per year
Source: DOC 1993.

Table D–21 Los Alamos National Laboratory 1993-1996 Joint Frequency Distributions at 11-m (36-ft) Height

Wind Speed (m/sec)	*Stability Class*	*Wind Blows Toward*															
		S	***SSW***	***SW***	***WSW***	***W***	***WNW***	***NW***	***NNW***	***N***	***NNE***	***NE***	***ENE***	***E***	***ESE***	***SE***	***SSE***
0.78	A	0.12	0.26	0.5	0.84	0.74	0.54	0.45	0.32	0.18	0.11	0.08	0.05	0.06	0.06	0.07	0.07
	B	0.03	0.05	0.12	0.19	0.16	0.09	0.08	0.07	0.04	0.01	0.02	0.01	0.02	0.02	0.01	0.02
	C	0.05	0.09	0.14	0.2	0.16	0.09	0.09	0.09	0.07	0.04	0.03	0.03	0.02	0.03	0.02	0.03
	D	0.86	0.69	0.57	0.45	0.47	0.34	0.33	0.33	0.38	0.35	0.33	0.31	0.35	0.4	0.57	0.72
	E	0.59	0.45	0.33	0.23	0.22	0.15	0.13	0.13	0.17	0.24	0.32	0.28	0.29	0.4	0.51	0.62
	F	0.26	0.28	0.27	0.19	0.18	0.17	0.2	0.25	0.3	0.32	0.22	0.17	0.15	0.2	0.24	0.25
2.5	A	0.03	0.07	0.17	0.45	0.56	0.43	0.33	0.22	0.18	0.08	0.06	0.05	0.04	0.03	0.03	0.03
	B	0.02	0.05	0.2	0.39	0.42	0.31	0.27	0.22	0.16	0.1	0.06	0.05	0.05	0.04	0.03	0.02
	C	0.05	0.15	0.46	0.68	0.65	0.45	0.46	0.59	0.59	0.26	0.16	0.12	0.16	0.12	0.07	0.05
	D	0.95	1.09	0.94	0.72	0.56	0.34	0.47	1.3	2.12	1.89	1.93	0.95	1.08	0.81	0.56	0.63
	E	0.87	0.59	0.34	0.19	0.11	0.1	0.13	0.24	0.67	1.82	2.41	1.72	1.84	1.41	0.8	0.8
	F	0.09	0.07	0.05	0.03	0.01	0.01	0.05	0.1	0.25	0.33	0.11	0.36	0.39	0.39	0.12	0.07
4.5	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.01	0.02	0.01	0
	C	0.02	0.04	0.07	0.04	0.02	0.01	0.01	0.03	0.15	0.09	0.11	0.19	0.31	0.19	0.09	0.02
	D	0.81	0.8	0.42	0.16	0.07	0.04	0.11	0.99	3.24	3.52	2.59	1.61	1.86	1.05	0.54	0.44
	E	0.21	0.2	0.08	0.01	0	0	0.01	0.07	0.32	1.74	1.08	1.32	1.31	0.32	0.23	0.22
	F	0	0.01	0	0	0	0	0	0	0.02	0.04	0	0.05	0.05	0.01	0.01	0
6.9	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.01	0	0
	D	0.19	0.2	0.05	0	0	0	0.01	0.31	0.96	1.42	0.87	0.93	0.62	0.48	0.31	0.15
	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9.6	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	0.01	0.01	0	0	0	0	0	0.05	0.03	0.08	0.09	0.19	0.08	0.05	0.04	0.02
	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
105	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	0	0	0	0	0	0	0	0.01	0	0	0.01	0.01	0	0	0	0
	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Source: LANL 1997.

D.1.4 Sample Batch Flow Diagrams and Supplemental Data

This section contains a sample "process alternative" batch data summary for Rocky Flats (vitrification of ash). Included are a process description, personnel radiation exposure estimates, operations requirements, and input/output diagrams. A separate Technical Report (SAIC 1998a) includes all batch data summaries (i.e., technology descriptions) for all processing alternatives at each site examined in this EIS.

Drum Unloading/Bag-In

F (emissions)

A (feed)

B (reagents)

C (product)

Batch Data	
Pu Content:	840 g; nominal 1 drum
Am Content:	N/A
Container(s) Volume:	55-gal. drum; nominal 5 4-liter containers/drum
Batch Time:	2 hr.
Batches/shift:	2
pH:	N/A
Temperature:	N/A

D (solids) **E** (liquids)

Total Components	A	B	C	D	E	F
Pu (kg)	1,164		1,164			<1E-12
Am						
Residue Matrix (kg)	20,057		20,057			
Water/Acid						
Other						
No. of containers in drums	6,400		6,400			
No. of drums	1,280			1,280		
No. of other containers	530		530			
Total No. of containers			6,930			

Radiation levels: - 14 mrem/hr whole body on contact
- 1.37 mrem/hr whole body (Background & 6' from source)

Operations Data

Workstations:
- Transportation
- Contam. Cntrl. Enclosure
- Bag-in at glovebox
-

Staffing:
- 3 shifts/day; 5 days/week
- 3 Operators at unit
- 0.5 hours/shift in gloves
- 14 Opr. exp. dose rate in gloves
- 5 Total personnel at unit
- 2 hours/shift in area
- 1.37 Exp. dose rate

Batches/week: 2x8=16 (RAM factor)

Special Requirements: - None

Process Data

Equipment:
- Contam. Cntrl. Enclosure
- Hand tools
- Glovebox bag-in
- Drum Handling Equip.

Space Requirements: - 2250 ft^2

Utilities:
- No Electricity
- No Water
- No Air
- No Steam
- No Other
- No Other

Location: - Building 707, Modules D/E

New Equipment Cost: - $0K

Feedasd Preparation

F (emissions)

A (feed)

B (reagents)

Batch Data
Pu Content: 83.5 g
Am Content: N/A
Container(s) Volume: 3.5 liters working volume; 8.2 liters total volume
Batch Time: 2.5 hr.
Batches/shift: 12
pH: N/A
Temperature: N/A

C (product)

D (solids) **E (liquids)**

Total Components	A	B	C	D	E	F
Pu (kg)	1,164		1,152	12		1E-8
Am						
Residue Matrix (kg)	20,057			207		
Residue and Frit Matrix (kg)			39,700			
Water/Acid						
Glass Frit (kg)		19,850				
No. of 8.2 liter containers		13,800	13,800			
No. 4 liter/other feed containers	6,930			6,930		
No. of Batches	6,930		13,800			

Radiation levels: - 0 mrem/hr whole body on contact
- 0.5 mrem/hr whole body (Background & 6' from source)

Operations Data

Workstations:
- Sort
- Crush
- Sieve/Batch/Blend
- Trash Removal

Staffing:
- 3 shifts/day; 5 days/week
- 4 Operators at unit
- 3 hours/shift in gloves
- 0 Opr. exp. dose rate in gloves
- 6 Total personnel at unit
- 6 hours/shift in area
- 0.5 Exp. dose rate

Batches/week: - 12x8=96 (RAM factor)

Special Requirements: - None

Process Data

Equipment:
- Crusher
- Rototap/Sieves
- Scales
- Gram Estimator
- Blender
- Glovebox Bag-out

Space Requirements: - 360 ft' (glovebox)

Utilities:
- Yes Electricity
- No Water
- No Air
- No Steam
- No Other
- No Other

Location: - Building 707, Module E

New Equipment Cost: - $0K

Vitrification

F (emissions)

A (feed)

B (reagents)

Batch Data	
Pu Content:	83.5 g
Am Content:	N/A
Container(s) Volume:	3.5 liters working volume; 8.2 liters total volume
Batch Time:	4 hr.
Batches/shift:	12
pH:	N/A
Temperature:	700-1300° C

C (product)

D (solids) **E (liquids)**

Total Components	A	B	C	D	E	F
Pu (kg)	1,152		1,152			1E-8
Am (kg)						
Residue + Frit (kg)	39,700		34,500			
Water/Acid (liters)						
Scrubber K_2CO_3 (kg)		397		397		
No. of 8.2-liter containers	13,800		13,800			
No. of convenience cans		13,800	13,800			
Nominal Carbon (kg) (as CO_2)						5,200 (19,100)

Radiation levels: - 15 mrem/hr whole body on contact
- 0.6 mrem/hr whole body (Background & 6' from source)

Operations Data

Workstations:
- Furnace Load/Unload
- Cooling/Staging/Weighing
- Sealing/Taping Can
- Bag-out at Glovebox
- Convenience Canning

Process Data

Equipment:
- Furnace (6)
- Solid-phase Scrubber (6)
- Heat Exchanger (6)
- Scale
- Glovebox Bag-out

Staffing:
- 3 shifts/day; 5 days/week
- 3 Operators at unit
- 0.5 hours/shift in gloves
- 1.5 Opr. exp. dose rate in gloves
- 5 Total personnel at unit
- 6 hours/shift in area
- 0.6 Exp. dose rate

Space Requirements: - 480 ft² (glovebox)

Utilities:
- Yes Electricity
- No Water
- Yes Air
- No Steam
- Yes Other
- Yes Other

Batches/week: - 12x8=96 (RAM factor)

Location: - Building 707, Module E

Special Requirements: - None

New Equipment Cost: - $100K

NDA

F (emissions)

A (feed)

B (reagents)

C (product)

<u>Batch Data</u>

Pu Content:	83.5 g
Am Content:	N/A
Container(s) Volume:	3.5 liters working volume; 8.2 liters total volume
Batch Time:	3/4 hr.
Batches/shift:	12
pH:	N/A
Temperature:	N/A

D (solids) **E (liquids)**

Total Components	A	B	C	D	E	F
Pu (kg)	1,152		1,152			<1E-12
Am (kg)						
Residue + Frit (kg)	34,500		34,500			
Water/Acid (liters)						
No. of 8.2-liter containers	13,800		13,800			
No. of convenience cans	13,800		13,800			

Radiation levels: - 1.5 mrem/hr whole body on contact
- 0.6 mrem/hr whole body (Background & 6' from source)

Operations Data

Workstations:
- NDA
- Transportation
-
-

Process Data

Equipment:
- Segmented Gamma Scanner
- Carts
-

Staffing:
- 3 shifts/day; 5 days/week
- 2 Operators at unit
- 1 hours/shift in gloves
- 1.5 Opr. exp. dose rate in gloves
- 3 Total personnel at unit
- 6 hours/shift in area
- 0.6 Sppt. exp. dose rate

Space Requirements: - No gloveboxes

Utilities:
- Yes Electricity
- No Water
- No Air
- No Steam
- No Other
- No Other

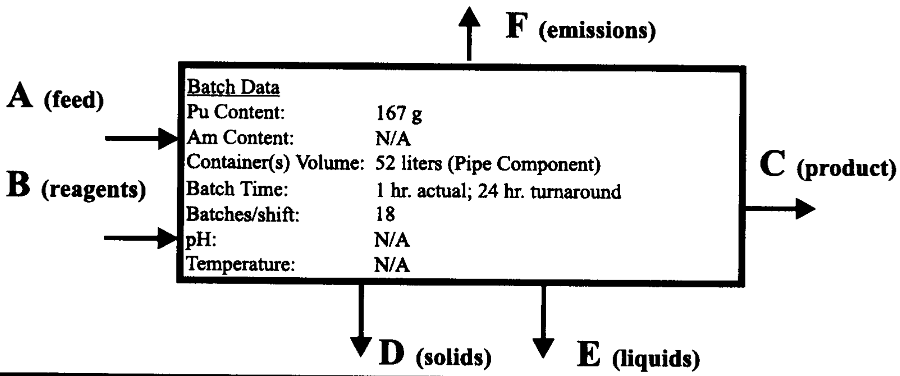
Batches/week: - 12x8=96 (RAM factor)

Location: - Building 707, Module E

Special Requirements: - None

New Equipment Cost: - $300-600K

Final Drum Packaging and Storage



Total Components	A	B	C	D	E	F
Pu (kg)	1,152		1,152			<1E-12
Am (kg)						
Residue + Frit (kg)	34,500		34,500			
Water/Acid (liters)						
No. of 8.2-liter containers	13,800		13,800			
No. of convenience cans	13,800		13,800			
No. of Pipe Components		6,900	6,900			
No. of drums w/Celetex		6,900	6,900			

Radiation levels: - 1.5 mrem/hr whole body on contact
- 0.6 mrem/hr whole body (Background & 6' from source)

Operations Data

Workstations:
- Drum Packaging
- Transportation
- Storage

Process Data

Equipment:
- Drum Moving Equip.
-
-

Staffing:
- 1 shifts/day; 5 days/week
- 2 Operators at unit
- 1 hours/shift in gloves
- 1.5 Opr. exp. dose rate in gloves
- 4 Total personnel at unit
- 6 hours/shift in area
- 0.6 Exp. dose rate

Space Requirements: - No gloveboxes

Utilities:
- No Electricity
- No Water
- No Air
- No Steam
- No Other
- No Other

Batches/week: 18x3=54 (RAM factor)

Location: - Various

Special Requirements: - None

New Equipment Cost: - $0K

D.2 NORMAL OPERATIONAL RADIOLOGICAL RELEASES AND IMPACTS TO THE ENVIRONMENT

This section presents compilations of radiological releases to the environment as well as resulting impact ranges from processes associated with all alternatives assessed in this EIS. The total releases of radioactivity to the environment associated with processes common to processing/storage activities are given in **Table D–22**. The releases, by radionuclide, include those for applicable operations at each site in question and differ according to site location and were based on information given in detailed technical descriptions of all the process options assessed in the EIS. These descriptions were supplied by each of the sites being addressed in the EIS.

For processing at Rocky Flats or Los Alamos National Laboratory, the amounts of plutonium and americium released to the environment, in mass units, were based on an analysis of each processing step in the glove box to determine the amounts of plutonium and americium present in each of these steps. For those steps that involve actions with unsealed material, one tenth of one percent of this material was assumed to get into the glove box atmosphere. The exhaust from the glove box would then pass through four sets of High-Efficiency Particulate Air filters in series, each assumed to have a reduction factor of 100 (99% efficient), before being released to the outside atmosphere.

The isotopic composition of the plutonium and americium released to the atmosphere was based on a document titled "Rocky Flats Calculation 95-SAE-002", January 3, 1996. (RF 1996) This composition is given in Table D–23, which provides the conversion of mass units to curies. The distribution of plutonium and americium radionuclides accounts for changes that have taken place over the storage period due to decay and growth of americium-241. The additional amount of americium for salt residues (noted in a footnote to the table) accounts for the higher amounts of americium present in salt residues and scrub alloy than in the other residues.

For processing at the Savannah River Site, the releases from the canyons to the atmosphere are based on operating experience with similar materials. The releases were adjusted to account for the specific throughputs of materials assessed in the EIS.

Tables D-24 through **D-26** present the maximum impacts associated with each site. These tables are provided to illustrate the largest possible incident-free impacts associated with each residue type that could exist at each site for all possible alternatives examined in this EIS. The detailed results of the impact assessments are given in Chapter 4 of this EIS.

Table D–22 Total Radioactive Releases During Normal Operation of Processing/Storage Processes (Ci) [a]

Process Radionuclides	*Rocky Flats*	*Savannah River Site*	*Los Alamos National Laboratory*
Calcining/Cementation of Ash			
Plutonium 238	2.2×10^{-7}	—	—
Plutonium 239	2.5×10^{-6}	—	—
Plutonium 240	5.6×10^{-7}	—	—
Plutonium 241	0.000015	—	—
Plutonium 242	5.2×10^{-11}	—	—
Americium 241	2.6×10^{-8}	—	—
Immobilization (Calcination/Vitrification) of Ash			
Plutonium 238	1.0×10^{-7}	—	—
Plutonium 239	1.2×10^{-6}	—	—
Plutonium 240	2.6×10^{-7}	—	—
Plutonium 241	6.9×10^{-6}	—	—
Plutonium 242	2.4×10^{-11}	—	—

Process Radionuclides	**Rocky Flats**	**Savannah River Site**	**Los Alamos National Laboratory**
Americium 241	1.2×10^{-8}	—	—
Cold Ceramification of Incinerator Ash			
Plutonium 238	1.2×10^{-7}	—	—
Plutonium 239	1.3×10^{-6}	—	—
Plutonium 240	3.0×10^{-7}	—	—
Plutonium 241	7.8×10^{-6}	—	—
Plutonium 242	2.8×10^{-11}	—	—
Americium 241	1.4×10^{-8}	—	—
Blend Down of Ash			
Plutonium 238	1.7×10^{-7}	—	—
Plutonium 239	2.0×10^{-6}	—	—
Plutonium 240	4.4×10^{-7}	—	—
Plutonium 241	0.000011	—	—
Plutonium 242	4.1×10^{-11}	—	—
Americium 241	2.0×10^{-8}	—	—
Preprocess Ash at Rocky Flats for Transport to the Savannah River Site (for Mediated Electrochemical Oxidation at the Savannah River Site)			
Plutonium 238	1.5×10^{-7}	—	—
Plutonium 239	1.7×10^{-6}	—	—
Plutonium 240	3.8×10^{-7}	—	—
Plutonium 241	0.000010	—	—
Plutonium 242	3.6×10^{-11}	—	—
Americium 241	1.8×10^{-8}	—	—
Preprocess Ash at Rocky Flats for Transport to the Savannah River Site (for Purex at the Savannah River Site)			
Plutonium 238	1.5×10^{-7}	—	—
Plutonium 239	1.7×10^{-6}	—	—
Plutonium 240	3.8×10^{-7}	—	—
Plutonium 241	0.000010	—	—
Plutonium 242	3.6×10^{-11}	—	—
Americium 241	1.8×10^{-8}	—	—
Sand, Slag, and Crucible Purex Process—Rocky Flats Size Reduced			
Plutonium 238	—	0.000025	—
Plutonium 239	—	0.000026	—
Americium 241/243	—	0.000017	—
Fusion/Purex Process for Ash			
Plutonium 238	—	0.00029	—
Plutonium 239	—	0.00031	—
Americium 241/243	—	0.00020	—
Mediated Electrochemical Oxidation for Ash			
Plutonium 238	—	0.00017	—
Plutonium 239	—	0.00018	—
Americium 241/243	—	0.00012	—
Repackage for Ash			
Plutonium 238	5.9×10^{-8}	—	—
Plutonium 239	6.8×10^{-7}	—	—
Plutonium 240	1.6×10^{-7}	—	—
Plutonium 241	3.9×10^{-6}	—	—
Plutonium 242	1.4×10^{-11}	—	—
Americium 241	7.0×10^{-9}	—	—
Pyro-oxidation of Salts			
Plutonium 238	1.0×10^{-7}	—	—
Plutonium 239	1.2×10^{-6}	—	—

Process Radionuclides	***Rocky Flats***	***Savannah River Site***	***Los Alamos National Laboratory***
Plutonium 240	2.6×10^{-7}	—	—
Plutonium 241	6.8×10^{-6}	—	—
Plutonium 242	2.4×10^{-11}	—	—
Americium 241	3.5×10^{-7}	—	—
Pyro-oxidation/Blend Down of Salts			
Plutonium 238	2.5×10^{-7}	—	—
Plutonium 239	2.9×10^{-6}	—	—
Plutonium 240	6.4×10^{-7}	—	—
Plutonium 241	0.000017	—	—
Plutonium 242	6.0×10^{-11}	—	—
Americium 241	8.8×10^{-7}	—	—
Salt Scrub for Pyro Salts/Ship Scrub Alloy to the Savannah River Site			
Plutonium 238	1.5×10^{-7}	—	—
Plutonium 239	1.7×10^{-6}	—	—
Plutonium 240	3.9×10^{-7}	—	—
Plutonium 241	0.000010	—	—
Plutonium 242	3.6×10^{-11}	—	—
Americium 241	4.9×10^{-7}	—	—
Preprocess Salt Residues at Rocky Flats for Transport to Los Alamos National Laboratory (All Salts)			
Plutonium 238	1.1×10^{-7}	—	—
Plutonium 239	1.3×10^{-6}	—	—
Plutonium 240	2.9×10^{-7}	—	—
Plutonium 241	7.4×10^{-6}	—	—
Plutonium 242	2.6×10^{-11}	—	—
Americium 241	3.7×10^{-7}	—	—
Salt Distillation (MSE/ER Salts)			
Plutonium 238	1.8×10^{-7}	—	4.3×10^{-8}
Plutonium 239	2.0×10^{-6}	—	5.0×10^{-7}
Plutonium 240	4.5×10^{-7}	—	1.1×10^{-7}
Plutonium 241	0.000012	—	2.9×10^{-6}
Plutonium 242	4.2×10^{-11}	—	1.0×10^{-11}
Americium 241	2.9×10^{-7}	—	7.3×10^{-8}
Dissolution of Salt Residues from Plutonium Oxide (Water Leach) - (All Salts at Rocky Flats; DOR Salts Only at LANL)			
Plutonium 238	3.7×10^{-7}	—	9.4×10^{-9}
Plutonium 239	4.3×10^{-6}	—	1.1×10^{-7}
Plutonium 240	9.7×10^{-8}	—	2.4×10^{-8}
Plutonium 241	0.000025	—	6.3×10^{-7}
Plutonium 242	8.9×10^{-11}	—	2.2×10^{-12}
Americium 241	1.3×10^{-6}	—	1.1×10^{-7}
Preprocess Salt Residues at Rocky Flats for Transport to Los Alamos National Laboratory (MSE/ER Salt-IDC 409 only)			
Plutonium 238	2.4×10^{-8}	—	—
Plutonium 239	2.7×10^{-7}	—	—
Plutonium 240	6.1×10^{-8}	—	—
Plutonium 241	1.6×10^{-6}	—	—
Plutonium 242	5.6×10^{-12}	—	—
Americium 241	2.8×10^{-9}	—	—
Salt Distillation (MSE/ER Salt-IDC 409 only)			
Plutonium 238	—	—	2.3×10^{-8}
Plutonium 239	—	—	2.7×10^{-7}
Plutonium 240	—	—	6.1×10^{-8}
Plutonium 241	—	—	1.6×10^{-6}
Plutonium 242	—	—	5.6×10^{-12}

Process Radionuclides	***Rocky Flats***	***Savannah River Site***	***Los Alamos National Laboratory***
Americium 241	—	—	2.8×10^{-9}
Preprocess Salt Residues at Rocky Flats for Transport to Los Alamos National Laboratory (DOR Salts-IDCs 365, 413, and 427			
Plutonium 238	1.4×10^{-8}	—	—
Plutonium 239	1.6×10^{-7}	—	—
Plutonium 240	3.6×10^{-8}	—	—
Plutonium 241	9.5×10^{-7}	—	—
Plutonium 242	3.4×10^{-12}	—	—
Americium 241	2.1×10^{-7}	—	—
Acid Dissolution (DOR Salts-IDC's 365, 413, and 427			
Plutonium 238	—	—	3.5×10^{-8}
Plutonium 239	—	—	4.0×10^{-7}
Plutonium 240	—	—	9.0×10^{-8}
Plutonium 241	—	—	2.3×10^{-6}
Plutonium 242	—	—	8.3×10^{-12}
Americium 241	—	—	5.0×10^{-7}
Repackage of Salts			
Plutonium 238	1.4×10^{-7}	—	—
Plutonium 239	1.6×10^{-6}	—	—
Plutonium 240	3.6×10^{-7}	—	—
Plutonium 241	9.3×10^{-6}	—	—
Plutonium 242	3.3×10^{-11}	—	—
Americium 241	5.1×10^{-7}	—	—
Neutralize/Dry (Aqueous) Combustibles			
Plutonium 238	1.6×10^{-9}	—	—
Plutonium 239	1.6×10^{-8}	—	—
Plutonium 240	3.9×10^{-9}	—	—
Plutonium 241	9.5×10^{-8}	—	—
Plutonium 242	3.4×10^{-13}	—	—
Americium 241	1.7×10^{-10}	—	—
Thermal Desorption/Steam Passivation (Organic) Combustibles			
Plutonium 238	1.0×10^{-9}	—	—
Plutonium 239	1.2×10^{-8}	—	—
Plutonium 240	2.6×10^{-9}	—	—
Plutonium 241	6.8×10^{-8}	—	—
Plutonium 242	2.4×10^{-13}	—	—
Americium 241	1.2×10^{-10}	—	—
Repackage (Dry Combustibles)			
Plutonium 238	5.5×10^{-10}	—	—
Plutonium 239	6.0×10^{-9}	—	—
Plutonium 240	1.0×10^{-9}	—	—
Plutonium 241	3.7×10^{-8}	—	—
Plutonium 242	1.3×10^{-13}	—	—
Americium 241	6.6×10^{-11}	—	—
Sonic Wash (Aqueous, Organic, and Dry Combustibles)			
Plutonium 238	5.0×10^{-9}	—	—
Plutonium 239	5.8×10^{-8}	—	—
Plutonium 240	1.3×10^{-8}	—	—
Plutonium 241	3.4×10^{-7}	—	—
Plutonium 242	1.2×10^{-12}	—	—
Americium 241	6.0×10^{-10}	—	—
Digestion (Aqueous, Organic, and Dry Combustibles)			

Process Radionuclides	Rocky Flats	Savannah River Site	Los Alamos National Laboratory
Plutonium 238	3.2×10^{-9}	—	—
Plutonium 239	3.7×10^{-8}	—	—
Plutonium 240	8.4×10^{-9}	—	—
Plutonium 241	2.2×10^{-7}	—	—
Plutonium 242	7.7×10^{-13}	—	—
Americium 241	3.9×10^{-10}	—	—
Blend Down (Aqueous, Organic, and Dry Combustibles)			
Plutonium 238	2.0×10^{-9}	—	—
Plutonium 239	2.5×10^{-8}	—	—
Plutonium 240	6.0×10^{-9}	—	—
Plutonium 241	1.4×10^{-7}	—	—
Plutonium 242	5.2×10^{-13}	—	—
Americium 241	2.6×10^{-10}	—	—
Mediated Electrochemical Oxidation for Aqueous/Organic-Contaminated and Dry Combustibles			
Plutonium 238	5.2×10^{-9}	—	—
Plutonium 239	6.0×10^{-8}	—	—
Plutonium 240	1.4×10^{-8}	—	—
Plutonium 241	3.5×10^{-7}	—	—
Plutonium 242	1.2×10^{-12}	—	—
Americium 241	6.2×10^{-10}	—	—
Acid Dissolution/Plutonium Oxide Recovery for Plutonium Fluorides			
Plutonium 238	3.6×10^{-8}	—	—
Plutonium 239	4.1×10^{-7}	—	—
Plutonium 240	9.1×10^{-8}	—	—
Plutonium 241	2.4×10^{-6}	—	—
Plutonium 242	8.5×10^{-12}	—	—
Americium 241	4.8×10^{-9}	—	—
Blend Down of Plutonium Fluorides			
Plutonium 238	N/E	—	—
Plutonium 239	N/E	—	—
Plutonium 240	N/E	—	—
Plutonium 241	N/E	—	—
Plutonium 242	N/E	—	—
Americium 241	N/E	—	—
Preprocess Plutonium Fluorides at Rocky Flats for Shipment to the Savannah River Site			
Plutonium 238	7.5×10^{-9}	—	—
Plutonium 239	8.1×10^{-8}	—	—
Plutonium 240	1.8×10^{-8}	—	—
Plutonium 241	4.7×10^{-7}	—	—
Plutonium 242	1.7×10^{-12}	—	—
Americium 241	8.4×10^{-10}	—	—
Fluorides Purex Process			
Plutonium 238	—	0.000038	—
Plutonium 239	—	0.000041	—
Americium 241/243	—	0.000027	—
Neutralize/Dry All Filter Media			
Plutonium 238	1.7×10^{-8}	—	—
Plutonium 239	1.9×10^{-7}	—	—
Plutonium 240	4.3×10^{-8}	—	—
Plutonium 241	1.1×10^{-6}	—	—
Plutonium 242	4.0×10^{-12}	—	—
Americium 241	2.0×10^{-9}	—	—

Process Radionuclides	***Rocky Flats***	***Savannah River Site***	***Los Alamos National Laboratory***
Neutralize/Dry Filter Media (IDC's 331 and 338 only)			
Plutonium 238	1.6×10^{-8}	—	—
Plutonium 239	1.9×10^{-7}	—	—
Plutonium 240	4.3×10^{-8}	—	—
Plutonium 241	1.1×10^{-6}	—	—
Plutonium 242	4.0×10^{-12}	—	—
Americium 241	2.0×10^{-9}	—	—
Immobilization (Vitrification) of High-Efficiency Particulate Air Filter Media			
Plutonium 238	1.0×10^{-8}	—	—
Plutonium 239	1.2×10^{-7}	—	—
Plutonium 240	2.6×10^{-8}	—	—
Plutonium 241	6.7×10^{-7}	—	—
Plutonium 242	2.4×10^{-12}	—	—
Americium 241	1.0×10^{-9}	—	—
Blend Down Filter Media			
Plutonium 238	1.1×10^{-8}	—	—
Plutonium 239	1.3×10^{-7}	—	—
Plutonium 240	2.8×10^{-8}	—	—
Plutonium 241	7.3×10^{-7}	—	—
Plutonium 242	2.6×10^{-12}	—	—
Americium 241	1.0×10^{-9}	—	—
Sonic Wash of Filter Media			
Plutonium 238	2.3×10^{-8}		
Plutonium 239	2.6×10^{-7}	—	—
Plutonium 240	5.9×10^{-8}	—	—
Plutonium 241	1.5×10^{-6}	—	—
Plutonium 242	5.5×10^{-12}	—	—
Americium 241	3.0×10^{-9}	—	—
Mediated Electrochemical Oxidation for Filter Media			
Plutonium 238	2.2×10^{-8}	—	—
Plutonium 239	2.5×10^{-7}	—	—
Plutonium 240	5.7×10^{-8}	—	—
Plutonium 241	1.5×10^{-6}	—	—
Plutonium 242	5.2×10^{-12}	—	—
Americium 241	2.6×10^{-9}	—	—
Repackage of HEPA Filters (All IDC's except 338)			
Plutonium 238	1.0×10^{-10}	—	—
Plutonium 239	1.2×10^{-9}	—	—
Plutonium 240	2.7×10^{-10}	—	—
Plutonium 241	6.9×10^{-9}	—	—
Plutonium 242	2.4×10^{-14}	—	—
Americium 241	1.2×10^{-11}	—	—
Filter/Dry Sludges			
Plutonium 238	3.0×10^{-9}	—	—
Plutonium 239	3.1×10^{-8}	—	—
Plutonium 240	7.0×10^{-9}	—	—
Plutonium 241	1.8×10^{-7}	—	—
Plutonium 242	6.4×10^{-13}	—	—
Americium 241	3.2×10^{-10}	—	—
Filter/Dry Sludges (All IDC's except 89, 99, 332)			
Plutonium 238	2.6×10^{-9}	—	—
Plutonium 239	3.0×10^{-8}	—	—

Process Radionuclides	***Rocky Flats***	***Savannah River Site***	***Los Alamos National Laboratory***
Plutonium 240	6.6×10^{-9}	—	—
Plutonium 241	1.7×10^{-7}	—	—
Plutonium 242	6.1×10^{-13}	—	—
Americium 241	3.1×10^{-10}	—	—
Immobilization (Vitrification) of Sludges			
Plutonium 238	3.0×10^{-9}	—	—
Plutonium 239	3.5×10^{-8}	—	—
Plutonium 240	8.0×10^{-9}	—	—
Plutonium 241	2.0×10^{-7}	—	—
Plutonium 242	7.2×10^{-13}	—	—
Americium 241	3.6×10^{-10}	—	—
Blend Down of Sludges			
Plutonium 238	2.7×10^{-9}	—	—
Plutonium 239	3.1×10^{-8}	—	—
Plutonium 240	7.1×10^{-9}	—	—
Plutonium 241	1.8×10^{-7}	—	—
Plutonium 242	6.4×10^{-13}	—	—
Americium 241	3.2×10^{-10}	—	—
Blend Down of Sludges (IDC's 89, 99, 332)			
Plutonium 238	9.0×10^{-11}	—	—
Plutonium 239	1.0×10^{-9}	—	—
Plutonium 240	2.3×10^{-10}	—	—
Plutonium 241	6.1×10^{-9}	—	—
Plutonium 242	2.2×10^{-14}	—	—
Americium 241	1.1×10^{-11}	—	—
Dissolution (Nitric Acid) of Sludges			
Plutonium 238	6.1×10^{-9}	—	—
Plutonium 239	7.1×10^{-8}	—	—
Plutonium 240	1.6×10^{-8}	—	—
Plutonium 241	4.1×10^{-7}	—	—
Plutonium 242	1.5×10^{-12}	—	—
Americium 241	7.6×10^{-10}	—	—
Repackage of Sludges (IDC's 089, 099, and 332)			
Plutonium 238	9.5×10^{-11}	—	—
Plutonium 239	1.1×10^{-9}	—	—
Plutonium 240	2.5×10^{-10}	—	—
Plutonium 241	6.4×10^{-9}	—	—
Plutonium 242	2.3×10^{-14}	—	—
Americium 241	1.1×10^{-11}	—	—
Neutralize/Dry Raschig (Glass) Rings			
Plutonium 238	N/E	—	—
Plutonium 239	N/E	—	—
Plutonium 240	N/E	—	—
Plutonium 241	N/E	—	—
Plutonium 242	N/E	—	—
Americium 241	N/E	—	—
Immobilization (Vitrification) of Raschig (Glass) Rings			
Plutonium 238	5.0×10^{-10}	—	—
Plutonium 239	5.8×10^{-9}	—	—
Plutonium 240	2.2×10^{-10}	—	—
Plutonium 241	3.3×10^{-8}	—	—
Plutonium 242	1.2×10^{-13}	—	—

Process Radionuclides	***Rocky Flats***	***Savannah River Site***	***Los Alamos National Laboratory***
Americium 241	6.0×10^{-11}	—	—
Blend Down of Raschig (Glass) Rings			
Plutonium 238	5.0×10^{-10}	—	—
Plutonium 239	5.8×10^{-9}	—	—
Plutonium 240	2.2×10^{-10}	—	—
Plutonium 241	3.3×10^{-8}	—	—
Plutonium 242	1.2×10^{-13}	—	—
Americium 241	6.0×10^{-11}	—	—
Sonic Wash of Raschig (Glass) Rings			
Plutonium 238	N/E	—	—
Plutonium 239	N/E	—	—
Plutonium 240	N/E	—	—
Plutonium 241	N/E	—	—
Plutonium 242	N/E	—	—
Americium 241	N/E	—	—
Mediated Electrochemical Oxidation for Raschig (Glass) Rings			
Plutonium 238	1.3×10^{-9}	—	—
Plutonium 239	1.5×10^{-8}	—	—
Plutonium 240	3.3×10^{-9}	—	—
Plutonium 241	8.5×10^{-8}	—	—
Plutonium 242	3.0×10^{-13}	—	—
Americium 241	1.5×10^{-10}	—	—
Direct Repackaging of Graphite			
Plutonium 238	N/E	—	—
Plutonium 239	N/E	—	—
Plutonium 240	N/E	—	—
Plutonium 241	N/E	—	—
Plutonium 242	N/E	—	—
Americium 241	N/E	—	—
Preprocess Graphite at Rocky Flats for Transport to the Savannah River Site			
Plutonium 238	4.9×10^{-9}	—	—
Plutonium 239	5.6×10^{-8}	—	—
Plutonium 240	1.3×10^{-8}	—	—
Plutonium 241	3.3×10^{-7}	—	—
Plutonium 242	1.2×10^{-12}	—	—
Americium 241	5.8×10^{-10}	—	—
Immobilization (Cementation) of Graphite			
Plutonium 238	2.0×10^{-8}	—	—
Plutonium 239	2.3×10^{-7}	—	—
Plutonium 240	5.2×10^{-8}	—	—
Plutonium 241	1.3×10^{-6}	—	—
Plutonium 242	4.8×10^{-12}	—	—
Americium 241	2.4×10^{-9}	—	—
Immobilization (Vitrification) of Graphite			
Plutonium 238	9.5×10^{-9}	—	—
Plutonium 239	1.1×10^{-7}	—	—
Plutonium 240	2.5×10^{-8}	—	—
Plutonium 241	6.4×10^{-7}	—	—
Plutonium 242	2.3×10^{-12}	—	—
Americium 241	1.1×10^{-9}	—	—
Blend Down of Graphite			
Plutonium 238	9.5×10^{-9}	—	—

Process Radionuclides	***Rocky Flats***	***Savannah River Site***	***Los Alamos National Laboratory***
Plutonium 239	1.1×10^{-7}	—	—
Plutonium 240	2.5×10^{-8}	—	—
Plutonium 241	6.4×10^{-7}	—	—
Plutonium 242	2.3×10^{-12}	—	—
Americium 241	1.1×10^{-9}	—	—
Mediated Electrochemical Oxidation for Graphite			
Plutonium 238	2.4×10^{-8}	0.000024	—
Plutonium 239	2.8×10^{-7}	0.000026	—
Plutonium 240	6.2×10^{-8}	—	—
Plutonium 241	1.6×10^{-6}	—	—
Plutonium 242	5.8×10^{-12}	—	—
Americium 241/243	2.9×10^{-9}	0.000017	—
Direct Repackage of Inorganic Residue			
Plutonium 238	N/E	—	—
Plutonium 239	N/E	—	—
Plutonium 240	N/E	—	—
Plutonium 241	N/E	—	—
Plutonium 242	N/E	—	—
Americium 241	N/E	—	—
Preprocess Inorganics at Rocky Flats for Transport to the Savannah River Site			
Plutonium 238	9.0×10^{-10}	—	—
Plutonium 239	1.1×10^{-8}	—	—
Plutonium 240	2.3×10^{-9}	—	—
Plutonium 241	6.1×10^{-8}	—	—
Plutonium 242	2.1×10^{-13}	—	—
Americium 241	1.1×10^{-10}	—	—
Immobilization (Vitrification) of Inorganics			
Plutonium 238	2.0×10^{-9}	—	—
Plutonium 239	2.3×10^{-8}	—	—
Plutonium 240	5.2×10^{-9}	—	—
Plutonium 241	1.3×10^{-7}	—	—
Plutonium 242	4.8×10^{-13}	—	—
Americium 241	2.4×10^{-10}	—	—
Blend Down of Inorganics			
Plutonium 238	1.8×10^{-9}	—	—
Plutonium 239	2.0×10^{-8}	—	—
Plutonium 240	4.6×10^{-9}	—	—
Plutonium 241	1.1×10^{-7}	—	—
Plutonium 242	4.2×10^{-13}	—	—
Americium 241	2.1×10^{-10}	—	—
Mediated Electrochemical Oxidation for Inorganics			
Plutonium 238	4.4×10^{-9}	0.000004	—
Plutonium 239	5.2×10^{-8}	0.000004	—
Plutonium 240	1.2×10^{-8}	—	—
Plutonium 241	3.0×10^{-7}	—	—
Plutonium 242	1.1×10^{-12}	—	—
Americium 241/243	5.3×10^{-10}	2.9×10^{-6}	—
Direct Repackage of Scrub Alloy Residue			
Plutonium 238	2.0×10^{-8}	—	—
Plutonium 239	2.3×10^{-7}	—	—
Plutonium 240	5.2×10^{-8}	—	—
Plutonium 241	1.4×10^{-6}	—	—

Process Radionuclides	*Rocky Flats*	*Savannah River Site*	*Los Alamos National Laboratory*
Plutonium 242	4.8×10^{-12}	—	—
Americium 241	1.3×10^{-6}	—	—
Repackaging of Scrub Alloy at Rocky Flats for Shipment to the Savannah River Site			
Plutonium 238	6.5×10^{-9}	—	—
Plutonium 239	7.5×10^{-8}	—	—
Plutonium 240	1.7×10^{-8}	—	—
Plutonium 241	4.4×10^{-7}	—	—
Plutonium 242	1.6×10^{-12}	—	—
Americium 241	6.5×10^{-7}	—	—
Immobilization (Calcination/Vitrification) of Scrub Alloy Buttons			
Plutonium 238	3.0×10^{-8}	—	—
Plutonium 239	3.5×10^{-7}	—	—
Plutonium 240	7.7×10^{-8}	—	—
Plutonium 241	2.0×10^{-6}	—	—
Plutonium 242	7.2×10^{-12}	—	—
Americium 241	1.9×10^{-6}	—	—
Existing Scrub Alloy Purex System			
Plutonium 238	—	0.000045	—
Plutonium 239	—	0.000048	—
Americium 241/243	—	0.000032	—
Pyrochemical Salts Scrub Alloy Purex System			
Plutonium 238	—	0.00022	—
Plutonium 239	—	0.00023	—
Americium 241/243	—	0.00015	—

N/E = no emissions

[a] All releases were to the atmosphere.

Note: Ash includes the general categories of incinerator ash/firebrick fines (78%), graphite fines (6%), sand, slag, crucible (11%), and inorganic (5%).

Salt includes the categories of sodium chloride/potassium chloride (88%) and calcium chloride (12%).

Combustibles includes the categories of aqueous (44%), organic (30%), and dry (26%).

Filter media includes the categories of high-efficiency particulate air (83%) and Ful Flo (17%).

Source: SAIC 1998a.

Table D–23 Releases [a] per 1 gram-mix of Weapons-Grade Plutonium (Ci) for Processing Alternatives (Normal Operations) at Rocky Flats

Process Radionuclides	*Releases (per 1 gram-mix)*
Plutonium 238	0.005
Plutonium 239	0.058
Plutonium 240	0.013
Plutonium 241	0.34
Plutonium 242	1.2×10^{-6}
Americium 241 [b]	0.0006

[a] All releases were to the atmosphere.

[b] For all salt and scrub alloy processes, there was an extra independent quantity (not within the weapons-grade mix) of Americium-241 released from operational procedures. One gram of Americium-241 contains 3.4 curies.

Source: SAIC 1996.

Table D–24 Radiological Impacts Due to Incident-Free Management of Plutonium Residues and Scrub Alloy—Rocky Flats Maximum Impacts

Material	*Offsite Population*		*Offsite Maximally Exposed Individual*		*Worker Population*	
	Collective Dose (person-rem)	*Latent Cancer Fatalities (number of cancers)*	*Annual Dose (mrem)*	*Cancer Probability*	*Collective Dose (person-rem)*	*Latent Cancer Fatalities (number of cancers)*
Incinerator Ash	0.0051	2.55×10^{-6}	0.00024	1.20×10^{-10}	376	0.150
Sand, Slag, and Crucible	0.00077	3.85×10^{-7}	0.000036	1.80×10^{-11}	57	0.0228
Inorganic Ash	0.00029	1.45×10^{-7}	0.000013	6.50×10^{-12}	26	0.0104
Graphite Fines	0.00042	2.10×10^{-7}	0.000020	1.00×10^{-11}	30	0.012
Molten Salt Extraction/ Electrorefining Salts	0.0091	4.55×10^{-6}	0.00039	1.95×10^{-10}	664	0.266
Direct Oxide Reduction Salts	0.0031	1.55×10^{-6}	0.00015	7.50×10^{-11}	155	0.062
Combustibles	0.00016	8.00×10^{-8}	7.40×10^{-6}	3.70×10^{-12}	42	0.0168
Plutonium Fluorides	0.00098	4.90×10^{-7}	0.000043	2.15×10^{-11}	356	0.142
High-Efficiency Particulate Air Filter Media	0.00057	2.85×10^{-7}	0.000027	1.35×10^{-11}	84	0.034
Ful Flo Filter Media	0.00012	6.00×10^{-8}	5.70×10^{-6}	2.85×10^{-12}	28	0.011
Sludge Residues	0.00016	8.00×10^{-8}	7.40×10^{-6}	3.70×10^{-12}	39	0.016
Glass Residues	0.000038	1.90×10^{-8}	1.80×10^{-6}	9.00×10^{-13}	1.90	0.00076
Graphite Residues	0.00072	3.60×10^{-7}	0.000034	1.70×10^{-11}	36	0.0144
Inorganic Residues	0.00013	6.50×10^{-8}	6.30×10^{-6}	3.15×10^{-12}	7.4	0.0030
Scrub Alloy	0.0025	1.25×10^{-6}	0.000066	3.30×10^{-11}	142	0.0568
Totals	0.0242	0.0000121	0.00105	5.25×10^{-10}	2,044	0.818

Table D–25 Radiological Impacts Due to Incident-Free Management of Plutonium Residues and Scrub Alloy—Savannah River Site Maximum Impacts

Material	*Offsite Population*		*Offsite Maximally Exposed Individual*		*Worker Population*	
	Collective Dose (person-rem)	*Latent Cancer Fatalities (number of cancers)*	*Annual Dose (mrem)*	*Cancer Probability*	*Collective Dose (person-rem)*	*Latent Cancer Fatalities (number of cancers)*
Incinerator Ash	0.17	0.000085	0.0015	7.50×10^{-10}	231	0.0924
Sand, Slag, and Crucible	0.014	7.00×10^{-6}	0.00013	6.50×10^{-11}	17	0.0068
Inorganic Ash	N/A	N/A	N/A	N/A	N/A	N/A
Graphite Fines	0.0071	3.55×10^{-6}	0.000064	3.20×10^{-11}	12	0.0048
Salts	0.12	0.000062	0.0012	6.00×10^{-10}	120	0.048
Combustibles	N/A	N/A	N/A	N/A	N/A	N/A
Plutonium Fluorides	0.022	0.000011	0.00020	1.00×10^{-10}	34	0.0136
High-Efficiency Particulate Air Filter Media	N/A	N/A	N/A	N/A	N/A	N/A

Material	***Offsite Population***		***Offsite Maximally Exposed Individual***		***Worker Population***	
	Collective Dose (person-rem)	***Latent Cancer Fatalities (number of cancers)***	***Annual Dose (mrem)***	***Cancer Probability***	***Collective Dose (person-rem)***	***Latent Cancer Fatalities (number of cancers)***
Ful Flo Filter Media	N/A	N/A	N/A	N/A	N/A	N/A
Sludge Residues	N/A	N/A	N/A	N/A	N/A	N/A
Glass Residues	N/A	N/A	N/A	N/A	N/A	N/A
Graphite Residues	0.014	7.00×10^{-6}	0.00012	6.00×10^{-11}	25	0.010
Inorganic Residues	0.0023	1.15×10^{-6}	0.000021	1.05×10^{-11}	4.50	0.0018
Scrub Alloy	0.0255	0.0000128	0.00024	1.20×10^{-10}	25	0.010
Totals	0.375	0.000187	0.00348	1.74×10^{-9}	469	0.187

N/A = not applicable (these materials are not processed at the Savannah River Site)

Table D–26 Radiological Impacts Due to Incident-Free Management of Plutonium Residues—Los Alamos Maximum Impacts

Material	***Offsite Population***		***Offsite Maximally Exposed Individual***		***Worker Population***	
	Collective Dose (person-rem)	***Latent Cancer Fatality (number of cancers)***	***Annual Dose (mrem)***	***Cancer Probability***	***Collective Dose (person-rem)***	***Latent Cancer Fatality (number of cancers)***
Incinerator Ash	N/A	N/A	N/A	N/A	N/A	N/A
Sand, Slag, and Crucible	N/A	N/A	N/A	N/A	N/A	N/A
Inorganic Ash	N/A	N/A	N/A	N/A	N/A	N/A
Graphite Fines	N/A	N/A	N/A	N/A	N/A	N/A
Salts	0.00235	1.18×10^{-6}	0.000799	4.00×10^{-10}	160	0.064
Combustibles	N/A	N/A	N/A	N/A	N/A	N/A
Plutonium Fluorides	N/A	N/A	N/A	N/A	N/A	N/A
High-Efficiency Particulate Air Filter Media	N/A	N/A	N/A	N/A	N/A	N/A
Ful Flo Filter Media	N/A	N/A	N/A	N/A	N/A	N/A
Sludge Residues	N/A	N/A	N/A	N/A	N/A	N/A
Glass Residues	N/A	N/A	N/A	N/A	N/A	N/A
Graphite Residues	N/A	N/A	N/A	N/A	N/A	N/A
Inorganic Residues	N/A	N/A	N/A	N/A	N/A	N/A
Scrub Alloy	N/A	N/A	N/A	N/A	N/A	N/A
Totals	0.00235	1.18×10^{-6}	0.000799	4.00×10^{-10}	160	0.064

N/A = not applicable (these materials are not processed at Los Alamos National Laboratory)

Tables D-24 through D-26 present the largest possible incident-free impacts associated with each residue type, that could exist at each site for all possible alternatives examined in this EIS. They should be viewed as a set of bounding values which cannot be exceeded for any of the processes under any feasible combination. The preferred and strategic alternatives also fall under the realm of being bounded by the impact quantities presented in the tables. It should be noted that not all residue processes are applicable to each site; in these situations, N/A ("not applicable") is denoted in the appropriate locations.

D.3 ACCIDENT AND RISK ANALYSIS METHODOLOGY, ASSUMPTIONS, AND RESULTS

Section D.3 describes the methodology and assumptions used for estimating radiation exposure (dose) and the risk to individuals and the general public from releases of radioactivity resulting from potential accident scenarios during processing and stabilization of certain Rocky Flats plutonium residues.

D.3.1 Exposure Impacts To Be Evaluated

The impact of radiation exposure on the following segments of the population is calculated for each accident scenario:

- ❒ **Worker—**An individual (a noninvolved worker) located 100 m (330 ft) from the radioactive material release point.[1] The dose to the worker is calculated for the 50th-percentile meteorology only, as specified in DOE-STD-1027-92 (DOE 1992). Workers are exposed unprotected to the plume for a limited time (a maximum of 5 minutes). Workers are exposed to radioactivity via inhalation, air immersion, and ground surface pathways only.

- ❒ **Maximally Exposed Individual—**A hypothetical individual living at the management site boundary and receiving the maximum exposure. The hypothetical member of the public is located directly downwind of the accident and is exposed to radioactivity via inhalation, ingestion, air immersion, and ground surface pathways. The individual would be exposed to the plume for the entire release duration.

- ❒ **Population—**The general public living within an 80-km (50-mi) radius of the facility, residing directly downwind of the accident, and receiving the maximum exposure via inhalation, ingestion, air immersion, and ground surface pathways.

The doses to the maximally exposed individual and the general public are calculated for the 50th- and 95th-percentile meteorological conditions. The details of exposure times for maximally exposed individuals, workers, and the general public are given in Section D.1.2.2.

The radiation dose to individuals and the public resulting from exposure to radioactive contamination was calculated using the following potential pathways:

- *Air Immersion*—External direct exposure from immersion in the airborne radioactive material
- *Ground Surface*—External direct exposure from radioactive material deposited on the ground
- *Inhalation*—Internal exposure from inhalation of radioactive aerosols and suspended particles
- *Ingestion*—Internal exposure from ingestion of contaminated terrestrial food and animal products.

The radiation dose is estimated by the GENII computer program in a manner recommended by the International Commission on Radiological Protection in Publications 26 and 30 (ICRP 1977, ICRP 1982). Committed dose

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[1] *For elevated release, the worker dose was calculated at a point of maximum dose. The distance at which the maximum dose occurs is frequently greater than 100 m (330 ft) for an elevated release.*

equivalents[2] are calculated individually for organs such as the gonads, breast, red bone marrow, lungs, thyroid, and bone surface; calculations are combined for the liver, upper large intestine, lower large intestine, small intestine, and stomach. Weighting factors are used for various body organs to calculate weighted or committed effective dose equivalent from radiation inside the body due to inhalation or ingestion. The committed effective dose equivalent value is the summation of the committed dose equivalent to a specific organ weighted by the relative risk to that organ compared to an equivalent whole-body exposure. Deep-dose equivalent for the external exposure pathways (immersion in the radioactive material and exposure to the ground contamination) and 50-year committed effective dose equivalent for the internal exposure pathways are calculated. The sum of the deep-dose equivalent for external pathways and committed effective dose equivalent for internal pathways is called the total dose in this EIS.

The exposure from ingestion of contaminated terrestrial food and animal products is calculated on a yearly basis. It is expected, however, that continued consumption of contaminated food products by the public would be suspended if the projected dose should exceed that of the protective action guidelines in a radiological accident event (EPA 1991). No reduction of exposure because of protective actions or evacuation of the public was accounted for in this analysis, however. This conservative approach may result in overestimating health effects within an exposed population but allows for consistent comparisons between alternatives.

D.3.2 Selection of Facility Accidents for Detailed Evaluations

The large number of material categories and the processing technologies under consideration in this EIS produce more than 50 different process/material combinations that need to be evaluated (see Figure 2–2 of this EIS). The selected technologies are either (1) well established with active facilities currently in operation or (2) considered to be feasible (existing laboratory scale) and becoming operational in the near future. For the well-established processing technologies with active facilities, the selection of accident scenarios is based on those evaluated in the facility safety analysis reports. For those processing technologies that have not been in full production, a set of similar process-independent accidents are postulated.

Postulated facility accident scenarios were developed based on the review of the analyzed accidents in previous safety analysis, risk assessment, and environmental assessment documents at Rocky Flats, Savannah River Site, and Los Alamos National Laboratory facilities where plutonium is handled or processed.

After reviewing a wide range of documents, postulated accident scenarios were developed based on information contained in the following:

- *Safety Analysis-200 Area, Savannah River Site F-Canyon Operation, F-Canyon SAR Addendum* (WSRC 1994)
- *Basis for Interim Operation, Savannah River Site H-Canyon and Outside Facilities, H-Canyon Basis for Interim Operation* (WSRC 1996)
- *Safety Analysis, H-Canyon Basis for Interim Operation Addendum, Addendum 1, Revision 0* (WSRC 1997)
- *Nuclear Safety Technical Report, Safety Analysis in Support of the Environmental Assessment for Consolidation and Interim Storage of Special Nuclear Material in Building 371* (EG&G 1995)

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[2] The definitions of committed dose equivalents, committed effective dose equivalents, and total effective dose equivalents are consistent with those given in 10 Code of Federal Regulations (CFR) Part 835, "Occupational Radiation Protection; Final Rule" (DOE 1993a).

- *Environmental Assessment, Finding of No Significant Impact, and Response to Comments, Solid Residue Treatment, Repackaging, and Storage* (DOE 1996d)

- *Basis for Interim Operation Building 371/374 Complex, Rocky Flats Environmental Technology Site* (KHC 1997a)

- *TA-55 Final Safety Analysis Report* (LANL 1996).

Based on this review of analyzed accident scenarios at Rocky Flats, Savannah River Site, and Los Alamos National Laboratory facilities that deal with plutonium, a spectrum of potential accidents was identified. This process started with systematically identifying initiating events, subsequent accident progressions, and onsite or offsite releases. Then, based on accident initiators, selected accidents were grouped into the following three categories:

- Natural phenomena (e.g., earthquake, tornado),
- External events (e.g., aircraft crash), and
- Process-related events (e.g., explosion, nuclear criticality, fire, spills).

The potential process-related events include high-, medium-, and low-energetic events, which are defined as follows:

- *High-Energetic*—A high-energetic event is defined as one that releases sufficient energy to destroy the first confinement barrier and breach the secondary confinement barrier, allowing radioactive materials to directly reach rooms occupied by personnel or directly reach the environment outside the facility. An example of such event would be an explosion of a magnitude that potentially could produce severe damage to the glovebox and cause damage to the filtration system or the building confinements (walls), creating a direct path to the environment. If an explosion could not create a direct path to the environment, it is covered as a medium-energetic impact event.

- *Medium-Energetic*—A medium-energetic event is defined as one that would cause penetration of the primary confinement barrier and potentially cause materials to bypass the second confinement barrier for a short period of time. Events which could lead to medium-energetic events are nuclear criticality, uncontrolled chemical reaction (including a sudden eruption or belching of a content of vessel, foaming, boil over, gassing, or simply an undesirable high temperature resulting in material degradation or toxic vapor evolution), fire (spontaneous combustion involving plutonium, cellulose, and other strong oxidizing agents such as nitric acid), and impacts (a projectile or a dropped object impacting process equipment).

- *Low-Energetic*—A low-energetic event is defined as one that would not destroy the primary confinement barrier, but activity may penetrate it. These events usually occur due to human errors such as transfer errors, overflows, chemical addition errors, spills, over pressurization, and equipment failures such as leaks.

The energy categorization is one of the indices that affects the outcome of all components of the building source term except the material at risk (see Section D.3.3.2). Under some circumstances, therefore, the health effects of a medium-energetic event could exceed those of a high-energetic event. A careful review of the accidents will lead to the amount of materials at risk as being the major contributing factor to the results that appear to be counterintuitive at first glance.

A review of the accident scenarios indicated that only severe accident conditions could result in a significant release of radioactive material to the environment or an increase in radiation levels. Some types of accidents, such as procedure violations, spills of small materials containing radioactive particles, and most other types of common human error occur more frequently than the more severe accidents analyzed. However, these accidents do not involve enough radioactive material or radiation to result in significant release to the environment. Natural phenomena (e.g., earthquake) and fire accidents creating a direct path for releases to the environment represented the situation with the most consequences to the public. The process-related accidents occurred inside the building, and, therefore, represented the situation with the most significant consequences to the operational personnel. The airborne particles from a process-related accident would normally pass through at least one bank and possibly two to four banks of high-efficiency particulate air filters before entering the environment. Plutonium handling and operations are performed inside such confinement barriers as gloveboxes or canyon walls. The gloveboxes are equipped with safety significant features, such as inert gas atmosphere, pressure control, and heat detection. These features are credited when their operabilities can be ensured.

Based on these reviews and on guidance provided by DOE in Section 6.9 of *Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements* (DOE 1993d), the following types of accidents were selected for each processing technology:

- Explosions
- Nuclear criticality
- Fire
- Earthquake
- Aircraft crash
- Spills.

Finally, no specific analyses of the results of terrorist or sabotage acts were considered. This is because the existing security measures in effect at the management sites would essentially preclude any sabotage or terrorist activity. In addition, any acts of terrorism are expected to result in consequences that are bounded by the results of the accident scenarios selected for detailed evaluation.

Table D–27 summarizes the selected accident scenarios and the associated frequency ranges. Details of the actual frequency, given in the following sections, are site specific.

Table D–27 Selected Accident Scenarios

Accident Type	*Scenario*	*Frequency Range (per year)*
High-Energy Impact	Explosion	10^{-3} > Frequency>10^{-6}
Medium-Energy Impact	Nuclear Criticality [a] Fire: a. Room b. Dock	10^{-2} > Frequency > 10^{-5} 10^{-2} > Frequency > 10^{-4}
Low-Energy Impact	Spills: a. Outside Glovebox b. Inside Glovebox c. Loading Dock	Frequency > 10^{-3}
Natural Phenomena	Earthquake (DBE)	10^{-2} > Frequency$\geq$ 10^{-4}
External Event	Aircraft Crash	10^{-5} > Frequency
Severe Accident	Earthquake (BDBE) Earthquake with Fire	10^{-4} > Frequency $\geq 10^{-7}$

DBE = design (evaluation) basis earthquake BDBE = beyond design basis earthquake.

[a] Only plutonium criticalities are evaluated. The potential for an americium criticality was considered but dismissed because of the limited americium mass and purity. Americium is only present in plutonium residues in small quantities.

Note: Event frequencies are site dependent.
For the beyond design basis events (severe accidents) only events with frequencies above 10^{-7} per year are considered. Events with lower frequencies are considered to be not reasonably foreseeable.

D.3.3 Accident Evaluation

D.3.3.1 Basic Assumptions

Unless otherwise stated, the following conditions were used in the calculations:

❒ **Meteorological Data**

- Site-specific joint frequency distribution weather data are used to define 50- and 95-percentile meteorological conditions for each processing technology at management sites.

- The release is assumed to occur at an elevated level, unless otherwise stated, consistent with the site's effluent emission stack height. No credit is taken for jet plume rise through the stack.

- Mixing layer height is 1,000 m (3,280 ft). Airborne materials freely diffuse in the atmosphere near the ground level in what is known as the mixing depth. A stable layer exists above the mixing depth and restricts vertical diffusion above 1,000 m.

- Wet deposition is zero (it is assumed that no rains occur to accelerate deposition and reduce the size of area affected by the release).

- Dry deposition of the cloud is modeled. During movement of the radioactive plume, a fraction of the radioactive material in the plume is deposited on the ground due to gravitational forces. The quantity of deposited radioactive material is proportional to the particle size and deposition velocities (in meters per second). For the plutonium isotopes, the deposition velocity is 0.001 m/sec. The deposited material contributes to the exposure from ground surface radiation and ingestion.

❒ **Inhalation Data**

- Breathing rate is 330 cubic centimeters (cm^3)/sec (0.7 cubic feet per minute [ft^3/min]) for the worker and the general public at the site boundary and beyond (maximally exposed individual and population) during the passage of the plume; it is 270 cm^3/sec (0.57 ft^3/min) for the general public during the other times.

- Particle size is 1.0 microns (0.04 mils).

- Solubility (or lung clearance) class[3] (for dose effect when inhaled) in this analysis will use class "Y" for plutonium oxides and class "W" for other plutonium compounds such as fluorides and metals.

- The internal exposure period is 50 years for the individual organs and tissues evaluated.

D.3.3.2 Source Term

[3] *A classification of inhaled material based on its clearance half-time, in order of days "D," weeks "W," or years "Y," from the pulmonary region of the lung to the blood and gastrointestinal tract.*

The source term (or building source term) is the amount of respirable radioactive material that is released to the air, in terms of Curies or grams. The airborne source term is typically estimated by the following five-component linear equation:

Source term = MAR × DR × ARF × RF × LPF

where:

MAR	=	Material-at-Risk (grams or curies)
DR	=	Damage Ratio
ARF	=	Airborne Release Fraction (or Airborne Release Rate for continuous release)
RF	=	Respirable Fraction
LPF	=	Leak Path Factor.

- **Material at Risk—**The material at risk is the amount of the radionuclides (in Curies or gram of activity for each radionuclide) available to be acted upon by a given physical stress (i.e., an accident). The material at risk is specific to a given process in the facility of interest. It is not necessarily the total quantity of material present but is that amount of material in the scenario of interest postulated to be available for release.

- **Damage Ratio—**This is the fraction of material exposed to the effects of the energy/force/stress generated by the postulated event. For the accident scenarios discussed in this document, the value of the damage ratio is assumed to be one, unless otherwise specified.

- **Airborne Release Fraction—**This is the fraction of the material that becomes airborne due to the accident. In this analysis, airborne release fraction values from the DOE Handbook on airborne release fraction are used (DOE 1994a).

- **Respirable Fraction—**This is the fraction of the material, with particle size of 10-micrometers (microns) aerodynamic equivalent diameter or less, that could be retained in the respiratory system following inhalation. The respirable fraction values are also taken from the DOE Handbook on airborne release fractions (DOE 1994a).

- **Leak Path Factor—**The leak path factor accounts for the action of removal mechanisms (e.g., containment systems, filtration, deposition) to reduce the amount of airborne radioactivity that is ultimately released to occupied spaces of the facility or the environment. A leak path factor of one (i.e., no reduction) is assigned in accident scenarios involving a major failure of confinement barriers.

D.3.3.3 Process Accident Scenario Description and Source Terms

This section describes the accident scenarios and corresponding source terms developed for Rocky Flats, the Savannah River Site, and Los Alamos National Laboratory. The spectrum of accidents described below were used to determine the incremental consequences (public and worker doses) and risks associated with the processing of certain Rocky Flats' residues at each site. These accident scenarios are consistent with those evaluated in either the facility safety analysis report, facility/site environmental reports, or various related DOE safety documents. Secondary accidents were considered when identified in the safety documents. The selected documents were identified and referenced in each of the accident scenarios described. When information was required to further clarify the accident condition, update some of the parameters, and facilitate the evaluation process, additional assumptions were made. Sometimes it was necessary to have different assumptions than those that were used in the referenced report. These are also identified. For example, the material at risk during an earthquake is different for the residue processing in this EIS than those considered in the facility safety analysis report. This change in assumption is necessary because the evaluations in this EIS focus only on the incremental risk resulting from the implementation of alternatives. Cumulative risks can be determined by adding the incremental risks to the existing risks.

D.3.3.3.1 Accident Scenarios Description and Source Terms at Rocky Flats

❒ **Description of Accident Scenarios—**The following accident scenarios are evaluated for each processing technology and material category considered in this EIS. Each accident scenario description sets the condition of the accident and provides a summary of material involved. As stated earlier, these accident scenarios are generic, but their applications are consistent with those evaluated in various Rocky Flats environmental and safety analyses documents (EG&G 1995, KHC 1997a, DOE 1996d). It is important to note that even though these accident scenarios are based on the existing production technologies, they will also be applicable to the new technologies because the new technologies are similar to the production technologies at operational levels. Additionally, these accidents are generic and process-independent.

- *Explosion*—Two explosion scenarios were postulated: acetylene and ion exchange explosions. The acetylene explosion was postulated to occur in both Building 707 and Building 371, whereas the ion exchange explosion was postulated to occur in Building 371 only. The acetylene explosion scenario was considered credible and analyzed for Buildings 371 and 707 (EG&G 1995). The scenario assumed for the analysis in this EIS is consistent with that analyzed earlier. The scenario assumes the development of a flammable cloud of acetylene in the vicinity of a glovebox. The source of the acetylene gas is the failure of an oxy-acetylene welding rig. The subsequent deflagration can result in damage to equipment and containers within the immediate vicinity of the explosion. The ensuing pressure wave from deflagration could breach the module wall and blow open a set of egress doors in Building 707, creating a path to the environment (EG&G 1995). The explosion force from an acetylene accident in Building 371 would be insufficient to damage the 40-cm (16-in) thick reinforced concrete outer building walls (EG&G 1995). Therefore, the release path would be through at least two banks of high-efficiency particulate air filters. The frequency of this accident was estimated at 5×10^{-5} per year (EG&G 1995). The material at risk for this EIS was considered to be the equivalent content of two drums.

  Ion exchange purification of plutonium is a secondary process for the plutonium separation processing alternative that uses the mediated electrochemical oxidation process. There are two alternative protocols possible—the purification of each batch using lab-scale columns or the accumulation of sufficient batches to make up an appropriate quantity of plutonium for use of a process-size column. Because the accumulation of plutonium results in a larger source term (a conservative assumption), this option is selected for evaluation. The accident was assumed to result from a strong exothermic reaction between nitric acid and the base resin during the elution phase of the plutonium purification process. The material at risk was assumed to be 1.6 kilograms (kg) (3.53 lb) of plutonium based on the processing schedule and throughput estimates of batch sizes. The accident scenario assumptions and evolutions are similar to those of the FB-Line ion-exchange explosion described in Section D.3.3.2 with the exception that no release is postulated for the feed tank. This is because the event is postulated to occur after the feed tank is emptied into the column and additional material has not had a chance to accumulate. The Rocky Flats ion exchange columns are made up of 15-cm (6-in) borosilicate glass pipe wrapped in heavy mesh screen and are not assumed to generate fragments with an adequate force to defeat the carbonate plastic windows. Airborne release from the formation of a "flashing spray" from the eluate with boiling of the remaining solution due to the burning of the released resin on the floor of the glovebox are evaluated. The released materials would pass through at least two banks of high-efficiency particulate air filters, giving a leak path factor of 2×10^{-6}. The release from the building stack is estimated to be 0.245 mg (5.4×10^{-7} lb) of plutonium. The frequency of such an event was estimated to be 1×10^{-4} per year, consistent with that used for the same event at the Savannah River Site.

- *Room Fire*—A fire originating in the room could involve multiple gloveboxes. The fire could be initiated by welding, an electrical short, or other causes. The frequency of a room fire involving two gloveboxes was estimated to be 5×10^{-4} per year (EG&G 1995). This fire frequency was used in this EIS to represent a fire involving the entire room. Workers would evacuate the fire zone in about 20 seconds, and it is assumed that only one glovebox would be involved in the fire during this period. The amount of the combustibles in the room is insufficient to plug the filters, and the sprinklers would cool the fire plume sufficiently; therefore, no buoyancy effect is considered. The sprinkler effect would limit the amount of material that could be involved in the fire. The material at risk was assumed to be a 5-day supply for operation. The types of materials considered are high americium residues for the salts and aged weapon-grade plutonium for other residues. It was assumed that at least two banks of filters would be available. A fraction of the released material could bypass the ventilation system by escaping the room through cracks in egress doors. Because the ventilation system was assumed to be operating, approximately 10 percent of the material (due to temperature and air volume increase before the sprinkler started) was assumed to escape through the cracks.

- *Dock Fire*—A dock fire resulting in a direct release to the atmosphere is estimated to have a likelihood of 2×10^{-6} per year, based on the consideration that historically there were no dock fires, and the dock doors are open only one percent of the time (EG&G 1995). For the worker handling the materials inside the dock, the likelihood of the fire would be 2×10^{-4} per year. Various ranges of dock fires have been postulated at Rocky Flats (KHC 1997a, EG&G 1995). The scenario that was evaluated here assumes a large dock fire similar to the scenario evaluated in the Building 371 Basis for Interim Operation report (KHC 1997a). In this scenario, the material at risk was considered to be the contents of four plutonium residue drums. A conservative bounding mass, assuming that the content is in powder form, was used to estimate the mass (plutonium content) of a drum. Because the ventilation system would be in operation, it was assumed that approximately 50 percent of the released material would enter the atmosphere directly. The remaining airborne releases would pass through at least two banks of high-efficiency particulate air filters before entering the atmosphere.

- *Dock Spill*—A dock spill could occur if a package is dropped on the dock while loading and unloading a truck, resulting in breach of the drum and inner container and release of plutonium. This assumption is very conservative, because all containers used at Rocky Flats are required to withstand a 120-cm (4-ft) drop without loss of contents. The spill could result if the container is damaged or improperly sealed. The likelihood of occurrence of such an event was estimated to be 10^{-3} per year (EG&G 1995). The material at risk was assumed to be the content of one drum at its maximum limit. The event at worst would impact approximately 25 percent of the content. Upon a spill, the workers, both those involved with the operation and those not directly involved (e.g., security and drivers), would evacuate the area within 20 seconds. The workers handling the packages are required to wear respirators that would reduce their intake of contaminants by 99 percent. Because the ventilation system would be in operation, it was assumed that about 10 percent of the released material would directly enter the atmosphere. The remaining airborne releases would pass through at least two banks of high-efficiency particulate air filters before entering the atmosphere.

- *Room Spill*—A room spill could be caused by human error or deteriorated packaging materials during a transfer process. The material could be dry (metal/powder) or liquid. The workers handling the packaging materials are required to wear respirators. The frequency of occurrence of a dry spill was estimated to be 8×10^{-3} per year, based on a human error probability of 1×10^{-3} of dropping a container, a probability of 1×10^{-2} that the container fails and releases its contents as a result of drop, and an assumption that a bag-in occurs once per shift (3 shifts/day × 5 days/week × 50 weeks/year). The material at risk is assumed to be the content of one container at its limit. Liquid spill is a potential for activities in Building 371. In the Building 371 Basis for Interim Operation report (KHC 1997a), several scenarios for liquid spills (small to large) have been analyzed. In this EIS, the analysis considers a spill equivalent to a batch size solution volume. The spilled solution is assumed to flow by gravity into the criticality drain system. For the environmental assessment purposes, this analysis assumes that the likelihood of such an event in Building 371 is 8×10^{-3} per year.

- *Glovebox Spill*—A spill inside a glovebox could occur due to human error. This spill would be confined inside the glovebox. The probability of occurrence of such an event is estimated to be 0.8 per year, based on similar assumptions of human reliability and operational activities as stated for the room spill scenario. The immediate workers would be exposed to the spilled materials if a tear occurred in the gloves simultaneously with the spill and some of the materials escaped from the glovebox. For the purposes of this EIS, it was assumed that, at most, 1 percent of the materials released to the glovebox could escape through the tear and enter the room. The probability of such an event was estimated to be 8×10^{-2} per year, based on the probability of a glove tear of 0.10 per year (EG&G 1995). The material at risk is assumed to be the content of one feed preparation container (the size of one batch).

- *Earthquake*—An evaluation (design) basis earthquake would cause different consequences to Buildings 707 and 371 at Rocky Flats. Building 707 is expected to collapse from an earthquake having a peak ground acceleration of 0.106 g with a return period of about 385 years (frequency of 2.6×10^{-3} per year) (CAI 1997). The collapse of Building 707 would cause the collapse of the eastern portion of Building 707A which houses Modules J through K (CAI 1997). Building 371 is not expected to collapse from earthquakes with a return period of less than 10,700 years (frequency of 9.4×10^{-5} per year) (CAI 1995). For Building 707, a 0.106 peak ground acceleration (design basis earthquake) earthquake was assumed. Such an earthquake would cause widespread damage throughout Building 707, which houses Modules A through H, and Building 707A, which houses Modules J through K. The consequences of such an accident involving various plutonium and transuranic waste materials have already been analyzed in the building safety analysis report. For this EIS, the material at risk was assumed to be that of a 5-day supply in different packages and gloveboxes within the operational area. The released materials were assumed to enter the environment through a leak path factor of 0.10.

  The assumption of a leak path factor of 0.1 in an earthquake is based on the following combination of factors considered: (1) after an earthquake, the building fails before the materials are released (due to impact); (2) the released materials are buried, or confined, under the rubble; (3) minimal air flow is available to force the material out; and (4) structural debris acts as a filter, absorbing the particulates as they pass through before entering the environment. In addition, DOE-HDBK-3010 (DOE 1994a) recommends an order of magnitude reduction of the airborne release fraction for powders buried under debris. The values given for the airborne release fraction did not consider such a reduction, and this reduction was assigned to the leak path factor.

  The consequences of several levels of earthquakes have also been evaluated in the Building 371 Basis for Interim Operation report (KHC 1997a). The minimum peak ground acceleration that could cause equipment damage resulting in material release was estimated to be 0.15 g with a 900-year return period (frequency of 1.1×10^{-3} per year). At this peak ground acceleration level (design basis earthquake), the following accidents could occur: spills, fire, and explosion. A criticality event was not considered as likely, because no damage to the equipment containing liquids was expected at this earthquake level. Spills were assumed to occur in the laboratories, downdraft tables, and gloveboxes. Fire was postulated to occur anywhere within Building 371. It was assumed that a large fire could occur and could pressurize the facility resulting in a high ambient leak path factor of 0.1. The fire was considered to eventually burn itself out, or be extinguished by the fire department. Explosion was postulated to occur in the analytical laboratory involving propane gas. The propane explosion was assumed to topple a glovebox, causing its contents to spread in the room. The explosion was assumed to cause a high leak path factor of 0.10.

With a 2,000-year return period (frequency of 5×10^{-4} per year) earthquake, 0.25 peak ground acceleration, it was postulated that in addition to events identified above, a criticality event could also occur from a mixture of materials in the collapsed gloveboxes and water from failed fire suppression systems (moderated and fully reflected metal criticality). A nuclear criticality may be characterized by a flash of fissions that produce a pulse of penetrating radiation, followed by a period of much lower radiation lasting from a few minutes to several hours depending on the self limiting properties of critical mass. A criticality event is very different from a nuclear detonation, which is almost instantaneous fissions of all materials. There is no potential for a nuclear detonation at the site. Due to the uncertainties in the ways that a criticality accident could occur, for the purposes of analysis in this EIS, a criticality event with a 10^{18} fission yield was assumed, that is, a single burst or pulse of fissions (DOE 1994a). The fission gas release source term for this criticality event was assumed to be 1/10 of the values provided in the Nuclear Regulatory Commission's Regulatory Guide 3.35 (NRC 1979); the source term in this regulatory guide is for a plutonium solution criticality event with 10^{19} fissions.

- *Criticality*—Various criticality events were postulated to occur during plutonium processing and handling activities. These are bare plutonium metal criticality, water moderated and reflected plutonium criticality, and plutonium solution criticality. Among these accidental events, criticality in plutonium solutions is expected to yield the highest amount of fissions. DOE-HDBK-3010-94 (DOE 1994a) identifies the following fission yields for each of the above criticality events:

– Bare metal	10^{17} fissions
– Fully moderated and reflected solid metal	10^{18} fissions
– Solution	10^{19} fissions

The amount of fission gas and halogen nuclide source terms from a criticality event is proportional to the number of fissions per event. A solution criticality will have 100 times more of these nuclides than will a bare metal criticality and also will release aerosols (particulate plutonium), which a bare metal criticality will not. A fully moderated and reflected solid metal criticality will produce 10 percent of the amount of fission gas and halogen source terms that is released in a solution criticality, and it will release no plutonium particulates. The solution criticality will dominate any other criticality event. The 10^{-4} per year frequency for a criticality event already considers violation of two administrative controls. The frequency of a solid criticality event will not be higher than 10^{-4} per year. Therefore, for analysis purposes, only solution criticality is modeled and evaluated. The frequency of a plutonium solution criticality is estimated at 1×10^{-4} per year (EG&G 1995). The source term for the solution criticality is given in **Table D–28**.

Table D–28 Criticality Source Term for 10^{19} Fissions in Plutonium Solution

Isotope	*Radioactivity (Ci)* [a]			*ARF* [b]	*LPF* [c]	*Source Term (Ci)*
	0-30 minutes	*30 min-8 hours*	*Total*			
Kr-83m	15	95	110	1	1	110
Kr-85m	9.9	61	70.9	1	1	70.9
Kr -85	0.00012	0.00072	0.00084	1	1	0.00084
Kr-87	60	370	430	1	1	430
Kr-88	32	200	232	1	1	232
Kr-89	1,800	11,000	12,800	1	1	12,800
Xe-131m	0.014	0.086	0.1	1	1	0.1
Xe-133m	0.31	1.9	2.21	1	1	2.21
Xe-133	3.8	23	26.8	1	1	26.8
Xe-135m	460	2,800	3,260	1	1	3,260
Xe-135	57	350	407	1	1	407
Xe-137	6,900	42,000	48,900	1	1	48,900
Xe-138	1,500	9,500	11,000	1	1	11,000
I-131	1.5	9.5	11	0.25	1	2.75
I-132	170	1,000	1,170	0.25	1	293
I-133	22	140	162	0.25	1	40.5
I-134	600	3,700	4,300	0.25	1	1,080
I-135	63	390	453	0.25	1	113
Pu-238 [c, d]			3.6	0.0005	0.005	0
Pu-239 [c, d]			170	0.0005	0.005	0.00043
Pu-240 [c, d]			39	0.0005	0.005	0.0001
Pu-241 [c, d]			2,400	0.0005	0.005	0.006
Pu-242 [c, d]			0.003	0.0005	0.005	7.50×10^{-9}

Ci = curie ARF = airborne release fraction LPF = leak path factor

[a] Regulatory Guide 3.35 (NRC 1979).

[b] Airborne release fractions are equal to 1.0 for noble gases, 0.25 for iodine, and 0.0005 for plutonium; all particles are assumed to be in the respirable range (i.e., Respirable Fraction = 1.0).

[c] Plutonium in 100 liters of solution.

[d] This plutonium is assumed to be released to the atmosphere through a high-efficiency particulate air filter (e.g., the Savannah River Site's sand filter) with a 0.995 efficiency. For Rocky Flats, the plutonium source terms are smaller by a factor of 0.0004 due to a higher number of filter banks. The plutonium values are the maximum solution concentration in the FB-Line (DOE 1993b).

- *Aircraft Crash*—Rocky Flats is located between 6.4 to 8 km (4 to 5 mi) from Jeffco airport and approximately 32 km (20 mi) from Denver International Airport. A hypothetical aircraft crash accident scenario into Buildings 707, 707A, and/or 371 was postulated. The frequency of such an event was estimated using the DOE Standard on *Accident Analysis for Aircraft Crash into Hazardous Facilities*, DOE-STD-3014-96 (DOE 1996b). This standard identifies that the aircraft (general aviation aircraft) crashes occurring during in-flight and takeoff and landing operations at Jeffco airport along with the potential crashes during in-flight operation of other aircrafts (e. g., air carriers, military aircraft) would need to be considered as potential hazards to Rocky Flats facilities. Using the facility dimensions of Building 707, it was determined that the frequency with which a large commercial (air taxi and larger sizes) and/or a high-powered military aircraft could crash into this building would be less than 10^{-7} per year. For the general aviation aircraft, an upper bound frequency of a crash into Buildings 707, 707A, or 371 was estimated to be 3×10^{-5}, 1×10^{-5} and 4×10^{-5} per year, respectively. The likelihood that a general aviation aircraft would hit the dock areas of Building 707 is approximately two orders of magnitude less (i.e., 2.2×10^{-7} per year). The crash of a general aviation aircraft into the building would not be as severe (both in magnitude and frequency) as that of an earthquake. Therefore, the consequences/risks of an earthquake would bound that of an aircraft crash. For analysis purposes, the material at risk for this scenario was assumed to be equal to that used in a 0.13 peak ground acceleration design basis earthquake.

❒ **Assumptions of Airborne Release Fraction and Respirable Fraction Values for Rocky Flats' Accident Scenarios—Table D–29** summarizes the airborne release fraction and respirable fraction values for each of the accidents and the types of materials involved. To differentiate the risks between various residue-processing combinations, an attempt is made to highlight the responses of the residue forms to different stresses. Airborne release fraction and respirable fraction factors are selected based on the best information available that would provide this separation between material forms. These values may be different from those used in the safety analysis documentation where the objectives are to "bound" potential releases. The technical bases for selection of these values are given in the next paragraph.

Assignment of the appropriate airborne release fractions and respirable fractions for residue materials was based on the categorization of the residue materials by pertinent physical characteristics that affect airborne suspension and assumption of the most suspendible form of the material. For the purposes of these analyses, the residue forms were categorized as follows:

- *Powders*—Ash residues; sand, slag, and crucible residues; fluoride residues; pyrochemical salt residues; and graphite residues
- *Surface Contamination on Solid Surfaces*—Combustible residues, including Ful Flo filter residues; glass residues; high-efficiency particulate air filter medium residues; inorganic residues
- *Metal*—Scrub alloy residues.

The accidents and the assumptions used to estimate the airborne release fraction and respirable fraction values are summarized in the following paragraphs.

Acetylene Explosion—This is an event that releases energy external to the residue material containers and generates a pressure impulse that impacts sealed 208-liter (L) (55-gallon [gal]) metal drums and gloveboxes nearby. It may displace or topple drums and gloveboxes and could potentially damage them. The displacement/toppling of the drums subjects both the surface contamination on the plastic wrap/container holding the residue materials and the residue materials themselves. The contamination displaced from the plastic wrap and the container can be vented by failure of the plastic wrap and can be released to the ambient atmosphere. The residue materials suspended inside the container have an additional barrier, the container seal, nonetheless, a conservative assumption is made that any materials airborne within the container also are vented.

- *Powder*—The values for suspension of a powder due to the impact of falling debris (DOE 1994a), an airborne release fraction of 1×10^{-3} with a respirable fraction of 0.1, are applied for residue materials categorized as powders. Two exceptions are noted for the respirable fraction of residue materials in this category:

- Unpublished test data for the respirable fraction for the finer fraction of pyrochemical salt residues, developed at Rocky Flats, indicate the respirable fraction for the residue does not exceed 0.001. This respirable fraction value is applied here, because the effects of explosions are not expected to further reduce the size of the material (i.e., make it more respirable).
- The size distribution of the initial fluoride residue are coarse and do not generate high respirable fractions under the accident stresses tested (e.g., thermal stress of fluoride powder generated overall respirable fractions ranging from 1×10^{-5} to 1×10^{-7}); therefore, a respirable fraction of 0.01 is applied here.

• *Surface Contamination on Solid Surfaces*—For residue materials categorized as surface contamination of solid surfaces, the airborne release fraction and respirable fraction values cited previously are also applied, except for the respirable fraction value for the high-efficiency particulate air filter medium residue. The high-efficiency particulate air filter medium is a very fine (4-micrometer diameter) glass fiber matrix. Larger airborne particles are collected on the surface on the mat and smaller particles are collected in the matrix. The collected particles tend to be agglomerated (stuck together). The finer fraction that would be part of the respirable fraction is surrounded and attached to the internal surfaces of the glass fiber and is difficult to suspend. Therefore, a respirable fraction value of 0.01 is applied for this material.

Table D–29 Airborne Release Fraction and Respirable Fraction Values for the Accident Scenarios at Rocky Flats

Accident	***Ash Residue*** [a]		***Pyro-Salts***		***Combustibles***		***Fluorides***		***Filter-Media***		***Glass Residue***		***Inorganic***		***Scrub Alloy*** [b]	
	ARF	***RF***	***ARF***	***RF***	***ARF***	***RF***	***ARF***	***RF***	***ARF***	***RF***	***ARF***	***RF***	***ARF***	***RF***	***ARF***	***RF***
Explosion	0.001	0.1	0.001	0.001	0.001	0.1	0.001	0.01	0.001	0.01	0.001	0.1	0.001	0.10	0.001	0.01
Dock Fire [c]	0.006	0.01	0.006	0.01	0.0005	1.00	0.001	0.001	0.006	0.01	0.006	0.01	0.006	0.01	0.006	0.01
Room Fire [d]	0.006	0.01	0.006	0.01	0.0005	1.00	0.001	0.001	0.006	0.01	0.006	0.01	0.006	0.01	0.006	0.01
Dock Spill	0.00008	0.5	0.00008	0.001	1.00×10^{-6}		0.00008	0.5	1.00×10^{-6}		1.00×10^{-6}		1.00×10^{-6}		1.00×10^{-6}	
Room Spill	0.00002	0.5	0.00002	0.001	See filter media		0.00002	0.01	Materials opened in the glovebox. No spill is considered						1.00×10^{-6}	
Glovebox Spill	0.00002	0.5	0.00002	0.001	1.00×10^{-6}		0.00002	0.01	1.00×10^{-6}		1.00×10^{-6}		1.00×10^{-6}		1.00×10^{-6}	
Earthquake Powder Spill [e]	0.002	0.3	0.002	0.3	0.001	0.1	0.002	0.3	0.002	0.3	0.001	0.1	0.001	0.1	0.001	0.1
Earthquake Liquid Spill	0.00005	0.7	0.00005	0.7	0.00005	0.7	0.00005	0.7	0.00005	0.7	0.00005	0.7	0.00005	0.7	0.00005	0.7

ARF = airborne release fraction RF = respirable fraction

[a] The airborne release fraction and respirable fraction values given for ash residues apply to graphites; sand, slag, and crucible; dried sludge residues; and other ash residues.

[b] A damage ratio of 0.01 is applied to scrub alloy. This is based on the assumption that less than 1 percent of the alloy undergoes corrosion on the surface of the metal. The values given below are for the surface corrosion/contamination products.

[c] Damage ratio of 1.0 for combustible and 0.01 for all others

[d] For graphites ARF=0.01, and RF=0.001, for Ful Flo filters ARF=0.0005 and RF=1.0. Damage ratio of 0.01 for the scrub alloy.

[e] For scrub alloy, the airborne release fraction value is applied to the surface corrosion; assume 1 percent of the mass is corroded, or a damage ratio of 0.01. The airborne release fraction and respirable fraction values do not include the potential for resuspension of particulates after the earthquake. A resuspension value of 1.92×10^{-4} needs to be added to all ARF×RF values.

- *Metal*—Only one residue material, scrub alloy, has the physical characteristics corresponding to the elastic-plastic deformation properties of metals. The shock-vibration stress induced by this event would not result in fragmentation of a metal and only corrosion products in particulate form on the outer surface of a metal would be affected. The respirable fraction has been diminished to reflect the assumption that less than 1 percent of the surface is corroded.

Dock Fire—The event postulated is an external fire that ignites the combustible materials in four sealed 208-L (55-gal) metal drums containing packaged residue materials. In most cases, the materials ignited are the combustible packaging materials. One category, combustibles, can ignite and burn and these materials are not always packaged inside the drums but are often a mixture of small plastic wrapped bundles of contaminated combustibles and loose potentially contaminated combustibles.

- *Powder*—Residue forms categorized as powder are predominantly plutonium oxide, a chemically unreactive material. The airborne release fraction and respirable fraction for this category of particles under thermal stress are 6×10^{-3} and 0.01, respectively (DOE 1994a). The airborne suspension for fluorides was experimentally measured, and the values—an airborne release fraction of 1×10^{-3} with a respirable fraction of 0.001—are applied here.

- *Surface Contamination on Solid Surface*—One material form in this category, combustibles, can be ignited, and the airborne release has been experimentally measured (DOE 1994a). An airborne release fraction of 5×10^{-4} with a conservative assumption of 1.0 for the respirable fraction are applied. The remaining materials are considered chemically unreactive particles under thermal stress, and the airborne release fraction and respirable fraction applied for powder is used.

- *Metal*—Although the aluminum alloy may melt at higher temperatures, the airborne release from the residue form is considered the suspension of a chemically inert particle resulting from corrosion (conservatively assumed to be 1 percent of the total mass of the material) of the alloy under thermal stress and the airborne release fraction and respirable fraction applied for powder is used.

Room Fire—The event postulated is the ignition of the combustible contents of sealed 208-L (55-gal) metal drums by an external heat source and the same airborne release fraction and respirable fraction values applied for the dock fire are used.

Dock Spill—Two events could result in the spill of the contents of the sealed 208-L (55-gal) metal drums during unloading. One or more drums could fall from the pallet during movement by a forklift and unseal by the force of the impact with the floor. The contents could spill from their containers due to the loss of the container seal and fall out of the containers due to the impact. The distance the material would spill is very small, less than 30 cm (1 ft).

The contents could be released by the inadvertent puncture of the drum and package by the forks of the vehicle during an attempt to off load the pallet. The forks are normally inserted at the bottom of the pallet and punctures near the base of the drum would be necessary for released material to fall from the drum after withdrawal of the forks. Since the level of the vehicle and dock are nearly at the same elevation, the fall distance for the material is less than 1 meter (3.3 ft).

- *Powder*—The maximum experimentally measured airborne release for a dry, cohesionless powder, with a density approximately that of plutonium oxide, for a fall distance of 1 m (3.3 ft) is an airborne release fraction of 8×10^{-5} with a respirable fraction of 0.5. These values are used for this category of residue material.

- *Surface Contamination on Solid Surfaces*—Under the conditions postulated (the puncture of the sealed 208-L [55-gal] metal drums and packaging by the forks of a forklift and the release of materials by withdrawal of the forks), the solid materials are not expected to fall from the drums except for incidental pieces that may be near the holes and are of the size to pass through the holes. Any suspension of the surface contamination would result from the shock-vibration due to the impact of the small piece with the floor. Some materials, such as combustibles, are not dense and their impact would not generate substantial forces. Therefore, the [airborne release fraction][respirable fraction] values of this material are assumed to be $\leq 1\times10^{-6}$. The combined airborne release fraction and respirable fraction values for surface-contaminated materials (filter media, glass residue, inorganic residues) are assumed to be less than those for the free-fall spill of a powder because the release from these material results from dislodgement by shock-vibration and suspension by turbulence generated by the falling object. Because the postulated scenario assumes that the drums are toppled during transport, even if these residue forms are released from the drums (which in reality have to pass through an inner container, two layers of plastic wrap, and the sealed metal drum), the material falls a short distance (inches) and rolls rather than impacting the hard, unyielding surface assumed for shock-vibration effects. Furthermore, the powder associated with high-efficiency particulate air filter media are attached to the surface of the medium in the filter frame, and the physical form of the filters discourages rolling.

  The combined value for the scrub alloy is based on the assumption that (1) the material is a metal that would not be deformed significantly by such a short fall and (2) the airborne release would only affect any surface corrosion products. Scrub alloy may be stored for appreciable periods of time before processing; some surface corrosion is inevitable and the [airborne release fraction] [respirable fraction] for shock vibration for surface contamination is 10^{-4}. If the corrosion is assumed to affect 1 percent of the total mass of scrub alloy, then the [airborne release fraction][respirable fraction] value of 10^{-6} is reasonably bounding for this phenomenon.

Room Spill—For powder-like residues in containers, a spill may occur inside the gloveboxes due to handling and pouring of the materials during the residue processing. The floors of the gloveboxes are elevated approximately 0.90 m (3 ft) in most cases to allow handling at the normal height for personnel. The potential fall distances are very small, ranging from a few centimeters (a few inches) during some pouring operations to 30 cm (1ft) if the container topples off a stand.

- *Powder*—The airborne release fraction and respirable fraction have been experimentally measured for the free-fall spill of dry, cohesionless powders of materials with high (uranium dioxide) and low (titanium dioxide) density with very fine size distributions of particles (the mass median diameters of both powders were approximately 1 to 2 micrometers geometric diameter). The minimum fall distance of 1 m (3.3 ft) was used. The airborne release fraction values ranged from 2×10^{-5} to 5×10^{-4} with respirable fraction values from 0.40 to 0.93 (DOE 1994a). Given that the maximum fall distance postulated for the event is approximately one-third the fall distance used in the experiments, the smallest measured value for the airborne release fraction of 2×10^{-5} and an average respirable fraction value for the data set of 0.5 are applied here. One exception is noted for fluoride residues; because of their demonstrated behavior, a respirable fraction of 0.01 is applied.

- *Surface Contamination on Solid Surfaces*—This category of materials is not bagged into the gloveboxes; the drum opening is inserted into the glovebox and the materials removed or poured onto the glovebox floor. Thus, spills are a normal activity during processing and are not considered an inadvertent event.

- *Metal*—Spills involving metal that exhibit elastic-plastic deformation falling short distances do not normally result in fragmentation of the metal. The impact with an unyielding surface could generate adequate shock-vibration forces to dislodge some particulate surface contamination. Because very little corrosion products on the outer surfaces of the scrub alloys are expected, an [airborne release fraction][respirable fraction] value of $\leq 1\times10^{-6}$ is applied.

Earthquake-Initiated Spill, Building 707—The event postulated is the complete failure of the structure and the spill of the glovebox contents due to toppling of the gloveboxes. It is assumed that materials are stored in sealed 208-L (55-gal) drums and that the metal drums fail. Crushing of the inner packages holding the residue materials is not anticipated due to the protection of the drums' contents by physical barriers.

- *Powders in the Glovebox*—It is assumed that residues in powder form may be in open containers and could be violently spilled during the toppling of the glovebox. The maximum measured values for the free-fall spill of dry, cohesionless particles for a distance of 3 m (10 ft) are an airborne release fraction of 2×10^{-3} with a respirable fraction of 0.3 (DOE 1994a) and are applied to this category of residues.

- *Surface Contamination on Solid Surfaces*—The suspension stress for this category of residue is the shock-vibration due to seismic acceleration, the impact of the glovebox with the floor due to toppling, and the impact of debris from the structure failure on the toppled glovebox structure. The maximum measured values for the impact of debris on powders are an airborne release fraction of 1×10^{-3} with a respirable fraction of 0.1 (DOE 1994a). For filter media, the powder values cited above were applied, due to a potential for the presence of fine, loose powder shaken from the media during handling and transport.

- *Metals in Glovebox*—The assumption is made that the shock-vibration forces described above suspend the surface corrosion products on the outer surface of the scrub alloy. It is conservatively assumed that 1 percent of the scrub alloy has corroded. Thus, the damage ratio is 0.01.

Earthquake-Initiated Free-Fall Spill, Building 371—For the operations in Building 371, all residue forms would be in liquid form due to the activities performed during processing (e.g., neutralization and shredding, sonic washing) and all materials are assigned the airborne release fraction and respirable fraction values for the release resulting from the free-fall spill of aqueous solutions, because the liquids are too dilute to act as slurries and are not viscous. Although the liquid is not a concentrated aqueous solution of heavy metal, it is assumed that the liquid would behave as such due to the presence of the heavy metal oxide particles. The maximum measured value for the free-fall spill of concentrated heavy metal solution from a 3-m (10-ft) or less height is 2×10^{-5} with a respirable fraction of 0.26 and 0.3 (DOE 1994a). Larger respirable fractions are found with other airborne release fraction values. For a respirable fraction value of 0.7, the maximum measured value, an airborne release fraction of 5×10^{-5} is applied here.

Earthquake-Initiated Fire, Building 371—At the acceleration level postulated for the design basis earthquake, analyses show that Building 371 would not fail. An airborne release would be due to the behavior and interaction of equipment and materials within the facility. The most severe consequences would result from the effect of fire initiated by the seismic event. Thus, the values cited for room fires are applicable to this situation.

Earthquake-Initiated Explosion, Building 371—As stated above, failure of the structure is not postulated for the design basis earthquake level of ground acceleration and the most severe consequences result from an explosion initiated by the seismic event.

D.3.3.3.2 Accident Scenarios Description and Source Terms at the Savannah River Site

❒ **Description of Accident Scenarios at the Savannah River Site—**The following facilities would be used to store or process Rocky Flats' plutonium residues at the Savannah River Site—F-Canyon (or H-Canyon), FB-Line (or HB-Line), plutonium storage facility, new special recovery facility, and Building 235 storage vault. The F-Canyon, FB-Line, new special recovery facility, and plutonium storage facility are part of the Building 221-F (or F-Canyon) structure. The H-Canyon and HB-Line are part of Building 221-H. Two processes will be used to separate the plutonium from the residues at the Savannah River Site: the mediated electrochemical oxidation process and the Purex process. In the mediated electrochemical oxidation process, the Rocky Flats plutonium residues are processed by dissolving ashes, graphite, and inorganics at the new special recovery facility; transferring the solution to the F-Canyon for separating and concentrating the plutonium solution; then pumping the solution to FB-Line for purification and solidification of plutonium metal (see the processing descriptions in Appendix C of this EIS). In the Purex process, the residues will be dissolved in the F-Canyon dissolvers and the process follows similar to the one stated earlier. The flow process at H-Canyon, in the mediated electrochemical oxidation process, starts with the dissolution of ashes, graphites, and inorganics in two new (to be installed later) silver dissolvers; thus is followed by the separation and concentration of plutonium; then the solution is pumped to the HB-Line facility for purification and oxidation, filtration, and separation of the plutonium oxide. The Purex process at H-Canyon can use the existing dissolvers, and the process will be similar to that of the mediated electrochemical oxidation process after the dissolution of residues. There are two main differences between the operations at F-Canyon and at H-Canyon. First, the final product from the H-Canyon processes is plutonium oxide powder, and that from F-Canyon is plutonium metal button. Second, when the Rocky Flats residues are processed at H-Canyon, the whole facility, including the HB-Line, will be dedicated to this operation; at F-Canyon, however, processing may be dedicated to the Rocky Flats residues or may include site-specific materials along with the Rocky Flats residues. Therefore, when the process becomes dissolver limited, the HB-Line operation will become intermittent.

Because processing operations at the Savannah River Site differ from those at Rocky Flats, process-dependent accident scenarios were postulated. These accident scenarios, defined in the following paragraphs, are applicable to the processing facilities as a whole (i.e., F-Canyon, H-Canyon, FB-Line, HB-Line, and new special recovery facilities). The mix of principal radionuclide releases from new special recovery, F-Canyon (H-Canyon), and FB-Line (HB-Line) was assumed to be similar to that of the Rocky Flats residues processed.

The consequences of potential accident scenarios for the vault and storage facilities are subsumed by the consequences of the hypothesized process accidents. This is because the repackaged residue materials received at the Savannah River Site would remain in their shipping containers while they are in storage vaults. The materials will be taken from the shipping containers outside of the storage vaults at the new special recovery, H-Canyon, or F-Canyon facility before being dissolved. Therefore, no accident scenarios that could result in releases comparable to those postulated for the processing were identified.

- *Explosion*—Two major explosions are postulated: hydrogen and ion exchanger explosions. In defining these explosion scenarios, the facility safety analysis reports as well as the DOE safety survey reports were reviewed to identify the bounding accident in one of the three facilities. Hydrogen explosion is bounded by the accident in the F-Canyon or the H-Canyon dissolver. The analysis of maximum hydrogen generation and explosion in the safety survey concluded the accident would not cause any building damage (DOE 1993c). The released materials would pass through the sand filter before entering the atmosphere. The probability of such an explosion was estimated to be 1.5×10^{-5}

per year (DOE 1993c). The combined [airborne release fraction][respirable fraction] for this accident was estimated to be 1×10^{-3} and would be independent of the type of materials dissolved. It was assumed that the dissolver content would be spread to the canyon floor.

An explosion in an ion exchange column in the FB-Line or HB-Line is postulated to result from a strong exothermic reaction between nitric acid and the base resin in the cation (or anion) exchange column during plutonium solution exchange. This would result in a thermally induced pressure failure of the ion exchange vessel and the resulting shrapnel would damage the product run tank and the product hold tank for this ion exchange pair. The explosion would breach the glovebox confinement. The plutonium in nitrite solution in the run and hold tanks would spill onto the cabinet floor and boil due to a subsequent resin fire. Based on the assumptions that the column was at its maximum load before the explosion and the maximum quantity of liquid at the maximum allowable concentration was present, the estimated release of plutonium through the sand filter and the stack was calculated to be 0.241 g of plutonium (DOE 1993b). The frequency of such an event is estimated to be 1×10^{-4} per year (DOE 1993b).

- *Fire*—In the F-Canyon safety analysis report (WSRC 1994) and the H-Canyon Basis for Interim Operation report (WSRC 1997), a fire was postulated to occur in the second plutonium cycle solvent extraction. The frequency of such a fire was estimated at 6.1×10^{-4} per year (WSRC 1994, WSRC 1997). The accident was assumed to burn the content of one tank. The material at risk, depending on the type of residue processed, would range from 1,000 to 12,000 g of plutonium. See **Table D–30** and **Table D–31** for details. The combined [airborne release fraction][respirable fraction] was estimated to be 1×10^{-2} (DOE 1994a). The airborne materials would pass through sand filter, with a leak path factor of 0.005, before entering the atmosphere.

Table D–30 Material at Risk, Airborne Release Fraction, Respirable Fraction, and Leak Path Factor Values for Savannah River Site F-Canyon Accident Scenarios

Accident	*Material at Risk* [a]								ARF×RF	LPF	Source Term (mg Pu)
	Ash MEO	*Ash Purex*	*SSC*	*Graphite*	*Salt-Scrub*	*Fluoride*	*Inorganic*	*Scrub Alloy*			
Explosion (hydrogen)	3	2	1	2	4	2	2	4	10^{-3}	0.005	Varies
Explosion (ion) [b]	180.75	120.5	60.25	120.5	241	120.5	120.5	241	N/A	N/A	Varies
Fire [c]	3	2	1	2	4	2	2	4	10^{-2}	0.005	Varies
Earthquake (F-Canyon)	9	6	3	6	12	6	6	12	0.000028 0.000019 [d]	0.10	Varies
Earthquake (FB-Line)	3	2	1	2	4	2	2	4	0.002 (p) [e] 0.0022 (m) 0.000047(l) 0(s)	0.10	Varies
Spill [f]	178	–	–	103	–	–	79	–	10^{-5}	0.005	Varies

MEO = mediated electrochemical oxidation SSC = sand, slag, and crucible ARF= airborne release fraction RF = respirable fraction
LPF = leak path factor Pu = plutonium N/A = not applicable

a The material-at-risk values are in terms of number of buttons produced. Each button is 2,000 g of plutonium.

b The values provided here are source term values in milligrams of plutonium released to the atmosphere through the stack. This value is arrived at by considering all combinations of accidents that follow an ion exchange explosion.

c Fire in the FB-Line would result in consequences that are a factor of 40 smaller than those presented here.

d This value corresponds to resuspended airborne respirable fraction. This number is added to 2.8×10^{-5} to get a combined value of 4.7×10^{-5} for the ARF×RF.

e These values include both the initial and resuspended ARF×RF values and p = powder, m = molten metal, l = liquid., and s = solid. (New buttons have no oxidation on the surface; thus, there is no release because of an earthquake.)

[f] The material-at-risk values given for the spill are in grams of plutonium.

Note: The combined value of ARF×RF is presented as opposed to individual values for each item as presented for Rocky Flats. This is because the ARF and RF values in Rocky Flats accident scenarios are material type and form dependent, whereas, those in Savannah River Site are in liquid (plutonium nitrite) or powder (plutonium oxide) form. The Savannah River Site ARF×RF values are independent of material type.

Table D–31 Material at Risk, Airborne Release Fraction, Respirable Fraction, and Leak Path Factor Values for Savannah River Site H-Canyon Accident Scenarios

Accident	*Material at Risk* [a]								*ARF×RF*	*LPF*	*Source Term (mg Pu)*
	Ash MEO	*Ash Purex*	*SSC*	*Graphite*	*Salt-Scrub*	*Fluoride*	*Inorganic*	*Scrub Alloy*			
Explosion (hydrogen)	6	1	1	4	6	1	4	6	10^{-3}	0.005	Varies
Explosion (ion) [b, c]	241	241	241	241	241	241	241	241	N/A	N/A	241
Fire [d]	6	3	3	6	6	3	6	6	10^{-2}	0.005	Varies
Earthquake (H-Canyon)	18	54	54	27	18	54	27	18	0.000028 0.000019 [e]	0.10	Varies
Earthquake (HB-Line) [c]	8	8	8	8	8	8	8	8	0.002 (p) [f] 0.000047 (1)	0.10	Varies
Spill [g]	178	–	–	103	–	–	79	–	10^{-5}	0.005	Varies

MEO = mediated electrochemical oxidation SSC = sand, slag, and crucible ARF= airborne release fraction RF = respirable fraction
LPF = leak path factor Pu = plutonium N/A = not applicable

[a] The material-at-risk values are in terms of number of cans produced. Each can is approximately 1,000 g of plutonium.

[b] The values provided here are source term values in milligrams of plutonium released to the atmosphere through the stack. This value is arrived at by considering all combinations of accidents that follow an ion exchange explosion.

[c] These values are for full and dedicated operation of HB-Line. These values need to be multiplied by the HB-Line duty cycle for each process. The duty cycles are as follows: ash Purex, and fluoride processes = 12.5%; graphite and inorganic processes = 60%; and ash MEO, salt scrub, and scrub alloy processes = 100%.

[d] Fire in the HB-Line would result in consequences that are a factor of 40 smaller than those presented here.

[e] This value corresponds to resuspended airborne respirable fraction. This number is added to 2.8×10^{-5} to get a combined value of 4.7×10^{-5} for the ARF×RF.

[f] These values include both the initial and resuspended ARF×RF values and p = powder and l = liquid.

[g] The material-at-risk values given for the spill are in grams of plutonium.

Note: The combined value of ARF×RF is presented as opposed to individual values for each item as presented for Rocky Flats. This is because the ARF and RF values in Rocky Flats accident scenarios are material type and form dependent, whereas, those in Savannah River Site are in liquid (plutonium nitrite) or powder (plutonium oxide) form. The Savannah River Site ARF×RF values are independent of material type.

- *Criticality*—A plutonium solution criticality was postulated. The criticality was assumed to consist of an initial burst of 1×10^{18} fissions in 0.5 seconds, followed at 10-minute intervals for the next 8 hours by bursts of 2×10^{17} fissions, for a total of 1×10^{19} fissions as specified in the Nuclear Regulatory Commission's Regulatory Guide 3.35 (NRC 1979) and NUREG-1320 (NRC 1988) and in the DOE-HDBK-3010-94 (DOE 1994a) report. The 10^{19} fission yield was based on the assumptions that the solution criticality occurred in a tank with a minimum volume of 3,785 L (100 gal) and that approximately 100 L of this volume evaporated due to heat released during the fission process. Based on the data provided in the DOE safety survey report (DOE 1993c), a 10^{19} criticality event in the FB-Line process would result in the bounding source term (Table D–28 gives the source terms). The frequency of such an event was estimated to be 1×10^{-4} per year, consistent with that used in the Rocky Flats analysis.

- *Earthquake*—Recent analyses of earthquake hazards at F-Canyon and H-Canyon indicate that a 0.24-g peak ground acceleration level earthquake—with a return period of 8,000 years (or a frequency of 1.25×10^{-4} per year) for the F-Canyon facility and a return period of 5,500 years (or a frequency of 1.82×10^{-4} per year) for the H-Canyon facility—could damage the structure and cause localized interior failures as well as interior and exterior wall cracks (DOE 1996c, DOE 1996d). Previous analyses of earthquake hazards at F-Canyon and H-Canyon estimated the consequences of such a magnitude earthquake with a higher frequency of occurrences—2×10^{-4} per year (DOE 1995a, WSRC 1994, and WSRC 1997). Using the assumptions in the F-Canyon H-Canyon Facility Safety Analysis Reports (WSRC 1994, WSRC 1997), a new source term was developed for an earthquake accident involving Rocky Flats residues. Given an earthquake, it was assumed that the plutonium contents in all the processes (F-Canyon and FB-Line or H-Canyon and HB-Line) would be spilled on the canyon floor (the total material at risk for each residue category is shown in Tables D–30 and D-31). It was further assumed that the airborne material would enter the environment through the building cracks, which are formed by the loss of sealant between the sections because of differential motion of the section, with a penetration leak path factor of 0.10.

- *Aircraft Crash*—The location of the F-Canyon or H-Canyon facility is far away from any airport; therefore, no takeoff and landing crash accidents need to be considered. The crashes that could occur during in-flight would need to be considered. According to the DOE Standard on aircraft crash analysis, DOE-STD-3014-96 (DOE 1996b), the expected crash frequency for the site is approximately 2×10^{-4} per square-mile per year from general aviation, 6×10^{-7} and 2×10^{-6} per square-mile per year from air carrier and air taxies, respectively, and 1×10^{-7} and 6×10^{-7} per square-mile per year from large military and small military aircraft, respectively. Using the building dimensions and the data provided in the DOE Standard for aircraft crash analysis, an upper bound frequency for an aircraft crash into the canyon buildings was estimated to be 4.6×10^{-6} and 1.5×10^{-7} per year for general aviation and commuter (air taxi) aircraft, respectively. These values were calculated without considering any site-specific effects (e.g., the topography and building structures around the facility). Considering the available skid distance of 60 m (200 ft) that an aircraft could skid before hitting the building, the frequency of an air taxi crashing into the building would be less than 10^{-8} per year. When only crashes that directly hit the structure were considered, general aviation aircraft would have the only estimated crash frequency greater than 10^{-7} per year. The F-Canyon or H-Canyon building is a maximum resistant construction structure designed to withstand a pressure of 47.9 kilopascal (1,000 lb/ft^2). Therefore, crashes of small aircraft (helicopter or a small observation/security aircraft) into these buildings are not expected to damage the buildings. If a general aviation aircraft were to crash into the buildings, its consequences (both in magnitude and frequency) would be smaller than that hypothesized for a design basis evaluation earthquake.

- *Spill*—An accidental spill was postulated. The scenario assumed that the operator accidentally dropped a plutonium powder container while unloading the materials from the shipping containers. The spill was assumed to occur at the new special recovery (or H-Canyon) facility's dissolver area because only materials opened in the new special recovery (or H-Canyon) facility would be in powder form. The materials in the shipping containers opened at the F-Canyon (or existing H-Canyon) dissolver area would be in powder form or solid form but are sealed in dissolvable cans and placed in the dissolvers without being opened; therefore, the consequences of any accidental drop of one of these cans would be subsumed by that of the powder spill. The workers handling the shipping containers and unpacking of the materials are required to wear respirators. The airborne materials would pass through sand filter before entering the atmosphere. The frequency of occurrence of a spill was estimated to be 1×10^{-2} per year, based on the human error probability of 1×10^{-3} of dropping a container, a probability of 1×10^{-2} that the container was improperly bagged and packaged, and an assumption that, on the average, a bag-in occurs once per shift (3 shifts/day × 5 days/week × 50 week/year). The material at risk was estimated to contain 206 g of powdered ash residues. The airborne release fraction and respirable fraction values for powder were estimated to be 2×10^{-5} and 0.5, respectively, consistent with those applied to the Rocky Flats event from materials and conditions.

- ❒ **Assessment of Material at Risk, Airborne Release Fraction, Respirable Fraction, and Leak Path Factor for Accidents at the Savannah River Site—**Tables D–30 and D–31 provide a summary of material at risk, airborne release fraction, respirable fraction, and leak path factor for accidents at the Savannah River Site. The material-at-risk values are representative of mass values for each material category that could be present at the time of an accident. These values are set based on the throughput of FB-Line (HB-Line) configuration to process the Rocky Flats residues. When a material at risk is less than the maximum value, it means that the Rocky Flats residues are being processed along with other Savannah River Site–specific materials. The values provided for the airborne release fraction and the respirable fraction are independent of the type of material processed. Therefore, for simplicity, a combined value is given for the airborne respirable fraction (i.e., [airborne release fraction]×[respirable fraction]).

  As mentioned previously, the same airborne release fraction and respirable fraction values are applied to the events at the Savannah River Site for the same materials as were applied at Rocky Flats (see Section D.3.3.1). For the cases where more than one phenomenon resulted in airborne releases from a single event (e.g., an ion exchange explosion event), a composite value for [airborne release fraction]× [respirable fraction], weighted for the fraction of the material at risk involved with each phenomenon, is provided.

D.3.3.3.3 Accident Scenarios Description and Source Term at Los Alamos National Laboratory

- ❒ **Description of Accident Scenarios at Los Alamos National Laboratory—**Rocky Flats plutonium residues (pyrochemical oxides salts) will be received, processed, and stored in the Los Alamos National Laboratory plutonium facility, Building 4, at Technical Area 55. Two processing technologies will be used at Los Alamos National Laboratory (salt distillation of molten salt extraction and electrorefining residue salts and water leach of direct oxide reduction residue salts). The accident scenarios evaluated for these processing technologies follow. They are similar to those analyzed at Rocky Flats and the Savannah River Site and are consistent with those analyzed in the Technical Area 55 final safety analysis report (LANL 1996).

  - *Explosions*—The Technical Area 55 safety analysis report considered two evaluation basis explosions: hydrogen explosions and ion exchange explosions (LANL 1996). Neither of these process-related explosions would breach the integrity of the gloveboxes proposed for the processing of the Rocky Flats residues because the proposed processing technologies do not use ion exchange and neither produce nor use hydrogen gas. The secondary impact from these explosions would have neither the energy nor the proximity to impact the proposed processing facilities.

  - *Criticality*—The material and the proposed technology limit the potential criticality event to a fully moderated and reflected solid metal (solid particles) criticality event. DOE Handbook, DOE-HDBK-3010-94 (DOE 1994a), identifies the fission yields for such an event as on the order of 10^{18} fissions (i.e., a single pulse) with no plutonium particulate evaporation. The fission gas and iodine released from such a criticality event will be a factor of 10 less than those provided previously in Table D–28. The frequency of such an event was assumed to be 1×10^{-4} per year, consistent with that used for the same event at Rocky Flats and the Savannah River Site.

- *Fire*—The accident scenario assumes a room fire that breaches glovebox confinement coupled with the loss of room ventilation. This accident scenario is similar to the fire scenarios analyzed in the Technical Area 55 safety analysis report (LANL 1996). The likelihood of a room fire in this safety analysis report was estimated to be between 10^{-6} to 10^{-2} per year. For consistency with the room fire scenario analyzed for Rocky Flats, a room fire frequency of 5×10^{-4} was assumed. Analysis of the effect of a bounding evaluation basis fire in the Technical Area 55 safety analysis report concluded that the evaluation basis fire accident would not damage the glovebox exhaust high-efficiency particulate air filter plenums; based on the building airflow, it was estimated that only 1.1 percent of the airborne materials would enter the environment without passing through at least two banks of high-efficiency particulate air filters. The same assumption of leak path factor (i.e., 0.011) will be used in this EIS. The material at risk for this EIS was assumed to be the supply for 1 week (4 days per week) of operation. The material at risk for the salt distillation technology is a two-week supply because the nominal batch size for the calcination process exceeds one-week of product from the distillation process.

- *Spill*—A room spill scenario similar to that used for the Savannah River Site operation is assumed. The airborne materials would pass through three banks of high-efficiency particulate air filters before entering the environment. The material at risk is assumed to be the plutonium content in one of the containers of the shipping cask. The frequency of occurrence of a spill is assumed to be 3×10^{-3} per year, based on the human error probability of 1×10^{-3} of dropping a container, on a probability of 1×10^{-2} that the container was improperly bagged and packaged, and on the average likelihood that a bag-in occurs once per shift (1 shift/day × 4 days/week × 50 weeks/year).

- *Earthquake*—An evaluation basis earthquake with a mean peak ground acceleration of 0.3 g was assumed. The frequency of such a magnitude earthquake was estimated at be 5×10^{-4} per year (or having a 2,000-year return period). The building structure is designed to withstand an earthquake of this magnitude (LANL 1996). Such an earthquake, however, would result in the collapse of some process enclosures (e.g., glovebox, storage tanks, pipes) caused by anchorage failure, support stands, or interaction with other equipment. These failures are assumed to result in a free fall of material at risk within these enclosures. The Technical Area 55 safety analysis did not identify any other secondary event (i.e., criticality, fire, or explosion) resulting from an earthquake. The airborne released materials were assumed to enter the environment through a leak path factor of 0.10. The material at risk is assumed to be the maximum amount of plutonium that could be in the glovebox at the time of accident.

❐ **Assessment of Air Release Fraction and Respirable Fraction Values for Accident at Los Alamos National Laboratory—**The residue materials processed at Los Alamos National Laboratory are in either powder or liquid slurry form. The airborne release fraction and respirable fraction values for the powder in similar accident scenarios given earlier for Rocky Flats and the Savannah River Site are applied here as well (see Sections D.3.3.3.1 and D.3.3.3.2 and Tables D–24 and D–25). For the liquid slurries, the combined [airborne release fraction]×[respirable fraction] values caused by an earthquake and a fire are estimated based on the data provided in the DOE Handbook (DOE 1994a). For an earthquake, a conservative combined value of 7×10^{-6} for [airborne release fraction]×[respirable fraction] is assigned. For a fire, a value of 6×10^{-5}, which corresponds to the airborne respirable fraction of powder in a fire accident, is assumed.

D.3.3.4 Storage Accident Scenario Descriptions and Source Terms

D.3.3.4.1 Alternative 1 - No Action

Under Alternative 1, the residues and scrub alloy will be stored for a period of 20 years in Rocky Flats Building 371 or in new Butler buildings. For the purpose of this storage analysis it is assumed that two 2,090 m^2 (22,500 ft^2) buildings, with a storage capacity of 11,250 drums per building (i.e., 500 drums per 93 m^2 (1,000 ft^2)), will be constructed in the protected area near Building 707 on previously disturbed land. Since the Butler building location has not been finalized, the EIS accident analysis assumed Building 707 coordinates for the location of releases from the Butler buildings. Following Alternative 1 processing and/or packaging, the plutonium residues and scrub alloy will be stored in either drummed pipe components, drums, 3013 containers, or convenience cans. **Table D–32** presents the storage configuration for Alternative 1.

Table D–32 Alternative 1 Storage

	Quantity		*Storage*			
				Location		
Material	*Pu (kg)*	*Drums*	*Drummed Pipe Component*	*Butler Building*	*Building 371 Vault*	*Storage Area (ft^2)*
Ash Residue	1,150	6,250	Yes	X		12,500
Salt Residue	994	6,509	Yes	X		13,018
Combustible Residue	21.3	916	No	X		1,832
Fluoride Residue	141	141 [a]	No		X	–
	0.4	10	No	X		20
Filter Media Residue	112	4,827	No	X		9,654
Sludge Residue	26.4	1,140	No	X		2,280
Glass Residue	0.06	7	Yes	X		14
Graphite Residue	96.4	575	Yes	X		1,150
Inorganic Residue	17.5	106	Yes	X		212
Scrub Alloy	200	276 [b]	No		X	–

[a] 3013 containers, not drums
[b] Convenience cans, not drums

❒ **Plutonium Residue and Scrub Alloy Vulnerability to Storage Accidents—** A spectrum of storage-related accidents were considered. The accidents were divided into two classes of accidents related to the handling of the drums and containers and accidents related to the storage in facilities. Handling accidents were dropped from further consideration because the consequences and risks of handling accidents are assessed for process-related accidents.

The selection of storage-related accidents considered the vulnerability of the Butler building and Building 371 to a spectrum of accidents. In addition, the robustness of the potential storage containers was also considered when screening accidents for further evaluation. The following representative set of storage-related accidents are evaluated in this EIS for Alternative 1, No Action.

- High Wind
- Large Aircraft Crash into Building
- Small Aircraft Crash into Building
- Room/Vault Fire
- Earthquake and Building Collapse

Table D–33 summarizes the vulnerability of the building and their applicable storage containers to the set of postulated accidents. **Table D–34** summarizes the vulnerability of the processed plutonium residues and scrub alloy in storage to the set of accidents.

Table D–33 Building and Storage Container Vulnerability

Accident	*Butler Building*			*Building 371*		
	Buildin g	*Storage in Drummed Pipe Component*	*Storage in Drum*	*Buildin g Vault*	*Storage in 3013 Container*	*Storage in Convenience Can*
High Wind	Yes	No	Yes	No	No	No
Large Aircraft Crash	Yes	Yes	Yes	Yes	Yes	Yes
Small Aircraft Crash	Yes	No	Yes	No	No	No
Room/Vault Fire	Yes	No	Yes	Yes	No	Yes
Earthquake and Building Collapse	Yes	No	Yes	Yes	Yes	Yes

Table D–34 Processed Plutonium Residue and Scrub Alloy Vulnerability During Storage

Material	*Stored Material Vulnerable to Accident*				
	High Wind	*Small Aircraft Crash*	*Large Aircraft Crash*	*Room/Vault Fire*	*Earthquake and Building Collapse*
Ash Residue [a]	No	No	No	No	No
Salt Residue	No	No	Yes	No	No
Combustible Residue	Yes [b]	Yes [b]	Yes	Yes	Yes [c]
Fluoride Residue [d]	No	No	Yes	No	Yes
Fluoride Residue [e]	Yes [b]	Yes [b]	Yes	Yes	Yes [c]
Filter Media Residue	Yes [b]	Yes [b]	Yes	Yes	Yes [c]
Sludge Residue	Yes [b]	Yes [b]	Yes	Yes	Yes [c]
Glass Residue	No	No	Yes	No	No
Graphite Residue	No	No	Yes	No	No
Inorganic Residue	No	No	Yes	No	No
Scrub Alloy	No	No	Yes	Yes	Yes

[a] Residue is cemented.
[b] The combustible, fluoride, filter media, and sludge residue stored in Butler buildings would not be vulnerable to the effects of the high wind and small aircraft accidents if all combustible, fluoride, filter media, and sludge residue drums were placed in the Butler building storage array configuration such that they were shielded from above and on the outer perimeter of the storage array configuration by drums that contain residue in pipe components. The analysis in this EIS took no credit for strategic placement of combustible, fluoride, filter media, and sludge residue drums in the Butler building storage array configuration.
[c] The combustible, fluoride, filter media, and sludge residue stored in Butler buildings would not be vulnerable to the effects of the earthquake and building collapse accident if all combustible, fluoride, filter media, and sludge residue drums were placed in the Butler building storage array configuration such that they were shielded from above, shielded on the outer perimeter of the storage array configuration, and shielded from building columns located within the storage array by drums that contain residue in pipe components. The analysis in this EIS took no credit for strategic placement of combustible, fluoride, filter media, and sludge residue drums in the Butler building storage array configuration.
[d] Stored in Building 371.
[e] Stored in Butler building.

❒ Accident Scenarios and Source Terms

Wind, Butler Building—The design basis straight wind for Performance Category (PC) 1 buildings at Rocky Flats is 175 km/hr (109 mi/hr) (DOE 1994b). The accident scenario postulated that high winds of 175 km/hr (109 mi/hr) breach the Butler storage buildings. While wind-driven missiles are not within the design basis for PC1 buildings, the scenario postulated that the 175 km/hr (109 mi/hr) wind picks up a 2x4 timber plank and the plank is driven into one of the Butler buildings with enough force to penetrate the building's steel siding. The analysis postulated that the wind-driven plank enters the building and breaches a single drum. Pipe components are not breached by the wind-driven plank. The analysis postulated that a drum containing combustible, fluoride, filter media, or sludge residue was breached and 10% of the contents was spilled. The conditional probability of the plank striking a drum containing either combustible, fluoride, filter media, or sludge residue was considered when estimating the accident risks. The analysis took no credit for strategic placement of combustible, fluoride, filter media, or sludge residue drums in the storage array configuration to reduce the source term. The accident source terms are presented in **Table D–35**.

Table D–35 High Wind Accident Source Term

Residue	*Mar Pu (g)*	*DR*	*ARF×RF*	*LPF*	*Source Term Pu (g)*	*Release Point*
Combustibles	23.2	0.1	1×10^{-6} [a]	1	2.32×10^{-6}	Ground
Fluoride	40.0	0.1	0.00004 [a]	1	0.00016	Ground
Filter Media	23.2	0.1	1×10^{-6} [a]	1	2.32×10^{-6}	Ground
Sludge	23.2	0.1	0.00004 [b]	1	0.0000928	Ground

MAR = material at risk DR = damage ratio ARF = airborne release fraction RF = respirable release fraction
LPF = leak path factor
[a] Source: Table D–29.
[b] Dry powder, assumed same as ash.

High Wind, Building 371—High winds and tornado-generated missiles do not damage Building 371 leading to a release (EG&G 1995).

Large Aircraft Crash—Using data derived from upper bound estimates for Building 707, it was determined that the frequency with which a large commercial aircraft and/or a high-powered military aircraft would crash into a Butler storage building was less than 1×10^{-7}. Section D.3.3.3.1 stated that for Building 371, the frequency was also less than 1×10^{-7}. Accidents with a frequency less than 1×10^{-7} are considered not reasonably foreseeable. Since the annual frequency for this accident is in the not reasonably foreseeable range, the accident consequences and risks were not evaluated.

Small (General Aviation) Aircraft Crash, Butler Building—The scenario postulated that: 1) The aircraft engine penetrated the building, up to six drums are breached by the impact of the engine, and a fire results from the aircraft fuel. 2) The aircraft engine would not breach any pipe components. 3) The fire would not cause the breach of additional drums due to the limited availability of combustibles in the Butler building storage area, the small amount of fuel available in the aircraft fuel tanks, the ability of the building's steel walls and roof to remove heat (i.e., transfer outside of building) from the fire, and the large area of the building available to dissipate the heat from the fire.

Only drums containing combustible, fluoride, filter media, and sludge residue are vulnerable to the postulated accident scenario. To assess the maximum consequence for the accident, the analysis assumed that either six combustible residue drums or six fluoride drums or six filter media drums or six sludge drums were breached by the aircraft engine and the breached drums were involved in the fire. The conditional probability of the aircraft engine striking drums containing either combustible, fluoride, filter media, or sludge residue was considered when estimating the accident risks. The analysis took no credit for strategic placement of combustible, fluoride, filter media, and sludge residue drums in the storage array configuration to reduce the source term. The accident source terms are presented in **Table D–36**.

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Table D–36 Small Aircraft Accident Source Term

Residue	*Mar Pu (g)*	*DR*	*ARF×RF*	*LPF*	*Source Term Pu (g)*	*Release Point* [c]
Combustibles	139 [a]	1	0.0005 [c]	1	0.0696	Ground
Fluoride	240 [b]	1	1×10^{-6} [c]	1	0.000240	Ground
Filter Media	139 [a]	1	0.00006 [c]	1	0.00835	Ground
Sludge	139 [a]	1	0.00006 [d]	1	0.00835	Ground

MAR = material at risk DR = damage ratio ARF = airborne release fraction RF = respirable release fraction
LPF = leak path factor
[a] 23.2 g plutonium per drum.
[b] 40.0 g plutonium per drum.
[c] Source: Table D–29
[d] Dry powder, assumed same as ash.
[e] The analysis took no credit for the fire's thermal plume to reduce accident consequences.

Small (General Aviation) Aircraft Crash, Building 371—The aircraft will not penetrate the Building 371.

Room Fire, Butler Building—The scenario postulated a non-mechanistic room fire in the open storage area. Due to the limited availability of combustibles in the Butler building storage area, the ability of the building's steel walls and roof to remove heat (i.e., transfer outside of building) from the fire, and the large area of the building available to dissipate the heat from the fire; the analysis assumed that the fire was very limited and would breach less than 0.1% of the drums in storage. The analysis also assumed that the fire would not breach pipe components. Only drums containing combustible, fluoride, filter media, and sludge residue are vulnerable to the postulated accident scenario. To assess the maximum consequence for the accident, the analysis assumed the combustible, fluoride, filter media, and sludge residue were stored in the same building, one combustible residue drum, one fluoride drum, five filter media drums, and two sludge drums were breached, and the contents of the drums were exposed to the fire. The accident source terms are presented in **Table D–37**.

Table D–37 Butler Building Room Fire Accident Source Term

Residue	Mar Pu (g)	DR	ARF×RF	LPF	Source Term Pu (g)	Release Point
Combustibles	23.2 [a]	1	0.0005 [c]	1	0.0116	Ground
Fluoride	40.0 [b]	1	1×10^{-6} [c]	1	0.0000400	Ground
Filter Media	116 [a]	1	0.00006 [c]	1	0.00696	Ground
Sludge	46.4 [a]	1	0.00006 [d]	1	0.00278	Ground

MAR = material at risk DR = damage ratio ARF = airborne release fraction RF = respirable release fraction
LPF = leak path factor
[a] 23.2 g plutonium per drum.
[b] 40.0 g plutonium per drum.
[c] Source: Table D–29
[d] Dry powder, assumed same as ash.

Vault Fire, Building 371—The scenario postulated a fire in the vault area. Due to the limited availability of combustibles in the vault area, the analysis assumed that the fire was very limited and would breach less than 0.1% of the convenience cans in storage. The analysis also assumed that the fire would not breach 3013 inner containers. Only convenience cans containing scrub alloy are vulnerable to the postulated accident scenario. To assess the maximum consequence for the accident, the analysis assumed that one convenience can inner container was breached and the contents exposed to the fire. The accident source term is presented in **Table D–38**.

Table D–38 Building 371 Vault Fire Accident Source Term

Material	Mar Pu (g)	DR [a]	ARF×RF	LPF	Source Term Pu (g)	Release Point
Scrub Alloy	725 [b]	0.01	0.00006	0.1	0.0000435	Ground

MAR = material at risk DR = damage ratio ARF = airborne release fraction RF = respirable release fraction
LPF = leak path factor
[a] For scrub alloy, the ARF value is applied to the surface corrosion; assume 1% of the mass is corroded, or a DR of 0.01. Reference Table D–29.
[b] 725 g plutonium per convenience can.

Earthquake and Butler Building Collapse–The scenario postulated that the earthquake collapsed the Butler storage buildings. Butler buildings have a light-weight structure and it is unlikely that collapse of the building will breach any of the drums. However for the purpose of this EIS, the analysis conservatively postulated that falling structural elements breached 1% of the drums. Pipe components in breached drums were not breached. The analysis also postulated that 10% of the combustible, fluoride, filter media, and sludge residue spilled out of the breached drums and were released. The analysis took no credit for strategic placement of combustible, fluoride, filter media, and sludge residue drums in the storage array configuration to reduce the accident source term. The accident source term is presented in **Table D–39**.

Table D–39 Earthquake and Butler Building Collapse Accident Source Term

Residue	*Mar Pu (kg)*	*DR*	*ARF×RF* [a]	*LPF*	*Source Term Pu (g)*	*Release Point*
Combustibles	21.3	0.01×0.1	0.000193	1	0.00411	Ground
Fluoride	0.4	0.01×0.1	0.000232	1	0.0000928	Ground
Filter Media	112	0.01×0.1	0.000193	1	0.0216	Ground
Sludge	26.4	0.01×0.1	0.000232 [b]	1	0.00612	Ground

MAR = material at risk   DR = damage ratio   ARF = airborne release fraction
RF = respirable release fraction   LPF = leak path factor
[a] The ARF×RF product for a spill is assumed equivalent to a dock spill. The ARF×RF product does not include the potential for resuspension of particulates after an earthquake. A resuspension value of 0.000192 needs to be added to all ARF×RF values. Reference Table D–29.
[b] Dry powder, assume same as ash.

Earthquake and Building 371 Collapse—The scenario postulated that the earthquake collapsed Building 371. The analysis conservatively postulated that 100% of the convenience cans and 1% of the 3013 containers were breached by the falling building debris. The accident source term is presented in **Table D–40**.

Table D–40 Earthquake and Building 371 Collapse Accident Source Term

Material	*Mar Pu (kg)*	*DR*	*ARF×RF*	*LPF*	*Source Term Pu (g)*	*Release Point*
Fluoride Residue	141	0.01	0.000792	0.1	0.112	Ground
Scrub Alloy	200	0.01 [a]	0.000292	0.1	0.0584	Ground

MAR = material at risk   DR = damage ratio   ARF = airborne release fraction   RF = respirable release fraction
LPF = leak path factor
[a] For scrub alloy, the ARF value is applied to the surface corrosion; assume 1% of the mass is corroded, or a DR of 0.01. Reference Table D–29.

- **Accident Frequency—** Accident frequencies were derived for each of the accidents. For the Butler Building high wind and small aircraft crash accidents, the building accident frequency was apportioned on units of storage area to calculate the frequency of a wind-driven missile or an aircraft impacting a specific cluster of storage drums. The analysis assumed residues would be processed, if necessary, and packaged on a campaign basis and stored as a cluster of drums in the storage area rather than being randomly dispersed throughout the facility. **Table D–41** presents the accident frequency for each of the storage buildings. **Table D–42** breaks down the accident frequency by the category of stored material.

Table D–41 Accident Frequency by Storage Building

Accident	*Accident Frequency (per year)*	
	Butler Building	*Building 371*
High Wind	0.02 (DOE 1994b) $4.44\times10^{-7}/ft^2$ of storage area [a]	N/A
Large Aircraft Crash	1×10^{-8}/building [b]	less than 1×10^{-7} [c]

Accident	Accident Frequency (per year)	
	Butler Building	Building 371
Small Aircraft Crash	3×10^{-6}/building [b] 1.33×10^{-10}/ft^2 of storage area	0.00004 [c]
Room/Vault Fire	0.00001/building [d]	1×10^{-6} (CID 1997) [e]
Earthquake and Building Collapse	0.002 (CID 1997)	0.000094 [c]

N/A = Not applicable.
[a] Wind-driven missile impacts a drum in storage area.
[b] Derived from upper bound estimates for Building 707 presented in Section D.3.3.3.1.
[c] Source: Section D.3.3.3.1.
[d] Estimated one order of magnitude more likely than a special nuclear material (SNM) vault fire.
[e] SNM vault fire.

Table D–42 Accident Frequency for Storage of Plutonium Residues and Scrub Alloy

Material	Accident Annual Frequency				
	High Wind	Small Aircraft Crash	Large Aircraft Crash	Room/Vault Fire	Earthquake and Building Collapse
Ash Residue	N/A	N/A	N/A	N/A	N/A
Salt Residue	N/A	N/A	N/A	N/A	N/A
Combustible Residue	0.000813	2.44×10^{-7}	N/A	0.00001	0.002
Fluoride Residue Stored in Bldg. 371	N/A	N/A	N/A	N/A	0.000094
Fluoride Residue Stored in Butler Bldg.	8.89×10^{-6}	2.67×10^{-9}	N/A	0.00001	0.002
Filter Media Residue	0.00429	1.29×10^{-6}	N/A	0.00001	0.002
Sludge Residue	0.00101	3.03×10^{-7}	N/A	0.00001	0.002
Glass Residue	N/A	N/A	N/A	N/A	N/A
Graphite Residue	N/A	N/A	N/A	N/A	N/A
Inorganic Residue	N/A	N/A	N/A	N/A	N/A
Scrub Alloy	N/A	N/A	N/A	1×10^{-6}	0.000094

N/A = not applicable

D.3.3.4.2 Alternative 2 – Processing Without Plutonium Separation

Following processing of plutonium residues and scrub alloy at Rocky Flats using Alternative 2 processing technologies, the processed material is packaged in pipe components and drummed prior to movement to an interim storage area or staging area for shipment to WIPP. For the purpose of this EIS, the analysis assumed that the packaged material will be stored in Butler Buildings similar to those described in Section D.3.3.4.1. **Table D–43** presents the storage configuration for each Alternative 2 process technology.

Table D–43 Alternative 2 Storage

Material	Process Technology	Storage		
			Location	
		Drummed Pipe Component	Butler Building	Building 371 Vault
Ash Residue	Calcination/Vitrification	Yes	X	
	Blend Down	Yes	X	
	Cold Ceramification	Yes	X	
Salt Residue	Blend Down	Yes	X	
Combustible Residue	Blend Down	Yes	X	
	Catalytic Chemical Oxidation	Yes	X	
	Sonic Wash	Yes	X	
Fluoride Residue	Blend Down	Yes	X	
Filter Media Residue	Calcination/Vitrification	Yes	X	
	Blend Down	No [a]	X	
	Sonic Wash	Yes	X	

Material	Process Technology	Storage		
		Drummed Pipe Component	Location	
			Butler Building	Building 371 Vault
Sludge Residue	Calcination/Vitrification	Yes	X	
	Blend Down	Yes	X	
Glass Residue	Calcination/Vitrification	Yes	X	
	Blend Down	Yes	X	
	Sonic Wash	Yes	X	
Graphite Residue	Calcination/Vitrification	Yes	X	
	Blend Down	Yes	X	
	Cementation	Yes	X	
Inorganic Residue	Calcination/Vitrification	Yes	X	
	Blend Down	Yes	X	
Scrub Alloy	Calcination/Vitrification	Yes	X	

[a] Stored in drummed convenience can.

❐ **Plutonium Residue and Scrub Alloy Vulnerability to Storage Accidents -** The same spectrum of storage-related accidents discussed in Section D.3.3.4.1 were considered.

Table D–44 summarizes the vulnerability of the Butler building and the drummed pipe components to the set of postulated accidents. **Table D–45** summarizes the vulnerability of the processed plutonium residues and scrub alloy in storage to the set of accidents. As discussed in Section D.3.3.4.1, the annual frequency for the large aircraft crash is in the not reasonably foreseeable range and the accident consequences are not evaluated.

Table D–44 Butler Building and Storage Container Vulnerability

Accident	Vulnerability		
	Butler Building	Material Stored in Drummed Pipe Component	Material Stored in Drummed Convenience Can
High Wind	Yes	No	Yes
Small Aircraft Crash	Yes	No	Yes
Room Fire	Yes	No	Yes
Earthquake and Building Collapse	Yes	No	Yes

Table D–45 Processed Plutonium Residue and Scrub Alloy Vulnerability During Storage

Material	*Stored Material Vulnerable to Accident*			
	High Wind	***Small Aircraft Crash***	***Room Fire***	***Earthquake and Building Collapse***
Ash Residue	No	No	No	No
Salt Residue	No	No	No	No
Combustible Residue	No	No	No	No
Fluoride Residue	No	No	No	No
Filter Media Residue	Yes [a]	Yes [a]	Yes [a]	Yes [a]
Sludge Residue	No	No	No	No
Glass Residue	No	No	No	No
Graphite Residue	No	No	No	No
Inorganic Residue	No	No	No	No
Scrub Alloy	No	No	No	No

[a] Filter media residue processed using the blend down technology.

❒ **Accident Scenarios and Source Terms—** Table D–44 and Table D–45 indicate that only filter media residue processed using the blend down technology is vulnerable to the postulated set of accidents. 112 kg of residue will be stored in 4,787 drums.

High Wind, Butler Building—The analysis postulated that a drum containing filter media residue was breached and 10% of the contents was spilled. The conditional probability of the plank striking a drum containing filter media residue was considered when estimating the accident risks. The analysis took no credit for strategic placement of filter media residue drums in the storage array configuration to reduce the source term. The accident source terms are presented in **Table D–46.**

Table D–46 High Wind Accident Source Term

Residue	*MAR Pu (g)*	*DR*	*ARF×RF*	*LPF*	*Source Term Pu (g)*	*Release Point*
Filter Media	23.2	0.1	1×10^{-6} [a]	1	2.32×10^{-6}	Ground

MAR = material at risk DR = damage ratio ARF = airborne release fraction RF = respirable release fraction
LPF = leak path factor
[a] Source: Table D–29.

Small (General Aviation) Aircraft Crash, Butler Building–The analysis assumed that six filter media drums were breached by the aircraft engine and the breached drums were involved in the fire. The conditional probability of the aircraft engine striking drums containing filter media residue was considered when estimating the accident risks. The analysis took no credit for strategic placement of filter media residue drums in the storage array configuration to reduce the source term. The accident source terms are presented in **Table D–47.**

Table D–47 Small Aircraft Accident Source Term

Residue	*MAR Pu (g)*	*DR*	*ARFxRF*	*LPF*	*Source Term Pu (g)*	*Release Point* [c]
Filter Media	139 [a]	1	0.00006 [b]	1	0.00835	Ground

MAR = material at risk DR = damage ratio ARF = airborne release fraction RF = respirable release fraction
LPF = leak path factor
[a] 23.2 g plutonium per drum.
[b] Source: Table D–29
[c] The analysis took no credit for the fire's thermal plume to reduce accident consequences.

Room Fire, Butler Building—The analysis assumed five filter media drums were breached and the contents of the drums were exposed to the fire. The accident source terms are presented in **Table D–48**.

Table D–48 Butler Building Room Fire Accident Source Term

Residue	*MAR Pu (g)*	*DR*	*ARF×RF*	*LPF*	*Source Term Pu (g)*	*Release Point*
Filter Media	116 [a]	1	0.00006 [b]	1	0.00696	Ground

MAR = material at risk DR = damage ratio ARF = airborne release fraction RF = respirable release fraction
LPF = leak path factor
[a] 23.2 g plutonium per drum.
[b] Source: Table D–29.

Earthquake and Butler Building Collapse—The analysis postulated that 10% of the filter media residue spilled out of the breached drums and were released. The analysis took no credit for strategic placement of filter media residue drums in the storage array configuration to reduce the accident source term. The accident source term is presented in **Table D–49**.

Table D–49 Earthquake and Butler Building Collapse Accident Source Term

Residue	*MAR Pu (kg)*	*DR*	*ARF×RF* [a]	*LPF*	*Source Term Pu (g)*	*Release Point*
Filter Media	112	0.01×0.1	0.000193	1	0.0216	Ground

MAR = material at risk DR = damage ratio ARF = airborne release fraction RF = respirable release fraction
LPF = leak path factor
[a] The ARF×RF product for a spill is assumed equivalent to a dock spill. The ARF×RF product does not include the potential for resuspension of particulates after an earthquake. A resuspension value of 0.000192 needs to be added to all ARF×RF values. Reference Table D–29.

❒ **Accident Frequency—** Accident frequencies presented in **Table D-50** were derived using Table D-41.

Table D–50 Accident Frequency for Storage of Filter Media Residue Processed Using the Blend Down Technology

Material	*Accident Annual Frequency*				
	High Wind	*Small Aircraft Crash*	*Large Aircraft Crash*	*Room/Vault Fire*	*Earthquake and Building Collapse*
Filter Media Residue	0.00429	1.29×10^{-6}	N/A	0.00001	0.002

D.3.3.4.3 Alternative 3 – Processing With Plutonium Separation

Plutonium residues and scrub alloy can be processed using Alternative 3 process technologies at Rocky Flats, the Savannah River Site, and the Los Alamos National Laboratory. The processing of plutonium residues and scrub alloy at the Savannah River Site or the Los Alamos National Laboratory requires preprocessing and/or packaging at Rocky Flats. Alternative 3 storage assessments address the following issues:

- storage after processing with plutonium separation at Rocky Flats,
- storage at Rocky Flats after preprocessing and/or packaging for offsite processing at the Savannah River Site or the Los Alamos National Laboratory,
- storage after processing with plutonium separation at the Savannah River Site, and
- storage after processing with plutonium separation at the Los Alamos National Laboratory.

Table D–51 presents the storage configuration for each Alternative 3 process technology.

Table D–51 Alternative 3 Storage

		Quantity		*Storage Location*				
Material	*Process Technology*	*Pu (kg)*	*Storage Containers*	*RF Butler Bldg.*	*RF Bldg. 371 Vault*	*SRS APSF Vault*	*LANL TA-55 Storage*	*LANL TA-55 Vault*
Ash Residue	Preprocess at RF and Purex at SRS (Incinerator Ash)	890	3,475 [a]		X			
		890	[b]			X		
	Preprocess at RF and MEO at SRS (Incinerator Ash and Graphite Fines)	974	2,740 [a]		X			
		974	[b]			X		
	Preprocess at RF and Purex at SRS (SS&C)	128	760 [a]		X			
		128	[b]			X		
Salt Residue	Salt Distillation at RF (ER & MSE)	804	269 [b]		X			
	Preprocess at RF and Salt Distillation at LANL (ER & MSE)	804	1,885 [a]		X			
		792	264 [b]					X
		12.3	338 [d]				X	
	Water Leach at RF (ER & MSE)	780	223 [a]		X			
		24	126 [c]	X				
	Water Leach at RF (DOR)	182	52 [b]		X			
		6	31 [c]	X				
	Preprocess at RF and Water Leach at LANL (DOR)	188	459 [a]		X			
		188	47 [b]					X
	Preprocess at RF and Acid Dissolution at LANL (DOR)	188	459 [a]		X			
		188	188 [b]					X
		0.7	162 [d]				X	
	Salt Scrub at RF and Purex at SRS	964	986 [e]		X			
		28	408 [d]	X				

Material	Process Technology	Quantity		Storage Location				
		Pu (kg)	Storage Containers	RF Butler Bldg.	RF Bldg. 371 Vault	SRS APSF Vault	LANL TA-55 Storag e	LANL TA-55 Vault
		964	[b]			X		
Combustible Residue	MEO at RF	0.1	53 [f]	X				
		20.9	7 [b]		X			
Fluoride Residue	Acid Dissolution at RF	0.4	10 [g]	X				
		141	141 [b]		X			
	Preprocess at RF and Purex at SRS	141	188 [a]		X			
		141	[b]			X		
Filter Media Residue	MEO at RF	1	129 [f]	X				
		109	37 [b]		X			
Sludge Residue	Acid Dissolution at RF	0.1	19 [g]	X				
		25.3	26 [b]		X			
Glass Residue	MEO at RF	0.1	7 [f]	X				
		4.9	2 [b]		X			
Graphite Residue	MEO at RF	0.1	104 [f]	X				
		95.3	32 [b]		X			
	Preprocess at RF and MEO at SRS	96.4	470 [a]		X			
		96.4	[b]			X		
Inorganic Residue	MEO at RF	0.2	23 [f]	X				
		17.1	6 [b]		X			
	Preprocess at RF and MEO at SRS	17.5	111 [a]		X			
		17.5	[b]			X		
Scrub Alloy	Preprocess at RF and Purex at SRS	200	200 [e]		X			
		200	[b]			X		

MEO = mediated electrochemical oxidation SRS = Savannah River Site RF = Rocky Flats Environmental Technology Site
LANL = Los Alamos National Laboratory TA = technical area APSF = Actinide Packaging and Storage Facility
DOR = direct oxide reduction salt residue ER & MSE = electrorefining and molten salt extraction salt residue
SS&C = sand, slag, and crucible ash residue
[a] 9975 containers
[b] 3013 containers
[c] 8802 container and convenience can drummed
[d] Drummed pipe components
[e] 6M containers
[f] Cemented and drummed
[g] Convenience cans drummed.

❒ **Storage After Processing With Plutonium Separation at Rocky Flats—Table D–52** identifies storage configuration for the residues stored at Rocky Flats following the processing, using Alternative 3 plutonium separation technologies, and packaging.

Table D–52 Alternative 3 Storage After Processing at Rocky Flats

Material	*Quantity Pu (kg)*	*Storage Container*	*Storage Location*	
			Butler Building	*Building 371 Vault*
Ash Residue	0	N/A		
ER & MSE Salt Residue	780	9975 Container		X
	24	8802 Container and Convenience Can Drummed	X	
DOR Salt Residue	182	9975 Container		X
	6	8802 Container and Convenience Can Drummed	X	
Combustible Residue	0.1	Cemented and Drummed	X	
	20.9	3013 Container		X
Fluoride Residue	0.4	Convenience Cans Drummed	X	
	141	3013 Container		X
Filter Media Residue	1	Cemented and Drummed	X	
	109	3013 Container		X
Sludge Residue	0.1	Convenience Cans Drummed	X	
	25.3	3013 Container		X
Glass Residue	0.1	Cemented and Drummed	X	
	4.9	3013 Container		X
Graphite Residue	0.1	Cemented and Drummed	X	
	95.3	3013 Container		X
Inorganic Residue	0.2	Cemented and Drummed	X	
	17.1	3013 Container		X
Scrub Alloy	0	N/A		

DOR = direct oxide reduction salt residue ER & MSE = electrorefining and molten salt extraction salt residue
N/A = not applicable.

Plutonium Residue Vulnerability to Storage Accidents—The same set of storage-related accidents discussed in Section D.3.3.4.1 were considered. **Table D–53** summarizes the vulnerability of the building and their applicable storage containers to the set of postulated accidents and **Table D–54** summarizes the vulnerability of the processed plutonium residues in storage to the set of accidents. As discussed in Section D.3.3.4.1, the annual frequency for the large aircraft crash at Rocky Flats is in the not reasonably foreseeable range and the accident consequences are not evaluated.

Table D–53 Building Storage Container Vulnerability

Accident	*Butler Building*			*Building 371 Vault*	
	Storage in Drummed 8802 Container and Convenience Can	***Storage in Drummed Convenience Can***	***Cemented Residue Storage in Drum***	***Storage in 3013 Container***	***Storage in 9975 Container***
High Wind	Yes	Yes	No	No	No
Small Aircraft Crash	Yes	Yes	No	No	No
Room/Vault Fire	Yes	Yes	No	No	No
Earthquake and Building Collapse	Yes	Yes	No	Yes	Yes

Table D–54 Processed Plutonium Residue Vulnerability During Storage

Material	*Location*	*Stored Material Vulnerable to Accident*			
		High Wind	***Small Aircraft Crash***	***Room/Vault Fire***	***Earthquake and Building Collapse***
Ash Residue	N/A	–	–	–	–
Salt Residue	Butler Bldg.	Yes	Yes	Yes	Yes
	Bldg. 371 Vault	No	No	No	Yes
Combustible Residue	Butler Bldg.	No	No	No	No
	Bldg. 371 Vault	No	No	No	Yes
Fluoride Residue	Butler Bldg.	Yes	Yes	Yes	Yes
	Bldg. 371 Vault	No	No	No	Yes
Filter Media Residue	Butler Bldg.	No	No	No	No
	Bldg. 371 Vault	No	No	No	Yes
Sludge Residue	Butler Bldg.	Yes	Yes	Yes	Yes
	Bldg. 371 Vault	No	No	No	Yes
Glass Residue	Butler Bldg.	No	No	No	No
	Bldg. 371 Vault	No	No	No	Yes
Graphite Residue	Butler Bldg.	No	No	No	No
	Bldg. 371 Vault	No	No	No	Yes
Inorganic Residue	Butler Bldg.	No	No	No	No
	Bldg. 371 Vault	No	No	No	Yes
Scrub Alloy	N/A	–	–	–	–

N/A = not applicable

Accident Scenarios and Source Terms—The accident scenarios are described in Section D.3.3.4.1.

High Wind, Butler Building—The analysis postulated that a drum containing salt, or fluoride, or sludge residues was breached and 10% of the contents was spilled. The accident source terms are presented in **Table D–55**.

Table D–55 High Wind Accident Source Term

Residue	*Mar Pu (g)*	*DR*	*ARF×RF*	*LPF*	*Source Term Pu (g)*	*Release Point*
ER & MSE Salt	188	0.1	8×10^{-8} [a]	1	1.50×10^{-6}	Ground
DOR Salt	194	0.1	8×10^{-8} [a]	1	1.55×10^{-6}	Ground
Fluoride	39.6	0.1	0.00004 [a]	1	0.000158	Ground
Sludge	5.3	0.1	0.00004 [b]	1	0.0000212	Ground

MAR = material at risk DR = damage ratio ARF = airborne release fraction RF = respirable release fraction

LPF = leak path factor DOR = direct oxide reduction salt residue
ER & MSE = electrorefining and molten salt extraction salt residue
[a] Source: Table D–29
[b] Source: Table D–29, residue was calcinated. Dry powder, assumed same as ash.

High Wind, Building 371—The postulated wind-driven missile will not penetrate Building 371.

Small (General Aviation) Aircraft Crash, Butler Building—To assess the maximum consequence for the accident, the analysis assumed that either six salt residue drums, six fluoride residue drums, or six sludge residue drums were breached by the aircraft engine and the breached drums were involved in the fire. The accident source terms are presented in **Table D–56**.

Table D–56 Small Aircraft Accident Source Term

Residue	*Mar Pu (g)*	*DR*	*ARF×RF*	*LPF*	*Source Term Pu (g)*	*Release Point* [c]
ER & MSE Salt	1,128	1	0.00006 [a]	1	0.0677	Ground
DOR Salt	1,164	1	0.00006 [a]	1	0.0698	Ground
Fluoride	238	1	1.0×10^{-6} [a]	1	0.000238	Ground
Sludge	31.8	1	0.00006 [b]	1	0.00191	Ground

MAR = material at risk DR = damage ratio ARF = airborne release fraction RF = respirable release fraction
LPF = leak path factor DOR = direct oxide reduction salt residue
ER & MSE = electrorefining and molten salt extraction salt residue
[a] Source: Table D–29
[b] Source: Table D–29, residue was calcinated.
[c] The analysis took no credit for the fire's thermal plume to reduce accident consequences.

Small (General Aviation) Aircraft Crash, Building 371—The aircraft will not penetrate the Building 371.

Room Fire, Butler Building—To assess the maximum consequence for the accident, the analysis assumed the salt, fluoride, and sludge residues were stored in the same building; one salt residue drum, one fluoride residue drum, and one sludge residue drum were breached; and the contents of the drums were exposed to the fire. The accident source terms are presented in **Table D–57**.

Table D–57 Butler Building Room Fire Accident Source Term

Residue	*Mar Pu (g)*	*DR*	*ARF×RF* [a]	*LPF*	*Source Term Pu (g)*	*Release Point*
DOR Salt	194	1	0.00006 [a]	1	0.0116	Ground
Fluoride	39.6	1	1.0×10^{-6} [a]	1	0.0000396	Ground
Sludge	5.3	1	0.00006 [b]	1	0.000318	Ground

MAR = material at risk DR = damage ratio ARF = airborne release fraction RF = respirable release fraction
LPF = leak path factor
[a] Source: Table D–29.
[b] Source: Table D–29, residue was calcinated. Dry powder, assumed same as ash.

Vault Fire, Building 371—No storage containers would be breached by the fire.

Earthquake and Butler Building Collapse—The accident scenario is described in Section D.3.3.4.1. The analysis postulated that 10% of the salt, fluoride, and sludge residues spilled out of the breached drums and were released. The accident source term is presented in **Table D–58**.

Table D–58 Earthquake and Butler Building Collapse Accident Source Term

Residue	*Mar Pu (kg)*	*DR*	*ARF×RF* [a]	*LPF*	*Source Term Pu (g)*	*Release Point*
ER & MSE Salt	24	0.01×0.1	0.000192 [a]	1	0.00461	Ground
DOR Salt	6	0.01×0.1	0.000192 [a]	1	0.00115	Ground
Fluoride	0.4	0.01×0.1	0.000232 [b]	1	0.0000928	Ground
Sludge	0.1	0.01×0.1	0.000232 [b,c]	1	0.0000232	Ground

MAR = material at risk DR = damage ratio ARF = airborne release fraction RF = respirable release fraction
LPF = leak path factor DOR = direct oxide reduction salt residue
ER & MSE = electrorefining and molten salt extraction salt residue
[a] The ARF×RF product for a spill is 8×10^{-8} (spill assumed equivalent to a dock spill). The ARF×RF product does not include the potential for resuspension of particulates after an earthquake. A resuspension value of 0.000192 needs to be added to all ARF×RF values. Reference Table D–29.
[b] The ARF×RF product for a spill is 0.00004 (spill assumed equivalent to a dock spill). The ARF×RF product does not include the potential for resuspension of particulates after an earthquake. A resuspension value of 0.000192 needs to be added to all ARF×RF values. Reference Table D–29.
[c] Source: Table D–29, residue was calcinated. Dry powder, assumed same as ash.

Earthquake and Building 371 Collapse—The scenario postulated that the earthquake collapsed Building 371. The analysis conservatively postulated that 1% of the 3013 containers and 0.1% of the 9975 containers were breached by the falling building debris. The 9975 container construction is much more robust than the 3013 containers. The accident source term is presented in **Table D–59**.

Table D–59 Earthquake and Building 371 Collapse Accident Source Term

Residue	Mar Pu (kg)	DR	ARF×RF [a]	LPF	Source Term Pu (g)	Release Point
ER & MSE Salt	780	0.001	0.000792	0.1	0.0618	Ground
DOR Salt	182	0.001	0.000792	0.1	0.0144	Ground
Combustible	20.9	0.01	0.000292	0.1	0.00610	Ground
Fluoride	141	0.01	0.000792	0.1	0.112	Ground
Filter Media	109	0.01	0.000792	0.1	0.0863	Ground
Sludge	25.3	0.01	0.000792	0.1	0.0200	Ground
Glass	4.9	0.01	0.000292	0.1	0.00143	Ground
Graphite	95.3	0.01	0.000292	0.1	0.0278	Ground
Inorganic	17.1	0.01	0.000292	0.1	0.00499	Ground

MAR = material at risk DR = damage ratio ARF = airborne release fraction RF = respirable release fraction
LPF = leak path factor DOR = direct oxide reduction salt residue
ER & MSE = electrorefining and molten salt extraction salt residue
[a] A resuspension value of 0.000192 needs to be added to all ARFxRF values. Reference Table D–29.

Accident Frequency— Accident frequencies were derived using Table D–41. **Table D–60** breaks down the accident frequency by the building and category of stored material.

Table D–60 Accident Frequency for Storage of Plutonium Residues

Residue	Location	Accident Annual Frequency			
		High Wind	Small Aircraft Crash	Room/Vault Fire	Earthquake and Building Collapse
ER & MSE Salt	Butler Bldg.	0.000112	3.35×10^{-8}	0.00001	0.002
	Bldg. 371 Vault	N/A	N/A	N/A	0.000094
DOR Salt	Butler Bldg.	0.0000275	8.25×10^{-9}	0.00001	0.002
	Bldg. 371 Vault	N/A	N/A	N/A	0.000094
Combustible	Butler Bldg.	N/A	N/A	N/A	N/A
	Bldg. 371 Vault	N/A	N/A	N/A	0.000094
Fluoride	Butler Bldg.	8.88×10^{-6}	2.66×10^{-9}	0.00001	0.002
	Bldg. 371 Vault	N/A	N/A	N/A	0.000094
Filter Media	Butler Bldg.	N/A	N/A	N/A	N/A
	Bldg. 371 Vault	N/A	N/A	N/A	0.000094
Sludge	Butler Bldg.	0.0000169	5.05×10^{-9}	0.00001	0.002
	Bldg. 371 Vault	N/A	N/A	N/A	0.000094
Glass	Butler Bldg.	N/A	N/A	N/A	N/A
	Bldg. 371 Vault	N/A	N/A	N/A	0.000094
Graphite Residue	Butler Bldg.	N/A	N/A	N/A	N/A

Residue	Location	Accident Annual Frequency			
		High Wind	Small Aircraft Crash	Room/Vault Fire	Earthquake and Building Collapse
	Bldg. 371 Vault	N/A	N/A	N/A	0.000094
Inorganic	Butler Bldg.	N/A	N/A	N/A	N/A
	Bldg. 371 Vault	N/A	N/A	N/A	0.000094

N/A = not applicable

❒ **Storage at Rocky Flats After Preprocessing and/or Repackaging for Offsite Processing— Table D–61** presents the storage configuration for the residues and scrub alloy stored at Rocky Flats following preprocessing and packaging of the material to be processed at the Savannah River Site or the Los Alamos National Laboratory using Alternative 3 plutonium separation process technologies.

Table D–61 Alternative 3 Storage at Rocky Flats After Preprocessing for Offsite Processing

Material	Quantity Pu (kg)	Storage Container	Storage Location	
			Butler Building	Building 371 Vault
Ash Residue	1,102	9975 Container		X
Salt Residue	964	6M Container		X
	28	Drummed Pipe Component	X	
Combustible Residue	0	N/A		
Fluoride Residue	141	9975 Container		X
Filter Media Residue	0	N/A		
Sludge Residue	0	N/A		
Glass Residue	0	N/A		
Graphite Residue	96.4	9975 Container		X
Inorganic Residue	17.5	9975 Container		X
Scrub Alloy	200	6M Container		X

N/A = not applicable

Plutonium Residue and Scrub Alloy Vulnerability to Storage Accidents—The same set of storage-related accidents discussed in Section D.3.3.4.1 were considered. **Table D–62** summarizes the vulnerability of the building and their applicable storage containers to the set of postulated accidents and **Table D–63** summarizes the vulnerability of the preprocessed plutonium residues in storage to the set of accidents. As discussed in Section D.3.3.4.1, the annual frequency for the large aircraft crash at Rocky Flats is in the not reasonably foreseeable range and the accident consequences are not evaluated.

Table D–62 Building Storage Container Vulnerability

Accident	*Butler Building*	*Building 371 Vault*	
	Storage in Drummed Pipe Component	***Storage in 6M Container***	***Storage in 9975 Container***
High Wind	No	No	No
Small Aircraft Crash	No	No	No
Room/Vault Fire	No	No	No
Earthquake and Building Collapse	No	Yes	Yes

Table D–63 Preprocessed Plutonium Residue and Scrub Alloy Vulnerability During Storage

Material	***Location***	***Stored Material Vulnerable to Accident***			
		High Wind	***Small Aircraft Crash***	***Room/Vault Fire***	***Earthquake and Building Collapse***
Ash Residue	Bldg. 371 Vault	No	No	No	Yes
Salt Residue	Butler Bldg.	No	No	No	No
	Bldg. 371 Vault	No	No	No	Yes
Combustible Residue	N/A	–	–	–	–
Fluoride Residue	Bldg. 371 Vault	No	No	No	Yes
Filter Media Residue	N/A	–	–	–	–
Sludge Residue	N/A	–	–	–	–
Glass Residue	N/A	–	–	–	–
Graphite Residue	Bldg. 371 Vault	No	No	No	Yes
Inorganic Residue	Bldg. 371 Vault	No	No	No	Yes
Scrub Alloy	Bldg. 371 Vault	No	No	No	Yes

N/A = not applicable

Accident Scenarios and Source Terms—The accident scenarios are described in Section D.3.3.4.1.

High Wind, Butler Building—The postulated wind-driven missile will not penetrate pipe components.

High Wind, Building 371—The postulated wind-driven missile will not penetrate Building 371.

Small (General Aviation) Aircraft Crash, Butler Building—The aircraft will not penetrate pipe components.

Small (General Aviation) Aircraft Crash, Building 371—The aircraft will not penetrate Building 371.

Room Fire, Butler Building—No pipe containers would be breached by the fire.

Vault Fire, Building 371—No storage containers would be breached by the fire.

Earthquake and Butler Building Collapse—No pipe containers would be breached by the earthquake.

Earthquake and Building 371 Collapse—The scenario postulated that the earthquake collapsed Building 371. The analysis conservatively postulated that 0.1% of the 6M and 9975 containers were breached by the falling building debris. 6M and 9975 containers have very robust structural designs. The accident source term is presented in **Table D–64**.

Table D–64 Earthquake and Building 371 Collapse Accident Source Term

Residue	*Mar Pu (kg)*	*DR*	*ARF×RF* [a]	*LPF*	*Source Term Pu (g)*	*Release Point*
Ash	1,102	0.001	0.000792	0.1	0.0873	Ground
ER & MSE Salt	847	0.001	0.000792	0.1	0.0671	Ground
DOR Salt	117	0.001	0.000792	0.1	0.00927	Ground
Fluoride	141	0.001	0.000792	0.1	0.0112	Ground
Graphite	96.4	0.001	0.000292	0.1	0.00281	Ground
Inorganic	17.5	0.001	0.000292	0.1	0.000511	Ground
Scrub Alloy	200	0.001×0.01 [b]	0.000292	0.1	0.0000584	Ground

MAR = material at risk DR = damage ratio ARF = airborne release fraction RF = respirable release fraction
LPF = leak path factor DOR = direct oxide reduction salt residue
ER & MSE = electrorefining and molten salt extraction salt residue
[a] A resuspension value of 0.000192 needs to be added to all ARF×RF values. Reference Table D–29.
[b] For scrub alloy, the ARF value is applied to the surface corrosion; assume one percent of the mass is corroded, or a DR = 0.01. Reference Table D–29.

❒ **Storage After Processing With Plutonium Separation at the Savannah River Site—Table D–65** identifies storage configuration for the residues and scrub alloy stored in the APSF vault following the processing and packaging of the material using Alternative 3 plutonium separation technologies in either the F-Canyon or the H-Canyon. When the material is processed in the F-Canyon, the stored product is in the form of plutonium metal. When the material is processed in the H-Canyon, the stored product is in the form of plutonium oxide powder.

Table D–65 Alternative 3 Storage with Processing at the Savannah River Site

Material	*Quantity Pu (kg)*	*Storage Container*	*Storage in APSF Vault*
Ash Residue	1,102	3013 Container	X
Salt Residue	964	3013 Container	X
Combustible Residue	0	N/A	
Fluoride Residue	141	3013 Container	X
Filter Media Residue	0	N/A	
Sludge Residue	0	N/A	
Glass Residue	0	N/A	
Graphite Residue	96.4	3013 Container	X
Inorganic Residue	17.5	3013 Container	X
Scrub Alloy	200	3013 Container	X
Total	2,521	3013 Container	X

APSF = Actinide Packaging and Storage Facility N/A = not applicable

Plutonium Residue and Scrub Alloy Vulnerability to Storage Accidents—The same set of storage-related accidents discussed in Section D.3.3.4.1 were considered. **Table D–66** summarizes the vulnerability of the building and their applicable storage containers to the set of postulated accidents and **Table D–67** summarizes the vulnerability of the processed plutonium residues in storage to the set of accidents.

Table D–66 APSF Vault and 3013 Storage Container Vulnerability

Accident	*APSF Vault*
	Storage in 3013 Container
High Wind	No
Large Aircraft Crash	Yes
Small Aircraft Crash	No
Vault Fire	No
Earthquake and Building Collapse	Yes

APSF = Actinide Packaging and Storage Facility

Table D–67 Canyon Product Vulnerability During Storage

Material	*Location*	*Stored Material Vulnerable to Accident*				
		High Wind	*Small Aircraft Crash*	*Large Aircraft Crash*	*Room/Vault Fire*	*Earthquake and Building Collapse*
F-Canyon Product (Plutonium metal)	APSF Vault	No	No	Yes	No	Yes
H-Canyon Product (Plutonium oxide)	APSF Vault	No	No	Yes	No	Yes

APSF = Actinide Packaging and Storage Facility

Accident Scenarios and Source Terms— The accident scenarios are described in Section D.3.3.4.1.

High Wind—The APSF vault construction will be very robust. The postulated wind-driven missile will not penetrate the APSF vault.

Large Aircraft Crash—The accident frequency is less than a large aircraft crash accident with the F-Canyon. Since the annual frequency for the F-Canyon large aircraft crash accident is in the not reasonably foreseeable range, the accident consequences were not evaluated for the APSF vault large aircraft crash accident.

Small (General Aviation) Aircraft Crash—The APSF vault construction will be very robust. The aircraft will not penetrate the APSF vault.

Vault Fire—No storage containers would be breached by the fire.

Earthquake and APSF Collapse—The scenario postulated that the earthquake collapsed the APSF. The analysis conservatively postulated that 1% of the 3013 containers were breached by the falling building debris. The accident source term is presented in **Table D–68**.

Table D–68 Earthquake and APSF Collapse Accident Source Term

Residue	*Mar Pu (kg)*	*DR*	*ARF×RF* [a]	*LPF*	*Source Term Pu (g)*	*Release Point*
F-Canyon Product (Plutonium metal)	2,521	0.01×0.001 [b]	0.000292	0.1	0.000736	Ground
H-Canyon Product (Plutonium oxide powder)	2,521	0.01	0.000792	0.1	2.00	Ground

MAR = material at risk DR = damage ratio ARF = airborne release fraction RF = respirable release fraction
LPF = leak path factor APSF = Actinide Packaging and Storage Facility
[a] A resuspension value of 0.000192 needs to be added to all ARF×RF values. Reference Table D–29.
[b] The ARF value in Table D–29 is applied to the surface corrosion and assumed one percent of the mass is corroded for aged scrub alloy. The surface corrosion on processed plutonium metal. stored in a sealed 3013 container would be significantly better than the condition of material at Rocky Flats. Assume an order of magnitude improvement and a DR = 0.001.

Accident Frequency—In accordance with DOE-STD-1020-94 (DOE 1994b), the APSF design is for a performance category (PC) 3 structure with an evaluation basis earthquake of 0.3 g. Beyond evaluation basis earthquake (BEBE) studies have shown that PC3 facilities have adequate margins built into the design so that the building will not collapse during a 0.5 g BEBE. (LANL 1996) For the purpose of this EIS it was conservatively assumed that a 0.5 g BEBE would collapse the APSF vault. Based on extrapolated data from DOE-EH-0529 (DOE 1996c), the return frequency for a 0.5 g BEBE near the APSF site is estimated at 0.00001 per year.

❒ **Storage After Processing With Plutonium Separation at the Los Alamos National Laboratory—Table D–69** identifies storage configuration for the residues and scrub alloy stored in the TA-55 plutonium vault following the processing and packaging of the material using Alternative 3 plutonium separation technologies.

Table D–69 Alternative 3 Storage with Processing at the Los Alamos National Laboratory

Material	*Quantity Pu (kg)*	*Storage Container*	*Storage in TA-55 Pu Vault*	*Storage in TA-55*
Ash Residue	0	N/A		
ER & MSE Salt Residue	792	3013 Container	X	
	12.3	Drummed Pipe Components		X
DOR Salt Residue	188	3013 Container	X	
Combustible Residue	0	N/A		
Fluoride Residue	0	N/A		
Filter Media Residue	0	N/A		
Sludge Residue	0	N/A		
Glass Residue	0	N/A		

Material	*Quantity Pu (kg)*	*Storage Container*	*Storage in TA-55 Pu Vault*	*Storage in TA-55*
Graphite Residue	0	N/A		
Inorganic Residue	0	N/A		
Scrub Alloy	0	N/A		

TA = technical area N/A = not applicable DOR = direct oxide reduction salt residue
ER & MSE = electrorefining and molten salt extraction salt residue.

Plutonium Residue Vulnerability to Storage Accidents—The same set of storage-related accidents discussed in Section D.3.3.4.1 were considered. **Table D–70** summarizes the vulnerability of the building and their applicable storage containers to the set of postulated accidents and **Table D–71** summarizes the vulnerability of the processed salt residues in storage to the set of accidents.

Table D–70 TA-55 Plutonium Residue Storage Container Vulnerability

Accident	*TA-55 Plutonium Vault*	*TA-55*
	Storage in 3013 Container	*Drummed Pipe Component*
High Wind	No	No
Large Aircraft Crash	Yes	Yes
Small Aircraft Crash	No	No
Vault Fire	No	No
Earthquake and Building Collapse	Yes	Yes

TA = technical area DOR = direct oxide reduction salt ER & MSE = electrorefining and molten salt extraction salt

Table D–71 Processed Salt Residue Product Vulnerability During Storage

Material	*Location*	*Stored Material Vulnerable to Accident*				
		High Wind	*Small Aircraft Crash*	*Large Aircraft Crash*	*Room/Vault Fire*	*Earthquake and Building Collapse*
ER & MSE Salt	TA-55 Plutonium Vault	No	No	Yes	No	Yes
	TA-55	No	No	Yes	No	Yes
DOR Salt	TA-55 Plutonium Vault	No	No	Yes	No	Yes

TA = technical area DOR = direct oxide reduction salt ER & MSE = electrorefining and molten salt extraction salt

Accident Scenarios and Source Terms—The accident scenarios are described in Section D.3.3.4.1.

High Wind, Vault Storage—The TA-55 plutonium vault construction is very robust. The postulated wind-driven missile will not penetrate the TA-55 plutonium vault.

High Wind, TA-55 Waste Storage Area—The postulated wind-driven missile will not penetrate the pipe component.

Large Aircraft Crash—Since the annual frequency for this accident is in the not reasonably foreseeable range, the accident consequences were not evaluated.

Small (General Aviation) Aircraft Crash, Vault Storage—The TA-55 plutonium vault construction is very robust. The aircraft will not penetrate the TA-55 plutonium vault.

Small (General Aviation) Aircraft Crash, TA-55 Waste Storage Area—The aircraft will not penetrate the pipe component.

Vault Fire—No storage containers would be breached by the fire.

TA-55 Waste Storage Area Fire—No storage containers would be breached by the fire.

Earthquake and TA-55 Plutonium Vault Collapse—The scenario postulated that the earthquake collapsed the vault. The analysis conservatively postulated that 1% of the 3013 containers were breached by the falling building debris. The accident source term is presented in **Table D–72**.

Table D–72 Earthquake and TA-55 Plutonium Vault Collapse Accident Source Term

Residue	*Mar Pu (kg)*	*DR*	*ARF×RF* [a]	*LPF*	*Source Term Pu (g)*	*Release Point*
ER & MSE Salt	792	0.01	0.000792	0.1	0.627	Ground
DOR Salt	188	0.01	0.000792	0.1	0.149	Ground

MAR = material at risk DR = damage ratio ARF = airborne release fraction RF = respirable release fraction
LPF = leak path factor TA = technical area DOR = direct oxide reduction salt
ER & MSE = electrorefining and molten salt extraction salt
[a] A resuspension value of 0.000192 needs to be added to all ARF×RF values. Reference Table D–29.

Earthquake and TA-55 Waste Storage Area Collapse—The scenario postulated that the earthquake collapsed the facility. The analysis conservatively postulated that 1% of the drummed pipe components were breached by the falling building debris. The accident source term is presented in **Table D–73**.

Table D–73 Earthquake and TA-55 Waste Storage Area Collapse Accident Source Term

Residue	*Mar Pu (kg)*	*DR*	*ARF×RF* [a]	*LPF*	*Source Term Pu (g)*	*Release Point*
ER & MSE Salt	12.3	0.01	0.000792	0.1	0.00974	Ground

MAR = material at risk DR = damage ratio ARF = airborne release fraction RF = respirable release fraction
LPF = leak path factor TA = technical area DOR = direct oxide reduction salt
ER & MSE = electrorefining and molten salt extraction salt
[a] A resuspension value of 0.000192 needs to be added to all ARF×RF values. Reference Table D–29.

Accident Frequency—The TA-55 Final Safety Analysis Report (LANL 1996) analyzed the impact of the evaluation basis earthquake (EBE) and beyond evaluation basis earth quakes (BEBEs) on the facility. The analysis disclosed that a 0.5 g BEBE would not cause structural collapse of the plutonium vault or the waste storage area in the basement. The 0.5 g BEBE was the most significant BEBE analyzed in the report. For the purpose of this EIS, it was conservatively assumed that a 0.5 g BEBE would collapse the TA-55 plutonium vault and waste storage area located in the basement. The return frequency for a 0.5 g BEBE is estimated at 0.000019 per year. (LANL 1996)

D.3.3.4.4 Alternative 4 – Combination of Processing Technologies

Following processing of plutronium residues at Rocky Flats using Alternative 4 processing technologies, the residue is packaged in drums, drummed convience cans, or drummed pipe components prior to movement to an interim storage area or staging area for shipment to WIPP. For the purpose of this EIS, the analysis assumed that the packaged material will be stored in Butler Buildings similar to those described in Section D.3.3.4.1. **Table D-74** presents the storage configuration for each Alternative 4 processing technology.

Table D–74 Alternative 4 Storage

Material		*Process Technology*	*Quantity*		*Storage*	
			Pu (kg)	*Drums*	*Drummed Pipe Component*	*Storage Area (ft^2)*
Ash Residue	Incinerator Ash	Calcination/Cementation	901	4,887	Yes	9,974
		Repackaging	901	5,304	Yes	10,608
	Sand, Slag, and Crucible	Calcination/Cementation	128	765	Yes	1,530
		Repackaging	128	773	Yes	1,546
	Graphite Fines	Calcination/Cementation	73	498	Yes	996
		Repackaging	73	431	Yes	862
	Inorganic Ash	Calcination/Cementation	51	273	Yes	546
		Repackaging	51	297	Yes	594
Pyrochemical Salt Residue	MSE Salt (IDC 409)	Repackaging	235	1,570	Yes	3,140
	MSE/ER Salt (all other IDCs)	Repackaging	569	3,800	Yes	7,600
	DOR Salt (IDCs 365, 413, 427)	Repackaging	138	834	Yes	1,668
	DOR Salt (all other IDCs)	Repackaging	51	306	Yes	612
Combustible Residue	Aqueous-Contaminated	Neutralization/Dry	9.4	405	No [a]	810
	Organic-Contaminated	Thermal Desorption/Steam Passivation	6.5	280	No [a]	560

Material		Process Technology	Quantity		Storage	
			Pu (kg)	Drums	Drummed Pipe Component	Storage Area (ft^2)
	Dry	Repackaging	5.4	231	No [a]	462

Material		Process Technology	Quantity		Storage	
			Pu (kg)	Drums	Drummed Pipe Component	Storage Area (ft^2)
Plutonium Fluoride Residue		None/ Not Applicable	0	0	-	0
Filter Media Residue	Full Flow Filters (IDC 331)	None/Not Applicable	0	0	-	0
	HEPA Filters (IDC 338)	Neutralization/Dry	91	3,920	No [a]	7,840
	HEPA Filters (all other IDCs)	Repackaging	2	87	No [a]	174
Sludge Residue	IDCs 089, 099, 332	Repackaging	0.94	6	Yes	12
	All other IDCs	Filter/Dry	25.4	1,095	No [b]	2,190
Glass Residue		Neutralization/Dry	0.06	7	Yes	14
Graphite Residue		Repackaging	96.4	575	Yes	1,150
Inorganic Residue		Repackaging	17.5	106	Yes	212
Scrub Alloy		None/ Not Applicable	0	0	-	0

[a] Drummed.
[b] Drummed convenience can.

❒ **Plutonium Residue Vulnerability to Storage Accidents—**The same spectrum of storage-related accidents described in Section D.3.3.4.1 were considered. **Table D–75** summarizes the vulnerability of the processed residues in storage to the applicable set of postulated accidents.

Table D–75 Alternative 4 Plutonium Residue Vulnerability During Storage

Material	Stored Material Vulnerable to Accident			
	High Wind	Small Aircraft Crash	Room Fire	Earthquake and Building Collapse
Ash Residue	No	No	No	No
Salt Residue	No	No	No	No
Combustible Residue	Yes[a]	Yes[a]	Yes	Yes [b]
HEPA Filter Media Residue	Yes [a]	Yes [a]	Yes	Yes [b]
Sludge Residue (IDCs 089, 099, 332)	No	No	No	No
Sludge Residue (all other IDCs)	Yes [a]	Yes [a]	Yes	Yes [b]
Glass Residue	No	No	No	No
Graphite Residue	No	No	No	No
Inorganic Residue	No	No	No	No

[a] The combustible, filter media, and sludge residues would not be vulnerable to the effects of the high wind and small aircraft accidents if all combustible, filter media, and sludge residue drums were placed in the Butler building storage array configuration such that they were shielded from above and on the outer perimeter of the storage array configuration by drums that contain residues in pipe components. The analysis in this EIS took no credit for strategic placement of combustible, filter media, and sludge residue drums in the Butler building storage array configuration.

[b] The combustible, filter media, and sludge residues would not be vulnerable to the effects of the earthquake and building collapse accident if all combustible, filter media, and sludge residue drums were placed in the Butler building storage array configuration such that they were shielded from above, shielded on the outer perimeter of the storage array configuration, and shielded from building columns located within the storage array by drums that contain residues in pipe components. The analysis in this EIS took no credit for strategic placement of combustible, filter media, and sludge residue drums in the Butler building storage array configuration.

❒ **Accident Scenarios and Source Terms—**The source terms associated with the high wind, small aircraft crash, and room fire accident scenarios for combustible, filter media, and sludge residue presented in Section D.3.3.4.1 for Alternative 1 are applicable for Alternative 4. The source term for the earthquake and building collapse accident scenario changes because sludge residue IDCs 089, 099, and 332, packaged in drummed pipe components, are not vulnerable to the accident scenario. The accident source term is presented in **Table D–76**.

Table D–76 Earthquake and Butler Building Collapse Accident Source Term

Residue	*Mar Pu (kg)*	*DR*	*ARF×RF [a]*	*LPF*	*Source Term Pu (g)*	*Release Point*
Combustibles	21.3	0.01×0.1	0.000193	1	0.00411	Ground
HEPA Filter Media	93	0.01×0.1	0.000193	1	0.0180	Ground
Sludge[b]	25.4	0.01×0.1	0.000232 [c]	1	0.00589	Ground

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

[a] The ARF×RF product for a spill is assumed equivalent to a dock spill. The ARF×RF product does not include the potential for resuspension of particulates after an earthquake. A resuspension value of 0.000192 needs to be added to all ARF×RF values. Reference Table D–29.

[b] IDCs 089, 099, and 332 are excluded.

[c] Dry powder, assumed same as ash.

❒ **Accident Frequency —**Accident frequencies were derived for the combustible, filter media and sludge residues using data presented in Table D–41. **Table D–77** presents the accident frequencies for Alternative 4 storage.

Table D–77 Alternative 4 Accident Frequency for Storage of Plutonium Residues

Material	Accident Annual Frequency			
	High Wind	Small Aircraft Crash	Room Fire	Earthquake and Building Collapse
Ash Residue	N/A	N/A	N/A	N/A
Salt Residue	N/A	N/A	N/A	N/A
Combustible Residue	0.000813	2.44×10^{-7}	0.00001	0.002
Filter Media Residue	0.00356	1.07×10^{-6}	0.00001	0.002
Sludge Residue	0.000972	2.91×10^{-7}	0.00001	0.002
Glass Residue	N/A	N/A	N/A	N/A
Graphite Residue	N/A	N/A	N/A	N/A
Inorganic Residue	N/A	N/A	N/A	N/A

N/A = not applicable

The storage period for Alternative 4 is not defined since these residues will be shipped to WIPP when resources at WIPP are available to accept the residues for storage and transportation resources are available. Since the storage period at Rocky Flats is not specifically defined for Alternative 4, annual accident risks are estimated.

D.3.3.5 Consequences and Risk Calculations

Once the source term for each accident scenario is determined, the radiological consequences are calculated. The calculations vary depending on how the release is dispersed, what material is involved, and which receptor is being considered. Risks are calculated based on the accident's frequency and its consequences. The composite risk from performing a specific processing technology can be calculated summing the individual risks for all scenarios analyzed.

Radiological consequences to four different receptors are evaluated: a maximally exposed offsite individual (an individual member of the public), general population, noninvolved worker (or a co-located worker), and facility worker. The consequences to the facility workers are qualitatively evaluated. For the other receptors, quantitative estimates of consequences are made; two types of dispersion conditions are considered—95th-percentile and 50th-percentile meteorological conditions (see Section D.3.1 for more detail). The 50th-percentile condition represents the median meteorological condition and is defined as that for which more severe conditions occur 50 percent of the time. The 95th-percentile condition represents relatively low probability meteorological conditions that produce higher calculated exposures; it is defined as that condition not exceeded more than 5 percent of the time. Both dispersion conditions are modeled using the GENII program, which determines the desired condition from the site-specific meteorological data in the form of a joint frequency distribution. Joint frequency data are usually produced from at least 3 consecutive years of site weather data in terms of percentage of time that the wind blows in specific directions (e.g., south, south-southwest, southwest) for the given midpoint (or average) wind speed class and atmospheric stability.

Radiological consequences to a receptor are estimated based on a calculated 50-year committed dose factor, (dose factor) resulting from releases of 1 g of respirable aged weapon-grade plutonium or high americium plutonium salts (building source term) to the atmosphere. **Table D–78** and **Table D–79** provide the dose factor, in rem or person-rem per 1 g of respirable plutonium release to the atmosphere, for each receptor at a management site for two material types (e.g., aged weapon-grade plutonium and high americium plutonium salts) in either a metal or an oxide form and for two dispersion conditions. The dose factors given for the plutonium metal form in each category represent clearance half-time (solubility class) of "W," and the dose factors given for the plutonium oxide form represent clearance half-time of "Y" (see Section D.3.3.1).

Table D–78 Receptors' Dose Factors for Accidental Releases of 1 g Aged Weapon-Grade Plutonium at Management Sites

Receptor	*Release Location*	*Rocky Flats Building 707*		*Rocky Flats Building 371*		*Savannah River Site Building 221-F*		*Savannah River Site Building 221-H*		*LANL TA-55*
		Oxide	*Metal*	*Oxide*	*Metal*	*Oxide*	*Metal*	*Oxide*	*Metal*	*Metal*
Dose factors (rem or person-rem) from a release of 1 g aged weapon-grade plutonium and 95th-percentile meteorological condition										
MEI	Ground	1.20	2.40	1.80	3.60	0.050	0.0920	0.037	0.069	6.2
MEI	Elevated	0.160	0.320	1.50	3.0	0.0190	0.0340	0.017	0.032	5.1
Population	Ground	25,000	42,000	25,000	42,000	2,000	3,300	1,900	3,100	7,800
Population	Elevated	8,700	15,000	25,000	42,000	1,000	1,800	1,000	1,600	7,800
Dose factors (rem or person-rem) from a release of 1 g aged weapon-grade plutonium and 50th-percentile meteorological condition										
MEI	Ground	0.13	0.26	0.18	0.36	0.00940	0.017	0.0074	0.0014	0.81
MEI	Elevated	0.06	0.12	0.17	0.34	0.00680	0.012	0.005	0.0096	0.76
Population	Ground	600	1,000	600	1,000	140	230	130	200	840
Population	Elevated	450	770	600	1,000	99	160	90	150	840
Worker	Ground	21	28	21	28	17	22	17	22	65
Worker	Elevated	0.14	0.19	1.80	2.50	0.076	0.10	0.076	0.10	4.50

LANL = Los Alamos National Laboratory TA = technical area MEI = maximally exposed individual
Metal = plutonium compounds having clearance class "W" Oxide = plutonium oxides having clearance class "Y"

Table D–79 Receptors' Dose Factors for Accidental Releases of 1 g High Americium Plutonium Salt at Management Sites

Receptor	*Release Location*	*Rocky Flats Building 707*		*Rocky Flats Building 371*		*Savannah River Site Building 221-F*		*Savannah River Site Building 221-H*		*LANL TA-55*
		Oxide	*Metal*	*Oxide*	*Metal*	*Oxide*	*Metal*	*Oxide*	*Metal*	*Oxide*
Dose factors (rem or person-rem) from a release of 1 g high americium plutonium salt and 95th-percentile meteorological condition										
MEI	Ground	14	16	22	24	0.56	0.60	0.42	0.45	38.0
MEI	Elevated	1.90	2.10	18	19	0.21	0.220	0.19	0.21	31.0
Population	Ground	2.60×10^{5}	2.80×10^{5}	2.60×10^{5}	2.80×10^{5}	20,000	21,000	19,000	20,000	50,000
Population	Elevated	90,000	96,000	2.60×10^{5}	2.70×10^{5}	11,000	12,000	10,000	11,000	36,000

Receptor	*Release Location*	*Rocky Flats Building 707*		*Rocky Flats Building 371*		*Savannah River Site Building 221-F*		*Savannah River Site Building 221-H*		*LANL TA-55*
		Oxide	*Metal*	*Oxide*	*Metal*	*Oxide*	*Metal*	*Oxide*	*Metal*	*Oxide*
Dose factors (rem or person-rem) from a release of 1 g high americium plutonium salt and 50th-percentile meteorological condition										
MEI	Ground	1.50	1.70	2.20	2.40	0.099	0.110	0.084	0.090	4.90
MEI	Elevated	0.72	0.79	2.10	2.20	0.077	0.082	0.059	0.063	4.60
Population	Ground	6,200	6,700	6,200	6,700	1,400	1,500	1,300	1,300	5,100
Population	Elevated	4,600	4,900	6,100	6,400	970	1,000	900	960	5,200
Worker	Ground	170	180	170	180	140	150	140	150	410
Worker	Elevated	1.20	1.20	16	16	0.63	0.66	0.63	0.66	2.80

LANL = Los Alamos National Laboratory TA = technical area MEI = maximally exposed individual
Metal = plutonium compounds having clearance class "W" Oxide = plutonium oxides having clearance class "Y"

The values given in these tables represent the maximum dose to the receptor and are obtained using the GENII program, as described in Sections D.3.1.1 and D.1.2.1 of this appendix. The compositions of the aged weapon-grade plutonium and the high americium plutonium salts are given in **Table D–80**. The selections of the aged weapon-grade plutonium and the high americium salts were made to bound the consequences of the accidents involving different plutonium residue materials. As weapon-grade plutonium ages, the concentration of americium increases. The specific activity of americium is significantly higher than that of weapon-grade plutonium. The radiological hazard in terms of committed effective dose equivalent associated with the 1 g of americium is approximately 43 times greater than for 1 g of weapon-grade plutonium, adjusting for the differences between specific activities and the committed effective dose equivalent dose conversion factors of each isotope. The aged weapon-grade plutonium reflects the highest amount of americium 241 that can be present in any of the weapon-grade plutonium residues except the molten salt extraction residues. For the salt residues, the composition of Item Description Codes (IDCs) 409–410 was used. Although these IDCs represent approximately 24 percent of the total salts, they have the highest content of americium 241.

Table D–80 Compositions of Different Types of Plutonium Mixture at Rocky Flats

Isotope	*Processed Weapon-Grade Plutonium* [a]		*Aged Weapon-Grade Plutonium*		*High Americium Salt* [b]	
	g/g-mix	*Ci/g-mix*	*g/g-mix*	*Ci/g-mix*	*g/g-mix*	*Ci/g-mix*
Plutonium 238	0.000292	0.005	0.000165	0.0028	0.00009	0.00147
Plutonium 239	0.926	0.0576	0.924	0.057	0.809	0.0503
Plutonium 240	0.0566	0.0129	0.0561	0.013	0.05	0.0114
Plutonium 241	0.00325	0.335	0.000102	0.011	0.0031	0.32
Plutonium 242	0.000306	1.20×10^{-6}	0.000306	1.2×10^{-6}	0.000259	1.02×10^{-6}
Americium 241	0.000175	0.0006	0.00305	0.011	0.138	0.473
Total	0.99	0.411	0.985	0.095	1	0.856

g/g-mix = gram/gram-mixture Ci/g-mix = curies per gram-mixture
[a] Rocky Flats weapon-grade plutonium compositions.
[b] Compositions of IDC 409 and IDC 410 were used.

Source: BIO Radiological Dose Consequence Template (RF 1996).

For each accident scenario except criticality, the radiological consequences (rem or person-rem) to each receptor are estimated by multiplying the calculated building source term with the receptor's dose factor, given in Table D–78 and Table D–79. For example, the maximally exposed individual dose at the Savannah River Site for releases caused by an accidental plutonium oxide (ash) powder spill in the new special recovery facility, is calculated by *multiplying* the building source term resulting from the spill, which is estimated to be ~0.01 mg ([178]×[10^{-5}]×[0.005]) of plutonium from values given in Table D–30, *with* the dose factor of 0.019 rem/g plutonium from Table D–78 to get a maximally exposed individual dose of 1.9×10^{-7} rem, or 1.9×10^{-4} mrem, per spill.

The maximally exposed individual risk from this event is the accident frequency, which is 0.01 per year (given in the accident scenario description in Section D.3.3.2) multiplied by the consequence (dose factor), resulting in 1.9×10^{-6} mrem/yr. The risk is also stated in terms of additional latent cancer fatalities resulting from a release using a conversion factor of 5×10^{-4} latent cancer fatalities per person rem for the individual member of the public and 4×10^{-4} latent cancer fatalities per person-rem for a worker. For this example, the risk to the maximally exposed individual is calculated by multiplying 1.9×10^{-6} mrem/yr, 0.001 rem/mrem, and 5×10^{-4} latent cancer fatalities per rem, which results in 9.5×10^{-13} latent cancer fatalities per year.

For the criticality accidents, direct calculations of consequences are made based on the fission gas and plutonium releases resulting from a solution criticality event of 1×10^{19} fissions at the Savannah River Site and at Rocky Flats. At Los Alamos National Laboratory, direct calculations of consequences are made based on fission gas releases during a criticality excursion event of 10^{18} fissions in terms of rem and/or person-rem for the 50th- and 95th-percentile meteorological conditions. **Table D-81** provides various receptor's doses from criticality accidents.

Table D–81 Criticality Accident Consequences at the Management Sites (Consequences Are in Terms of Rem for the Individuals and Person-rem for the Population)

Receptor	*Rocky Flats Building 371*		*SRS Building 221-F*		*SRS Building 221-H*		*LANL Building TA-55* [a]	
	95% Met	*50% Met*	*95% Met*	*50% Met*	*95% Met*	*50% Met*	*95% Met*	*50% Met*
MEI	0.79	0.11	0.011	0.0044	0.009	0.003	0.137	0.022
Population	6980	252	310	32	290	29	98.8	15.7
Worker	N/A	0.321	N/A	0.038	N/A	0.038	N/A	0.045

SRS = Savannah River Site LANL = Los Alamos National Laboratory TA = technical area
Met = meteorological data MEI = maximally exposed individual N/A = not applicable
[a] At Los Alamos National Laboratory, the doses are calculated for 10^{18} fissions; at other sites, the doses are for 10^{19} fissions.

Table D–82 Receptors' Dose Factors for Accidental Releases of 1 g Plutonium from Accident Initiated in FB-Line or HB-Line

Receptor	*Plutonium Oxide*		*Plutonium Metal*		*High Americium Salts (Metal)*	
	95% Met	*50% Met*	*95% Met*	*50% Met*	*95% Met*	*50% Met*
Accident Initiated in FB-Line						
MEI (rem)	0.015	0.0054	0.031	0.011	0.032	0.011

Receptor	Plutonium Oxide		Plutonium Metal		High Americium Salts (Metal)	
	95% Met	50% Met	95% Met	50% Met	95% Met	50% Met
Population (person-rem)	900	82	1600	150	1600	150
Worker (rem)	N/A	0.066	N/A	0.093	N/A	0.096
Accident Initiated in HB-Line						
MEI (rem)	0.013	0.0041	0.029	0.0088	0.031	0.009
Population (person-em)	900	75	1420	141	1470	144
Worker (rem)	N/A	0.066	N/A	0.093	N/A	0.096

Met = meteorological condition   MEI = maximally exposed individual   N/A = not applicable

For the accidents in the FB-Line or HB-Line facility, the receptors' dose factors would be lower than those presented in Tables D–78 and D–79. This is because the plutonium solutions entering the FB-Line or HB-Line processes are essentially americium-free solutions. **Table D–82** provides various receptors' dose factors from an FB-Line or HB-Line accidental release during the processing of Rocky Flats aged weapon-grade plutonium or high americium salts in terms of rem and/or person-rem for the 50th and 95th percentile meteorological conditions. The dose factors given in Table D–82 are applicable only to the ion exchange explosion accident. The plutonium materials released are metal compounds (i.e., have the clearance half-time of "W").

The consequences to involved workers are qualitatively assessed. This approach is used for two reasons: first, no adequate method exists for calculating meaningful consequences at or near the location where the accident occurs. Second, safety assurance for facility workers is demonstrated by both the workers' training and by the establishment of an Occupational Safety and Health Administration process safety management system (29 CFR 1910.119), the evaluations required by such a system, and the products derived from such evaluations (e.g., procedures, programs, emergency plans).

The consequences to the involved worker are accident dependent and site-specific. In facilities where the involved worker activities include remote operations, the consequences of accidents would be lower than in facilities where the workers are near the process. The following paragraphs summarize the various potential consequences to the involved workers from the hypothesized accidents at different management sites. Additionally, a limited number of fatalities could occur in an indirect or secondary manner—for example, the involved worker could be killed by an earthquake or explosion (see also **Table D–83** and **Table D–84**).

Table D–83 Involved Worker Consequences from Various Hypothesized Accidents

Accident	Rocky Flats	Savannah River Site	Los Alamos National Laboratory
Explosion (acetylene)	Could potentially result in fatal injuries (nonradiological) to the nearby involved workers.	N/A	N/A
Explosion (Ion Exchange)	Could potentially result in fatal injuries (nonradiological) to the nearby involved workers.	Could potentially result in fatal injuries (nonradiological) to the nearby involved workers.	N/A
Explosion (Hydrogen)	N/A	No fatality is expected due to remote operation.	N/A
Criticality	Could potentially result in fatal dose to the nearby involved workers.	Could potentially result in fatal dose to the nearby involved workers.	Could potentially result in fatal dose to the nearby involved workers.

Accident	*Rocky Flats*	*Savannah River Site*	*Los Alamos National Laboratory*
Fire	No fatality is expected, some nearby workers could inhale the dispersed radioactive materials before using respirator and leaving the area.	No fatality is expected, some nearby workers could inhale the dispersed radioactive materials before using respirator and leaving the area.	No fatality is expected, some nearby workers could inhale the dispersed radioactive materials before using respirator and leaving the area.
Earthquake	Some fatalities (nonradiological) are expected in Building 707.	No fatality is expected.	No fatality is expected.
Spill	Nearby workers could inhale the dispersed radioactive materials before using respirator and leaving the area.	Nearby workers could inhale the dispersed radioactive materials before using respirator and leaving the area.	Nearby workers could inhale the dispersed radioactive materials before using respirator and leaving the area.

N/A = not applicable

Table D–84 Involved Worker Summary

Accident Description	*Number of Involved Workers*	
Rocky Flats	**Building 707**	**Building 371**
Explosion, Acetylene	30	30
Explosion, Ion Exchange Column	N/A	30
Room Fire	30	30
Dock Fire	12	12
Room Spill	30	30
Glovebox Spill	0	0
Dock Spill	12	12
Earthquake	100	100
Savannah River Site—Purex Process (All Ash Residues)	**H-Canyon & HB-Line**	**F-Canyon & FB-Line**
Explosion, Hydrogen	16	21
Explosion, Ion Exchange Column	27	16
Nuclear Criticality	27	16
Fire	27	16
Earthquake	43	37
Savannah River Site—Purex Process (Not Ash Residue)	**H-Canyon & H-B Line**	**F-Canyon & F-B Line**
Explosion, Hydrogen	27	31
Explosion, Ion Exchange Column	27	16
Nuclear Criticality	27	16
Fire	27	16
Earthquake	54	47
Savannah River Site—Mediated Electrochemical Oxidation Process	**H-Canyon & HB-Line**	**F-Canyon & FB-Line**
Explosion, Hydrogen	16	23
Explosion, Ion Exchange Column	27	16
Nuclear Criticality	27	16
Fire	27	16
Spill	16	23
Earthquake	43	39
Los Alamos National Laboratory		
Nuclear Criticality	30	
Fire	30	

Accident Description	*Number of Involved Workers*
Spill	30
Earthquake	30

N/A = not applicable

- **Explosion—**The explosion could result in serious, even fatal, injuries to involved workers from the accident itself. Some of the involved workers could inhale the dispersed radioactive material before using their respirators and evacuating the area. No fatality is expected from the radiological consequences.

- **Fire—**Involved workers could inhale some radioactive material before using their respirators and immediately evacuating the building. No fatality is expected from the radiological consequences.

- **Spill—**Depending on the location of the spill, nearby workers may inhale the airborne radioactive materials before evacuating the area. Involved workers normally would be wearing respirators when handling the radioactive material containers. No fatality is expected to result from such an accident.

- **Earthquake—**Involved workers could receive lethal injuries from the accident itself. No fatality is expected from radiological consequences.

- **Aircraft Crash—**Consequences similar to those of an earthquake may result from the accident.

- **Criticality—**Involved workers could receive substantial, or potentially fatal, doses from prompt neutrons and gamma rays emitted from the first pulse. After the initial pulse, the workers would evacuate the area immediately on the initiation of the criticality monitoring alarms.

D.3.3.6 Analysis Conservatism and Uncertainty

To assist in evaluating the impact of the plutonium residue and scrub alloy processing options at Rocky Flats, the Savannah River Site, and Los Alamos National Laboratory on a common basis, a spectrum of generic accidents were postulated for each process location. The accident scenarios were based on similar accidents documented in various site documents. When required, accident assumptions were modified to enable comparison between the three sites. In cases where similar accidents were evaluated in site specific documents, the more conservative analysis assumptions were used for all sites to normalize the results for the purpose of comparison. The following accident analysis parameters have a major impact on accident consequence estimates (i.e., dose to the public and worker): the weather conditions existing at the time of the accident, the material at risk, the isotopic breakdown of the material at risk, and the source term released to the environment.

Weather conditions assumed at the time of the accident have a large impact on dose estimates. Accident impacts to the public were estimated using both 95 percentile and median 50 percentile weather data. The public impacts documented in the body of the EIS are based on the conservative 95 percentile weather data. The GENII computer code was used to calculate doses to the public within 80 km (50 miles) of the accident release point. The code calculates the public dose in each of 16 sectors centered at the accident release point. The GENII computer code also assumes that total source term is released into each sector and that there is no change in the weather (i.e., wind direction, wind speed, and stability class) while the accident plume is traversing the 80 km sector. The use of the conservative 95 percentile weather data rather than the expected or median 50 percentile weather data increases the dose to the public by more than a factor of 40.

Conservative assumptions were used to estimate the material at risk. If an accident scenario involved the contents of a room or a facility, the analysis assumed that the material at risk was equivalent to the amount of material that could be processed in one week. If an accident scenario involved one or more containers of material, the analysis assumed that the first container contained the maximum amount of material and any additional containers contained the average amount of material. Only a small percentage of containers contain the maximum amount.

The isotopic breakdown of the material at risk was also conservatively estimated. The composition of the Item Code Descriptions (IDCs) for each group of materials were reviewed and the IDCs with the most unfavorable isotopic breakdown, from a dose point-of-view, were selected as being representative for the group.

Uncertainties in accident frequencies do not impact the accident consequences, but do impact accident risk. The site/facility specific accident frequencies (i.e., earthquake induced building collapse and aircraft crash) were based on data provided by the sites. Process specific accident frequencies were estimated based on analyses provided in site specific documentation. In cases where similar accidents were evaluated in site specific documents, the more conservative accident frequency was used for all sites to normalize the results for the purpose of comparison.

Due to the layers of conservatism built into the accident analysis for the spectrum of postulated accidents, the estimated consequences and risk to the public represents the upper limit for the individual classes of accidents. The uncertainties associated with the accident frequency estimates and process batch sizes documented in the process data sheets are enveloped by the analysis conservatism.

D.3.3.7 Comparison of Analysis Results with Site Documents

The accident analysis consequences and risks should not be expected to be in agreement with accident analyses presented in site documentation (e.g., safety analysis reports, cumulative impact documents). To assist in evaluating the impact of the plutonium residue and scrub alloy processing options at Rocky Flats, the Savannah River Site, and Los Alamos National Laboratory on a common basis, a spectrum of generic accidents were postulated for each process location. The accident scenarios were based on similar accidents documented in various site documents. When required, accident assumptions were modified to enable comparison between the three sites.

The material at risk for each accident was estimated based on the process data sheets. For the purpose of comparison, a common set of ground rules was used to estimate the source term released to the environment during the accidents. A common computer code and site specific weather data were used to assess the impact of each accident. Public impacts were estimated using both 95 percentile and 50 percentile weather data. The public impacts documented in the body of the EIS are based on the conservative 95 percentile weather data. The impacts to the non involved worker, nominally located 100 meters from the accident radiological release point, are based on the median 50 percentile weather data.

In the event that accident analysis consequences and risks in this EIS are compared with accident analyses presented in site documentation (e.g., safety analysis reports, cumulative impacts documents, etc.), do not expect the analysis results to be the same. The differences in the results may be attributed to differences in one or more of the following:

- Computer codes used for analysis
- Analysis data bases (e.g., population, weather, agriculture)
- Accident scenario

- Analysis ground rules and assumptions
- Material at risk
- Source term released to the environment
- Source term isotopic breakdown
- Accident frequency
- Process duration.

For example, a comparison was made of a similar accident documented in the Rocky Flats Cumulative Impacts Document for the 1996 Baseline with this EIS. Both analyses evaluated an earthquake-induced collapse of Building 707. The cumulative impacts document estimated 0.52 latent cancer fatalities and this EIS estimated 147 latent cancer fatalities. Several factors are responsible for the differences between the two documents. They are provided below in approximate order of importance or impact.

- The cumulative impacts document uses the median value for weather and the EIS uses the conservative 95 percentile weather. For the earthquake accident scenario in this EIS, the 95 percentile weather yields a calculated value of 293,000 person-rem (147 latent cancer fatalities) for the population and the 50 percentile weather yields a calculated value of 7,000 person-rem (3.5 latent cancer fatalities) for the population).

- The cumulative impacts document uses the MACCS computer code and the EIS uses the GENII computer code. There are major differences in the calculational approaches used in the codes. The MACCS code calculates the dose based on sectors being sampled from the weather database, and the GENII code calculates the dose to each of 16 sectors for the specified sector weather condition. The sector with the largest dose is reported.

- The material at risk and isotopic breakdown of the material was estimated differently in the cumulative impacts document and the EIS. The cumulative impacts document used the actual material known to be in the building and calculated the amount of dispersible material based on conversion of plutonium metal to oxides, amount of oxides present, amount of residues present (with associated americium amounts) and amount of transuranic and low level waste present. The EIS used a simpler approach, in that it used two plutonium residue IDCs, 409 and 410, both molten salt extraction salts containing the maximum quantity of americium, as the worst case scenario, and assumed a 5-day supply of the residue to be present in Building 707 upon collapse from the earthquake. The high content of americium in the plutonium residue significantly increases the radiological dose from that residue.