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F

Accidents

APPENDIX F – ACCIDENTS

F.1 INTRODUCTION

This appendix documents the accident evaluations performed for the Sandia National Laboratories/ New Mexico (SNL/NM) Site-Wide Environmental Impact Statement (SWEIS) for operational, external, and natural phenomena accidents that have the potential for causing injury or fatality to workers or the public. It discusses potential accidents and impacts caused by the release of radioactive or hazardous chemical materials, explosions, earthquakes, and airplane crashes into SNL/NM facilities. It also discusses accident scenarios, source terms, and the origin or derivation of data used in the evaluations.

F.1.1 *National Environmental Policy Act* Requirements for Accident Impact Analysis

The U.S. Department of Energy's (DOE's) guidelines for the preparation of *National Environmental Policy Act* (NEPA) documents and the analysis of accident impacts have been defined (DOE 1993b) and were followed during the preparation of the SNL/NM SWEIS. The guidelines allow for a graded approach that analyzes accidents at a level of detail that is consistent with potential accident impacts. Indicators of potential accident impacts include the amounts of hazardous materials, existence of highly energetic forces, number of persons in the vicinity, and effectiveness of features that would mitigate an accident's occurrence, progression, and consequences to people and the environment.

The DOE requires that potential hazards be considered if they can lead to accidents that are reasonably foreseeable; that is, there is a mechanism for their occurrence and their probability of occurrence is generally greater than one chance in a million per year. Accidents that are less frequent may also be considered if they could result in high consequences and provide information important to decision-making.

The DOE's guidelines do not require that all potential accidents be evaluated, but do require evaluation of a sample of reasonably foreseeable accidents to demonstrate the range of potential impacts. The range should include both low-frequency–high-consequence and high-frequency–low-consequence events. An example of the former event would be an airplane crash into a facility containing radioactive materials, and an example of the latter event would be a laboratory spill of a small amount of a hazardous chemical.

F.1.2 Identification and Selection of Potential Accidents

The existence of hazardous conditions and potential accidents was determined through an investigative process that derived relevant information from facility experts, facility tours, and safety documentation.

- *Facility experts*—Meetings, discussions, and written communications with personnel familiar with facility operations, hazardous conditions, safety documentation, and mitigating features provided a basis for determination of potential accidents and direction of further inquiry.
- *Facility tours*—Facilities, in which operations were identified as having hazardous conditions and the potential for accidents affecting people and the environment, were toured to gain an understanding of the mechanisms that could cause an accident, existing mitigating features that would limit accident consequences, and factors needed for the development of accident scenarios.
- *Safety documentation*—The DOE requires those facilities, containing hazardous materials with the potential for accidents that could impact workers and the public, conduct safety studies and maintain documentation that ensures operations are conducted in a safe manner. Applicable documents such as safety analysis reports (SARs), safety assessments (SAs), hazard assessments (HAs), monitoring reports, and NEPA documents were reviewed.

The information and data obtained during these activities were used extensively for assessing hazards at SNL/NM facilities, identifying potential accidents, developing accident scenarios, and estimating accident impacts.

F.1.3 Screening Facilities

An initial screening of all facilities performed by SNL/NM provided a list of facilities to be addressed in the SWEIS (see Section 2.3 of this SWEIS and SNL/NM 1998a). The accident team screened this list of facilities further to eliminate those that, relative to other facilities, had low or no potential for accidents involving hazardous materials and impacting people and the environment. Additionally, based on discussions with facility experts, facility tours, and reviews of safety documents, some facilities, which were eliminated in the initial screening, were added to the accident team's list because of their hazardous material inventory and potential for accident impacts involving radioactive materials, chemicals, and explosives.

F.1.4 Accident Evaluation

Facilities subject to accident evaluation were placed into one of four groups as follows:

- *Group 1*—Facilities in this group were determined to have the highest potential accident impacts and required modeling and analysis to provide a uniform basis for the evaluation of alternatives. These facilities are generally addressed in Sections F.2, F.3, F.5, and F.7. In addition, the potential for an airplane crash into a facility containing hazardous materials was also analyzed and is described in Section F.4.
- *Group 2*—Facilities in this group were determined to have a high potential for accident impacts but were not modeled or analyzed, as was done for facilities in Group 1, because these facilities were similar to the facilities analyzed in Group 1 with respect to amounts and types of hazardous inventory and accident impacts and were, therefore, adequately represented by the Group 1 facilities. Accelerator facilities in Technical Area (TA)-IV, activities involving explosives in TAs-I and -II, and facilities containing hazardous chemicals in TAs-I, -II, and -III are examples of facilities in this group. Section F.6 provides additional information on the hazards and potential accidents associated with Group 2 facilities.
- *Group 3*—Facilities in this group were determined to have a lower potential for accident impacts compared to Group 1, have been previously evaluated for accident impacts, and have suitable documentation describing their accident impacts. These facilities and their potential accident impacts are generally addressed in Section F.6.
- *Group 4*—Facilities in this group were determined to have a lower potential for accident impacts compared to Group 3, based on discussions with facility experts, facility tours, and/or available documentation. Safety documentation was not required for these facilities, as it was required for facilities in the first three groups.

As indicated, accident impacts were analyzed for the facilities in Group 1. The analyses used computer codes such as the *MELCOR Accident Consequence Code System, Version 2 (MACCS)* (see Section F.2) for modeling the airborne dispersion of radiological materials and the *Areal Location of Hazardous Atmospheres (ALOHA)* code (see Section F.3) for the airborne dispersion of hazardous chemicals. Other formulas and techniques were used for estimating airplane crash probabilities (see Section F.4) and effects of explosions (see Section F.5). All analyses for Group 1 facilities were performed in a manner that produced mean (also referred to as average) consequences in a conservative manner. For this SWEIS, average values of input parameters were used when known. If the value of an input parameter was uncertain, a value that produced the most conservative effect was used. This combination of values yields a "realistic conservative" analysis. The analyses performed by SNL/NM for Groups 2 and 3 facilities varied according to facility preferences and requirements and reflected either average or worst-case values. The analyses for the Groups 2 and 3 facilities used various methods that are described in their supporting documentation.

F.1.5 Measures of Accident Impacts

The impacts to humans that could result from potential radiological accident scenarios were evaluated in terms of dose units (such as rem or person-rem) and excess latent cancer fatalities (LCFs). The dose-to-LCF conversion factors used were $5.0x10^{-4}$ LCFs per rem (or person-rem) and $4.0x10^{-4}$ LCFs per rem, respectively, for the public and workers. For chemical releases, the impacts were evaluated in terms of chemical concentrations in relation to environmental response planning guidelines (ERPG) levels for specified workers and the public (AIHA 1997). For explosions, the impacts were evaluated in terms of expected damage and injury as a function of distance from the explosion. Airplane crash probabilities for various facilities were estimated and used as events leading to the potential release of chemical and radioactive materials.

Dose units and LCFs are indications of an accident's consequences without regard to the probability that the accident will occur. The risk associated with an accident is normally calculated by taking the mathematical product of an accident's consequences and its probability of occurrence. Accident probabilities (sometimes referred to as frequencies) are identified in the SWEIS wherever they are known and applicable. In many cases, the accident probability is expressed as a range to indicate a level of uncertainty in the actual value. Risks are generally not shown but may be calculated as stated above.

F.1.6 Human Receptors

The impacts of accidents were measured in terms of the effects for the following six types of human receptors:

- members of the public located at 14 onsite locations such as schools, playgrounds, golf course, and family residences;
- a hypothetical member of the public circumferentially located at the 16 compass points of the Kirtland Air Force Base (KAFB) site boundary;
- a maximally exposed individual (MEI), which is the receptor with the highest mean exposure among the first two types of receptors;
- a noninvolved worker at 100 m or at a fence line or boundary, whichever is closer to the point of an accidental release;
- the offsite population, out to a distance of 50 mi, and
- involved workers (generally in the immediate vicinity of the accident).

Although there are many other locations on the site and off the site, these last four receptors and receptor locations will bound the impacts to any other receptor or receptor location.

F.1.7 Nonhuman Environmental Impacts

Any accidental release of radioactive or chemical materials could affect the nonhuman elements of the environment, such as surface water and groundwater, historical and archeological sites, and animals and their habitat. Brush fires and oil spills are examples of accidents that could have these effects. The SWEIS identifies the potential for these occurrences but does not analyze their impacts. The DOE has requirements and procedures in place for responding to an incident that could affect the environment. In such an event, an assessment of the contamination and damage would be made and corrective actions would be taken to minimize the impacts and to clean up the affected areas.

F.1.8 Uncertainties and their Effects

The estimates of impacts and probabilities can be affected by unavoidable uncertainties in the analyses. These uncertainties can be attributed to modeling techniques, amounts of hazardous materials, estimates of health effects of exposures to hazardous materials, accident scenario definitions, meteorology data, population estimates, and similar causes.

Several actions have been taken to minimize the effects of uncertainties on decision-making. The methodology used for accident analysis has received peer review and approval. The *MACCS* and *ALOHA* computer codes used for modeling the dispersion of radioactive and chemical releases respectively are accepted by the DOE and are also routinely used for this purpose by other agencies and industry.

Completed analyses receive peer and technical review to ensure accuracy and conformance with requirements. In the event of uncertainty and/or variability in input data and information, conservative assumptions have been made, such as using the largest inventory, which have the effect of overestimating the impacts of accidents. Similarly, in many instances, no credit is taken for mitigating actions, such as evacuation, which also has the effect of overestimating accident impacts.

The method of analysis provides an incremental assessment of impacts among the alternatives. Because the SWEIS does not estimate the total impacts or risks of accidents, this approach to uncertainty provides adequate information for the relative comparison of alternatives. Thus, to the extent that any analysis results contains the effects of uncertainties, the effects are uniformly applicable to each alternative thereby providing an accurate basis for comparison and decision-making.

F.1.9 Data Sources

Information and data on the safety of SNL/NM facilities are contained in referenced documents such as SARs, SAs, HAs, process hazard surveys (PHSs), NEPA documents, and facility safety and information documents (FSIDs). These documents differ in the level and method of analysis, reflecting the differences in hazards among the facilities. In addition, a chemical database known as CheMaster was used to provide chemical inventories for three facilities. Table F.1–1 presents a list of facilities for which existing documentation was reviewed and evaluated for potential use in the SWEIS.

Table F.1–1. Listing of Facilities, Documentation Reviewed, and Type of Evaluations Performed

BUILDING		REFERENCE	TYPE OF EVALUATION PERFORMED				
NAME	NUMBER		RADIOLOGICAL	CHEMICAL	EXPLOSION	AIRCRAFT CRASH	SEISMIC
Steam Plant	***605***	SNL/NM 1998a					
Center For National Security and Arms Control	***810***	SNL 1993, TtNUS 1998k, Zamorski 1998					
Systems Research and Development	***823***	SNL/NM 1998a, SNL/NM 1995i, SNL/NM 1996v		◆			◆
Weapons Production Primary Standards Laboratory[a]	***827***	SNL/NM 1998u					
Photovoltaic Systems Evaluation Laboratory	***833***	Sanchez-Brown & Wolf 1994, SNL 1995f, SNL/NM 1996y, SNL/NM 1996c					
Microelectronics Development Laboratory	***858***	SNL 1995a, SNL/NM 1993a, SNL/NM 1998a, SNL/NM 1998g, SNL/NM 1996w, TtNUS 1998k		◆	◆	◆	◆
Microsystems and Engineering Sciences Applications Complex	***No Number***	SNL 1996b		◆		◆	◆
Production Primary Standards Laboratory[a]	***864***	SNL/NM 1997z					

Table F.1–1. Listing of Facilities, Documentation Reviewed, and Type of Evaluations Performed (continued)

BUILDING		REFERENCE	TYPE OF EVALUATION PERFORMED				
NAME	NUMBER		RADIOLOGICAL	CHEMICAL	EXPLOSION	AIRCRAFT CRASH	SEISMIC
Industrial Hygiene Instrumentation Laboratory	*869*	SNL 1995g, SNL/NM 1998e		◆			◆
Neutron Generator Facility	*870*	DOE 1994a, DOE 1994d, Scientech 1994, Scientech 1995, SNL/NM 1993c, SNL/NM 1996l SNL/NM 1998a, SNL/NM 1998o, TtNUS 1998k	◆			◆	◆
Advanced Manufacturing Processes Laboratory	*878*	SNL 1994c, SNL 1994e, SNL/NM 1998a, TtNUS 1998k		◆		◆	◆
Computing Building	*880*	SNL 1995d		◆			
Photovoltaic Device Fabrication Laboratory	*883*	SNL 1995f, SNL/NM 1998a, TtNUS 1998k		◆			
6-MeV Tandem Van Der Graaf Generator	*884*	SNL/NM 1998a		◆			
Ion Beam Materials Research Laboratories	*884*	SNL/NM 1994f SNL/NM 1998a		◆			◆
Lightning Simulation Facility	*888*	SNL 1994d, SNL/NM 1995a, SNL/NM 1998a, SNL/NM n.d. (a)		◆			◆

Table F.1–1. Listing of Facilities, Documentation Reviewed, and Type of Evaluations Performed (continued)

BUILDING		REFERENCE	TYPE OF EVALUATION PERFORMED				
NAME	NUMBER		RADIOLOGICAL	CHEMICAL	EXPLOSION	AIRCRAFT CRASH	SEISMIC
Hazardous Waste Management Facility	*958*	SNL/NM 1998a, TtNUS 1998k				◆	
Excimer Laser Processing Laboratory[a]	*960*	DOE n.d. (a), Bendure 1995, SNL/NM 1998a					
Tera-Electron Volt Energy Superconducting Linear Accelerator (TESLA)[a]	*961*	SNL/NM 1998a					
Advanced Pulsed Power Research Module[a]	*963*	SNL/NM 1996q, SNL/NM 1998a					
High Power Microwave Laboratory[a]	*963*	SNL/NM 1995c, SNL/NM 1998a					
Repetitive High Energy Pulsed Power Unit II[a] *(RHEPP II)*	*963*	SNL/NM 1996d, SNL/NM 1998a					
High-Energy Radiation Megavolt Electron Source III (HERMES III) Accelerator[a]	*970*	SNL/NM 1996b, SNL/NM 1998a					
Sandia Accelerator & Beam Research Experiment (SABRE)[a]	*970*	SNL/NM 1995t, SNL/NM 1998a					

Table F.1–1. Listing of Facilities, Documentation Reviewed, and Type of Evaluations Performed (continued)

BUILDING		REFERENCE	TYPE OF EVALUATION PERFORMED				
NAME	NUMBER		RADIOLOGICAL	CHEMICAL	EXPLOSION	AIRCRAFT CRASH	SEISMIC
Hazardous Waste Management Facility	*958*	SNL/NM 1998a, TtNUS 1998k				◆	
Excimer Laser Processing Laboratory[a]	*960*	DOE n.d. (a), Bendure 1995, SNL/NM 1998a					
Tera-Electron Volt Energy Superconducting Linear Accelerator (TESLA)[a]	*961*	SNL/NM 1998a					
Advanced Pulsed Power Research Module[a]	*963*	SNL/NM 1996q, SNL/NM 1998a					
High Power Microwave Laboratory[a]	*963*	SNL/NM 1995c, SNL/NM 1998a					
Repetitive High Energy Pulsed Power Unit II[a] *(RHEPP II)*	*963*	SNL/NM 1996d, SNL/NM 1998a					
High-Energy Radiation Megavolt Electron Source III (HERMES III) Accelerator[a]	*970*	SNL/NM 1996b, SNL/NM 1998a					
Sandia Accelerator & Beam Research Experiment (SABRE)[a]	*970*	SNL/NM 1995t, SNL/NM 1998a					

Table F.1–1. Listing of Facilities, Documentation Reviewed, and Type of Evaluations Performed (continued)

BUILDING		REFERENCE	TYPE OF EVALUATION PERFORMED				
NAME	NUMBER		RADIOLOGICAL	CHEMICAL	EXPLOSION	AIRCRAFT CRASH	SEISMIC
Saturn Accelerator[a]	*981*	SNL/NM 1988					
Short-Pulse High Intensity Nanosecond X-Radiator (SPHINX)[a]	*981*	SNL/NM 1995s, SNL/NM 1998a					
Z-Machine	*983*	SNL/NM 1996s, SNL/NM 1998a, TtNUS 1998k	◆	◆		◆	◆
Repetitive High Energy Pulsed Power Unit I[a] *(RHEPP I)*	*986*	SNL/NM 1995r, SNL/NM 1998a					
Drop/Impact Complex[a]	*6510*	DOE n.d. (a), SNL/NM 1998a					
Centrifuge Complex[a]	*6520*	DOE n.d. (a), SNL/NM 1998a					
Radiant Heat Facility[a]	*6538*	DOE n.d. (a), DOE 1996d, Laskar 1997a, Walker 1996b					
Hot Cell Facility	*6580*	DOE 1996b, SNL/NM 1995e, SNL/NM 1998a, TtNUS 1998k	◆				◆
Hammermill	*6583*	SNL/NM 1998a					

Table F.1–1. Listing of Facilities, Documentation Reviewed, and Type of Evaluations Performed (continued)

BUILDING		REFERENCE	TYPE OF EVALUATION PERFORMED				
NAME	NUMBER		RADIOLOGICAL	CHEMICAL	EXPLOSION	AIRCRAFT CRASH	SEISMIC
Annular Core Research Reactor	*6588*	DOE 1996b, Schmidt 1998, SNL 1992b, SNL 1995e, SNL 1996d, SNL/NM 1997d, SNL/NM 1998a, TtNUS 1998k	◆				◆
Gamma Irradiation Facility	*6588*	SNL/NM 1995m, SNL/NM 1998a, TtNUS 1998k	◆				
Sandia Pulsed Reactor	*6593*	SNL/NM 1995v, SNL/NM 1996k, SNL/NM 1998a, TtNUS 1998k	◆				◆
Exterior Intrusion Sensor Field[a]	*6600A*	SNL/NM 1993b, SNL/NM 1994b, SNL/NM 1998a, TtNUS 1998k					
Liquid Metal Processing Laboratory[a]	*6630*	SNL 1996b, SNL/NM 1998a					
Thermal Treatment Facility[a]	*6715*	DOE n.d. (a), SNL/NM 1998a, TtNUS 1998k					
Sled Track Complex	*6740*	DOE n.d. (a), SNL/NM 1993d, SNL/NM 1997x, SNL/NM 1998a			◆		

Table F.1–1. Listing of Facilities, Documentation Reviewed, and Type of Evaluations Performed (concluded)

BUILDING		REFERENCE	TYPE OF EVALUATION PERFORMED				
NAME	NUMBER		RADIOLOGICAL	CHEMICAL	EXPLOSION	AIRCRAFT CRASH	SEISMIC
Terminal Ballistics Complex[a]	*6750*	SNL/NM 1994e, SNL/NM 1998a, TtNUS 1998k					
Radioactive and Mixed Waste Management Facility	*6920*	DOE 1993a, SNL/NM 1991, SNL/NM 1994c, SNL/NM 1998a, TtNUS 1998k	◆	◆	◆	◆	
Containment Technology Test Facility-West[a]	*9800*	Emerson 1992, SNL/NM 1998a					
Aerial Cable Facility	*9831*	Roybal 1996, SNL/NM 1995q, SNL/NM 1998a	◆		◆		
Explosives Application Laboratory[a]	*9930*	SNL/NM 1998a, SNL/NM n. d. (e)					
High-Explosive Assembly Building[a]	*9967*	SNL/NM 1998a, SNL/NM 1998n					
National Solar Thermal Test Facility[a]	*9980*	Harris 1992, SNL/NM 1996t, SNL/NM 1998a, TtNUS 1998k					
Manzano Waste Storage Facilities	*Various*	SNL/NM 1997q, SNL/NM 1998a	◆				◆
Lurance Canyon Burn Site[a]		SNL/NM 1998a, SNL/NM n.d. (f)					

Source: Original
MeV: million electron volt
[a] Existing safety documentation was reviewed for these facilities but no accident evaluations were performed because the accident impacts to the environment or to humans were less than those from the selected facilities.

F.2 RADIOLOGICAL ACCIDENTS

F.2.1 Introduction

Section F.2 describes the radiological accident analysis for the SNL/NM SWEIS. It begins with a discussion of the general methodology and accident scenario-independent data used for the radiological accident analysis (Sections F.2.2 through F.2.4). This is followed by separate subsections for TA-I and TA-II (Section F.2.5), TA-IV (Section F.2.6), TA-V (Section F.2.7), and the Manzano Waste Storage Facilities (Section F.2.8). Each subsection discusses the selection of accident scenarios, specific analysis assumptions, and results.

Accident scenario identifiers, or codes, were established for each radiological accident scenario that was analyzed for the SWEIS. These codes were used primarily in the tables of input data and also served as a positive means of identifying the scenarios. The codes were generally based on letters from the facility names and mode of operation (for example, AM scenarios are accidents at the Annular Core Research Reactor [ACRR], operating in the medical isotopes production configuration). The codes are discussed in detail in Sections F.2.5.1, F.2.6.1, F.2.7.1, and F.2.8.1.

F.2.2 Consequence Analysis Methodology

This section summarizes the methodology that was used to analyze postulated radiological accident scenarios for SNL/NM facilities and activities. This methodology describes the general process that was followed for source-term derivation and consequence (radiation dose) analysis, including models and computer codes that were used. The uncertainties associated with the selection of the values for the various parameters that affect the source term and the consequence analyses are also discussed.

F.2.2.1 Source Term Determination

The source terms and consequences identified in the SNL/NM safety documents were used for the initial review of SNL/NM facilities and accident scenarios and selection of accident scenarios. Sections F.2.5, F.2.6, F.2.7, and F.2.8 discuss the accident selection process and describe the selected accident scenarios for specific areas. These accident scenarios were modeled for the SWEIS and consequences were determined.

Accident source terms were obtained from various facility references that have different bases and assumptions. In order to present and compare accident impacts for facilities and alternatives on a uniform basis, the reference source terms were revised, or normalized, so that the amounts of radioactive material released used the same bases and assumptions. The differences in assumptions in reference documents were evident in the inconsistencies among facilities with respect to the models and assumptions used to determine the material at risk (MAR), damage ratio (DR), airborne release fraction (ARF) x respirable fraction (RF), and leak path factor (LPF). With respect to the LPF, assumptions (such as in-facility transport and filtration) were inconsistent from facility to facility because of facility-specific considerations.

For each accident selected, a source term was calculated using the 5-factor formula in DOE-HDBK-3010-94 (DOE 1994b). That is, the source term (also referred to as the building source term) was calculated based on the following equation:

$$\text{Source Term} = MAR \times DR \times ARF \times RF \times LPF \qquad \text{(Eq. F.2–1)}$$

Where:

- MAR = the material at risk;
- DR = the damage ratio, which is fraction of the MAR that is affected by the postulated accident scenario;
- ARF = the airborne release fraction, as specified by DOE-BK-3010-94;
- RF = the respirable fraction of airborne material (<10 micrometers aerodynamic equivalent diameter); and
- LPF = the leak path factor (or fraction of airborne respirable radioactive material that leaves the facility or building).

The source terms calculated for the SWEIS analysis were based on the following general assumptions:

- The MAR was based on the SNL/NM safety documentation and interviews with operating personnel to clarify uncertainties in the data. For all radiological accident scenarios, the MAR represents the maximum inventory of material that is at risk from the given accident scenario. As such, it represents the upper bound of the MAR for each facility/process affected by the postulated accident scenario. It is important to note that, under most circumstances, the accident scenarios selected from the SNL/NM safety documentation represent not only the bounding scenarios for the facility, but also a set of bounding assumptions with respect to the release.

- The DR was based on estimates presented in the SNL/NM safety documentation (for example, number of fuel elements affected by the accident scenario). The SWEIS assumed that all the DRs were 1.0, thus representing an extremely conservative assumption with respect to the impact of the energy of the postulated release on the MAR.
- The ARF and RF were obtained for various postulated accident scenarios directly from DOE-HDBK-3010-94. The ARFxRF represented the bounding values in the handbook.
- The LPF was assumed to be 1.0 for all accident scenarios at all facilities other than the ACRR. For ACRR accident scenarios, the LPF was assumed to be 1.0 for scenarios with a release originating outside the reactor pool. An LPF of 1.0 assumes that all airborne respirable radioactive material leaves the facility or building without any filtration, plate-out, or deposition during in-facility transport.
- For ACRR accident scenarios with a release of radioactive material originating in the reactor pool, an additional factor was used to determine the amount of radioactive material released from the pool to the reactor building. This factor, the decontamination factor (DF), accounts for the radioactive material absorbed in the pool water and not released into the building. For these scenarios, no further reduction was assumed between the pool surface and the building release point. The LPF for these scenarios is given by the equation 1.0/DF. For mechanical failure events (for example, fuel cladding ruptures), a DF of 1.0 was used for noble gases, 100 for halogens, and 1,400 for particulates. This translates to a release from the building of 100 percent of the noble gases, 1 percent of the halogens, and 0.071 percent of the particulates that are released from the source (for example, the ACRR fuel). These same DF values were used in the ACRR SAR for the limiting event accident. They were developed in the report entitled, *Annular Core Research Reactor (ACRR) Postulated Limiting Event Initial and Building Source Terms*, SAND91-057 (SNL 1992b). For accident scenarios that cause a very energetic release, such as a large reactivity insertion, more conservative, upper bound DF values were used for the SWEIS analysis. A DF of 1.0 was used for all fission products and actinides. Although the referenced report (SNL 1992b) supports the 1.0/100/1,400 DFs for even a very energetic release, lower DFs were chosen to bound the release. This assumption also introduces a distinction in pool absorption capability between low energy and very high energy events.

These factors are discussed further in Section F.2.3.5 and, for specific TA-V scenarios, in Section F.2.7.

Because the values for each of the five factor parameters in Equation F.2–1 represent bounding values for each of these variables, the values of the source term for each of the postulated accident scenarios represent, by default, bounding source terms.

F.2.2.2 Consequence Analysis

This section identifies the assumptions, uncertainties, models, and computer codes that were used to determine the consequences from postulated accident scenarios.

All radiological consequences were determined using the *MACCS2* computer code (SNL 1998c). *MACCS2* is a DOE/Nuclear Regulatory Commission (NRC)-sponsored computer code that has been widely used in support of probabilistic risk assessments for the nuclear power plant industry. It also has been widely used in many consequence analyses for preparing safety documentation (such as SARs, SAs, EAs, and EISs) for facilities throughout the DOE complex.

The *MACCS2* code uses three separate phases with input files (ATMOS, EARLY, and CHRONC) to perform transport and dose calculations for selected ranges or locations from a postulated release location. Other input files are also needed to support the model runs, including a meteorological data file, a site data file containing the population distribution around the postulated release location, and a dose conversion file.

The CHRONC input module was not used for the SNL/NM SWEIS because this module is designed to deal with long-term exposure pathways, such as ingestion. The ingestion pathway has no impact on the overall dose to the postulated onsite receptors because no foodstuffs are grown within KAFB. For receptors at or beyond the KAFB site boundary, the ingestion pathway has only a small impact on the overall dose (based on normal operational impacts).

For all cases, the postulated exposed individuals or populations were assumed to be exposed to the entire plume of released radioactive materials. That is, an individual would remain at one of these locations for the entire duration of the accident without taking any protective action.

Buoyant plume releases were modeled only for fire scenarios in which building confinement was assumed to be lost as part of the accident scenario (for example, an airplane crash). A heat release of 1 MW was assumed for these fires to create a buoyant release. The heat release of 1 MW represents a moderately small fire (DiNenno et. al. 1993). This size of fire at a facility is considered to be a good representation for most facility fires and represents conservative release conditions with respect to expected consequences to the MEI. Larger heat loads will lead to lower exposures to the MEI. All other releases were assumed to be nonbuoyant releases. Actual release heights were used for the various buildings as long as the postulated accident scenario did not affect the building integrity. Releases from the SPR were conservatively assumed to be at ground level rather than at the stack height because the stack height is relatively low.

All *MACCS2* runs used weather bin sampling from one year's worth of meteorological data (1996) (SNL/NM 1998j). Precipitation data were included in the meteorological input files, but were conservatively zeroed out for the analyses; however, dry deposition was assumed. This tended to overestimate the calculated short-term population doses.

In determining the consequence for the SWEIS, a stratified weather category bin sampling from one year's worth of meteorological data was used in running the *MACCS2* computer code. Over 100 samples of meteorological data were selected and used to model downwind dispersion and transport of the postulated release. Each of the meteorological samples included data on the wind speed, direction, and stability class.

MACCS2 sorts the meteorological data into 36 meteorological bins, representing combinations of stability categories, wind speeds, and rain intensity ranges. *MACCS2* samples randomly from each of these weather bins, thus ensuring a good representation of the entire weather data. The *MACCS2* User's Manual provides further detailed information on the sampling techniques available with the code (SNL 1998c). *MACCS2* provides results for each sample of meteorological data modeled and an annual probability of occurrence, thereby providing a rank-ordered distribution of consequences. The mean value of the consequence distribution calculated by *MACCS2* was used in this SWEIS.

The MAR inventories were input as part of ATMOS. The accident source term was determined by using the release fraction options for the various chemical groups in ATMOS. These release fractions were designed to match the calculated product of the DR, ARF, RF, and LPF from the source-term equation for each of the postulated release scenarios. The uncertainty associated with the consequence analysis is directly related to the uncertainties of both the source-term calculations (assumed to be at least one order of magnitude conservative) and the dispersion/transport modeling (assumed to be no less than the mean value). As such, the uncertainty of the consequences is at least no lower than the uncertainty of the source terms; that is, at least one order of magnitude more conservative.

To convert the *MACCS2* dose results into LCFs, the SWEIS used the International Commission on Radiological Protection (ICRP) factor of 5.0×10^{-4} additional latent cancers per person-rem for the members of the general public. For the noninvolved workers, the ICRP factor of 4.0×10^{-4} additional latent cancers was used, unless the reported dose was greater than 20 rem when the factor doubles.

F.2.3 Consequence Analysis Input

F.2.3.1 Source Term Data

Source term data (such as the quantity and form of the radioactive release) are discussed in general in the methodology section, above, and specifically for each accident scenario in the scenario descriptions later in this section.

To simplify the calculations where possible, some consequence calculations were performed for a unit release. In these cases, where source term isotopic distributions were the same but total quantities released were different, a *MACCS2* analysis was based on a unit activity release (such as 1 Ci of plutonium-239). The unit results were then scaled up to the total release to determine the consequences for the actual releases, as long as the product of ARFxRFxLPF did not change. It was possible to use one *MACCS2* run for multiple accident scenarios using this method. This scaling technique is not valid for releases that are much greater than 1 Ci. The technique was not used for such accident scenarios; scenario-specific calculations were performed for accident scenarios that involved releases greater than approximately 1 Ci.

It was assumed that all tritium released would be in the form of tritium oxide (tritiated water).

F.2.3.2 Meteorological Data

Actual site-specific meteorological data were obtained to support the consequence calculations. Meteorological data (such as wind speed, wind direction, and stability class), consisting of hourly sequential data and hourly precipitation rates, were obtained from SNL/NM (SNL/NM 1998j, 1999a). The data were for the years 1994 through 1996. The data were from two meteorological towers, A21 and A36. A21 is located in TA-II and A36 is located in TA-V. Based on discussions with SNL/NM personnel, these two towers were selected for accident modeling as being most representative of the atmospheric dispersion.

For *MACCS2* accident analyses, only the 1996 data were used. This year was considered to be the base year for the SWEIS. It is expected that the mean consequences would not vary much if data from other years were used.

F.2.3.3 Population Distributions

Four offsite population distributions, based on estimated 1995 population data, were provided by SNL/NM (Bleakly 1998a, 1998c). Two distributions were centered on TA-I and TA-V. The third distribution was centered on the Manzano Waste Storage Facilities. The fourth centered on the Aerial Cable Facility. The distributions were originally generated with the methodology used for the population distribution data for National Emissions Standards for Hazardous Air Pollutants (NESHAP) reports (Hylko 1998a, 1998b). These distributions were modified by SNL/NM to provide a finer grid for the radial spacing for input into *MACCS2*. The finer grid is necessary to evaluate the impacts to the population located within 5 mi of the release point. Tables F.2–1 and F.2–2 show the population distributions for TAs-I and -V, respectively, while Table F.2–3 shows the population distribution for the Manzano Waste Storage Facilities. Population distributions for the Aerial Cable Facility are shown in Section F.6 (Table F.6–24).

Population data were divided into 17 annular rings and 16 sectors corresponding to the 16 compass directions commonly used by *MACCS2*. *MACCS2* applies the dose at the mid-distance of the annular ring to all distances within that ring. Therefore, in order to provide information on dosage provided to a "noninvolved worker" close to the radionuclide source facility, the first annular ring, specified from zero to 0.8 km, was subdivided into two annular rings, ranging from zero to 0.2 km and from 0.2 to 0.8 km. This theoretical "noninvolved worker" was defined as a SNL/NM worker not involved with the facility where the accident occurs and located 100 m from the facility evaluated.

F.2.3.4 Location of Individual Receptors

For this SWEIS, two different types of individual receptors representing the general public were analyzed. The first, core receptors, represent locations where members of the public could be located within or close to the KAFB boundary. The second, boundary receptors, represent 16 locations on the KAFB boundary. Each type of receptor is discussed below.

Locations of Core Receptors

Members of the general public could be present during a potential accident at locations within or close to the KAFB boundary. These locations include the riding stables, child-care centers, base housing, and the National Atomic Museum, among others. It was conservatively assumed that an individual would remain outdoors at one of these locations for the entire duration of the accident without taking any protective action. The distance and direction to each receptor location were provided by SNL/NM (Bleakly 1998b, c). Fourteen different core receptor locations were selected to represent the many locations possible. Table F.2–4 provides each core receptor's distance, by direction, from each release point. The distance, by direction from the Aerial Cable Facility, by core receptor, is provided in Section F.6 (Table F.6–25). It should be noted that some receptor locations, due to their size or position, may occur within more than one sector and, therefore, may appear in the tables of consequence more than once.

The following 14 core receptor locations were identified:

- Base Housing
- Child Development Center-East
- Child Development Center-West
- Coronado Club
- Golf Course
- Kirtland Elementary School
- Kirtland Underground Munitions and Maintenance Storage Complex (KUMMSC)

Table F.2–1. Population Distribution Surrounding Technical Area-I

DIRECTION	DISTANCE (miles)									
	0.12	0.5	1	1.5	2	2.5	3	3.5	4	4.5
N	0	0	0	657	1,071	1,382	1,690	1,997	2,304	2,611
NNE	0	5	50	667	1,073	1,389	1,699	2,009	2,319	2,629
NE	0	5	361	759	1,069	1,379	1,686	1,993	2,300	2,346
ENE	0	18	461	758	1,066	1,378	1,679	1,714	1,154	130
E	0	6	117	275	847	1,373	1,643	1,398	72	82
ESE	0	5	14	24	110	313	164	87	0	0
SE	0	0	15	24	0	0	0	0	0	0
SSE	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	247	793	1,273
SW	0	0	0	0	0	0	0	399	1,957	2,600
WSW	0	0	0	0	62	155	181	566	1,430	2,419
W	0	0	0	0	303	407	514	728	1,500	2,605
WNW	0	0	0	0	993	1,378	1,684	1,991	2,298	2,604
NW	0	0	0	329	1,063	1,376	1,683	1,990	2,297	2,604
NNW	0	0	0	574	1,066	1,377	1,684	1,991	2,298	2,605
TOTAL	**0**	**39**	**1,018**	**4,067**	**8,723**	**11,907**	**14,307**	**17,110**	**20,722**	**24,508**

DIRECTION	DISTANCE (miles)								
	5	7.5	10	15	20	30	40	50	0-50 Total
N	2,918	19,217	9,978	1,727	9,654	2,009	1,145	1,473	59,833
NNE	2,939	20,771	756	1,171	289	825	1,645	2,921	43,157
NE	1,689	2,117	845	2,292	1,143	1,768	3,261	9,302	34,315
ENE	92	603	1,011	2,509	2,453	2,329	3,261	3,962	24,578
E	92	603	875	2,416	1,532	3,108	2,021	1,877	18,337
ESE	92	603	1,689	2,414	2,630	2,597	388	498	11,628
SE	0	0	844	2,413	1,906	502	1,314	498	7,516
SSE	0	603	844	1,177	216	279	508	1,370	4,997
S	0	602	843	975	1,261	3,323	4,091	610	11,705
SSW	1,733	15,973	3,983	1,156	3,318	7,031	8,947	172	44,626
SW	2,906	18,736	15,972	2,248	7,487	6,525	4,989	2,952	66,771
WSW	2,908	5,104	1,226	2,413	3,379	8,312	4,933	1,455	34,543
W	2,911	10,800	3,219	20,627	3,375	9,644	3,625	8,004	68,262
WNW	2,911	19,542	22,063	37,794	11,424	7,445	4,773	1,018	117,918
NW	2,911	17,265	16,422	62,300	12,928	855	1,158	1,490	126,671
NNW	2,911	19,130	18,769	18,955	21,424	3,493	1,131	1,453	98,861
TOTAL	**27,013**	**151,669**	**99,339**	**162,587**	**84,419**	**60,045**	**47,190**	**39,055**	**773,718**

Source: Bleakly 1998a

Table F.2–2. Population Distribution Surrounding Technical Area-V

DIRECTION	DISTANCE (miles)									
	0.12	0.5	1	1.5	2	2.5	3	3.5	4	4.5
N	0	0	0	0	0	0	0	63	411	1,054
NNE	0	0	0	0	0	0	0	75	1,235	2,629
NE	0	0	0	0	0	0	0	0	230	1,198
ENE	0	0	0	0	0	0	0	0	0	82
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	82
SSE	0	0	0	0	0	0	0	0	72	82
S	0	0	0	0	0	0	0	62	72	82
SSW	0	0	0	0	0	0	0	0	570	140
SW	0	0	0	0	0	86	965	1,869	2,293	2,346
WSW	0	0	0	0	15	1,117	1,680	1,987	2,294	2,601
W	0	0	0	0	190	1,379	1,686	1,992	2,298	2,605
WNW	0	0	0	0	24	756	665	1,395	2,295	2,329
NW	0	0	0	0	0	0	0	64	306	613
NNW	0	0	0	0	0	0	0	0	42	336
TOTAL	**0**	**0**	**0**	**0**	**229**	**3,338**	**4,996**	**7,507**	**12,118**	**16,179**

DIRECTION	DISTANCE (miles)								
	5	7.5	10	15	20	30	40	50	0-50 Total
N	1,987	19,199	26,879	31,920	1,581	13,313	1,145	1,473	99,025
NNE	2,882	15,958	12,638	8,352	1,085	828	1,700	3,036	50,418
NE	1,096	716	854	2,552	3,121	2,276	3,261	4,193	19,497
ENE	92	603	884	2,519	2,297	2,329	3,261	3,910	15,977
E	0	0	845	2,415	1,274	2,535	1,244	1,324	9,637
ESE	0	603	1,689	2,414	2,888	1,582	1,314	498	10,988
SE	92	603	719	1,189	126	277	387	498	3,973
SSE	92	546	323	326	164	277	1,380	498	3,760
S	91	448	315	900	1,260	3,200	2,981	218	9,629
SSW	91	520	315	893	1,251	10,555	2,275	172	16,782
SW	1,708	2,133	621	5,423	8,411	3,843	4,201	1,404	35,303
WSW	2,908	16,421	2,088	2,413	2,953	5,725	4,951	1,599	48,752
W	2,809	7,363	844	2,680	3,375	9,570	3,329	8,004	48,124
WNW	2,492	10,909	3,288	30,006	4,981	9,558	7,419	864	76,981
NW	1,396	17,475	25,879	57,572	57,770	3,592	1,158	1,490	167,315
NNW	4,562	19,130	26,332	38,540	40,338	18,549	1,131	1,453	150,413
TOTAL	**22,298**	**112,627**	**104,513**	**190,114**	**132,875**	**88,009**	**41,137**	**30,634**	**766,574**

Source: Bleakly 1998a

Table F.2–3. Population Distribution Surrounding Manzano Waste Storage Facilities

DIRECTION	DISTANCE (miles)									
	0.12	0.5	1	1.5	2	2.5	3	3.5	4	4.5
N	0	0	0	0	0	0	679	1,797	2,324	2,605
NNE	0	0	0	0	0	0	304	1,213	744	387
NE	0	0	0	0	0	0	0	61	75	84
ENE	0	0	0	0	0	0	0	61	71	88
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	0	0	0	0	0	0	0	0	0	77
S	0	0	0	0	0	0	0	0	0	80
SSW	0	0	0	0	0	0	0	0	0	77
SW	0	0	0	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0	0	129	1,725
W	0	0	0	0	0	0	0	0	765	2,120
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	61	1,067	1,469
TOTAL	**0**	**0**	**0**	**0**	**0**	**0**	**983**	**3,193**	**5,175**	**8,712**

DIRECTION	DISTANCE (miles)								
	5	7.5	10	15	20	30	40	50	0-50 TOTAL
N	2,911	19,155	26,817	14,213	387	5,873	1,147	1,474	79,382
NNE	765	1,784	856	2,431	841	1,090	4,029	10,468	24,912
NE	90	604	1,079	2,465	2,842	5,177	8,220	10,569	31,266
ENE	87	604	849	2,409	2,301	5,863	8,209	8,593	29,135
E	0	0	844	2,293	423	3,321	2,946	2,197	12,024
ESE	0	0	847	2,413	2,966	910	555	498	8,189
SE	0	602	837	1,501	187	540	823	498	4,988
SSE	99	583	388	141	97	276	1,380	498	3,539
S	99	520	315	824	1,011	2,580	2,821	253	8,503
SSW	89	584	341	893	1,250	6,146	2,803	174	12,357
SW	667	4,160	705	2,542	10,712	8470	4,620	1,698	33,574
WSW	3,153	18,750	13,989	2,396	3,078	6,135	5,231	2,635	57,221
W	2,779	16,938	5,713	6,921	3,372	9,644	5,642	7,108	61,002
WNW	152	12,712	18,012	41,775	7,875	13,277	8,335	1,236	103,374
NW	96	15,818	851	52,315	83,566	7,711	1,159	1,491	163,007
NNW	1,478	18,974	26,782	48,390	21,218	24,486	1,132	1,455	146,512
TOTAL	**12,465**	**111,788**	**99,225**	**183,922**	**142,126**	**101,499**	**59,052**	**50,845**	**778,985**

Source: Bleakly 1998c

Table F.2–4. Distance and Direction to Core Receptor Locations from Release Points

Core Receptor Location	Neutron Generator Facility (TA-I)		Explosive Components Facility (TA-II)		Z-Machine (TA-IV)		TA-V		Manzano Waste Storage Facilities	
	Direction	Distance (meters)	Direction	Distance (meters)	Direction	Distance (meters)	Direction	Distance (meters)	Direction	Distance (meters)
Closest Base Housing	W-WNW	1,800	WNW	2,300	NNW	2,300	NNW	5,900	NW	7,200
Child Development Center-East	NW	1,700	NW	2,500	NNW	2,900	NNW	6,900	NW	7,700
Child Development Center-West	WNW	5,500	WNW	6,100	WNW	5,900	NW	9,000	NW	10,800
Coronado Club	NW	1,500	NW	2,300	NNW	2,800	NNW	6,900	NW	7,600
Golf Course	SSE	2,700	SSE-S	2,000-2,100	ESE-SSE	1,500-1,600	N-NNE	1,900-2,000	WNW-NW	2,400-2,600
Kirtland Elementary School	W	5,900	WNW	6,500	WNW	6,200	NW	9,100	WNW	11,000
Kirtland Underground Munitions and Maintenance Storage Complex (KUMMSC)	S	4,300	SSW	3,900	SSW	2,700	NW	1,700	W	4,200
Lovelace Hospital	WNW	3,800	WNW	4,400	NW	4,300	NNW	7,600	NW	9,200
National Atomic Museum	WNW	1,100	WNW	1,800	NNW	2,100	NNW	6,100	NW	6,900
Riding Stables	SSE	4,800	SSE	4,100	SE	3,500	NE	1,800	WNW	1,600
Sandia Base Elementary School	NNW	1,600	NW-NNW	2,300	NNW	3,000	N	7,200	NW-NNW	7,600

Table F.2–4. Distance and Direction to Core Receptor Locations from Release Points (concluded)

Core Receptor Location	Neutron Generator Facility (TA-I)		Explosive Components Facility (TA-II)		Z-Machine (TA-IV)		TA-V		Manzano Waste Storage Facilities	
	Direction	Distance (meters)	Direction	Distance (meters)	Direction	Distance (meters)	Direction	Distance (meters)	Direction	Distance (meters)
Shandiin Day Care Center	W-WNW	1,700	WNW	2,300	NW	2,400	NNW	6,200	NW	7,300
Veterans Affairs Medical Center	W-WNW	3,600	WNW	4,200	WNW-NW	3,400-3,900	NW-NNW	7,200-7,300	NW	8,800
Wherry Elementary School	WNW	2,100	WNW-NW	2,900	NW-NNW	3,100	NNW	7,000	NW	8,000

Source: Bleakly 1998b, c

Notes: 1) If more than one direction is indicated, the core receptor location occurs within multiple sectors. The range in distance is also provided.

2) Distances are rounded to the nearest 100 meters.

- Lovelace Hospital
- National Atomic Museum
- Riding Stables
- Shandiin Day Care Center
- Sandia Base Elementary School
- Veterans Affairs Medical Center
- Wherry Elementary School

Location of Boundary Receptors

In addition to the selected core receptor locations, for each release point, KAFB was divided into 16 directions (sectors). The boundary receptors represent the maximum dose that any member of the public outside KAFB could receive in that direction. The distances from the various release points was provided by SNL/NM for each of the 16 directions (Bleakly 1998b, c). The distance was based on the minimum distance from the release point to the KAFB boundary within that direction. Because TA-V is small compared to the distance to the KAFB boundary, the distances for all release points within TA-V were based from the center of the area. Table F.2–5 presents the distances to the KAFB boundary, by direction, for the release points. Similar information for the Aerial Cable Facility is presented in Section F.6 (Table F.6–26).

Location of the Maximally Exposed Individual

As described in section F.2.2.2, *MACCS2* makes multiple runs for each accident, using representative sampling of the meteorological data throughout the year's input data file. The means of the concentrations at each chosen location are provided by *MACCS2* and are used in this SWEIS for the core receptors and boundary locations. The highest mean exposure of those receptors and locations is selected as the single MEI for the accident. The MEI dose applies to a hypothetical individual who remains outdoors at that location for the duration of the accident and takes no protective action.

F.2.3.5 Other Consequence Analysis Input

Release plumes were modeled using the "straight-line" plume dispersion model for all *MACCS2* runs. In accidents involving fires that affect the releases, plume buoyancy was implemented by specification of a 1-MW sensible heat source added to the plume.

For cases where a pool was functional and in a position to control or reduce releases, the following pool DFs were used, as described in the *Annular Core Research Reactor (ACRR) Postulated Limiting Event Initial and Building Source Terms*, SAND91-0571 (SNL 1992b):

- DF = 1 for noble gases,
- DF = 100 for halogens, and
- DF = 1,400 for all other radionuclide release groups.

For cases where a pool was unavailable or unable to control or reduce releases, pool DFs were specified as 1.

For accidents described by melted fuel or ruptured or mechanically damaged cladding, ARFxRF fractions were specified for each *MACCS2* radionuclide release group from the *Airborne Release Fractions/Rates and Respirable*

Table F.2–5. Minimum Distance and Direction to the KAFB Boundary by Release Point

DIRECTION	DISTANCE (meters)				
	TECHNICAL AREA-V	NEUTRON GENERATOR FACILITY	EXPLOSIVE COMPONENT FACILITY	Z-MACHINE	MANZANO WASTE STORAGE FACILTIES
N	5,000	2,000	700	3,600	4,300
NNE	5,000	900	400	1,900	4,400
NE	5,900	800	300	1,300	4,400
ENE	7,100	600	200	1,800	3,700
E	14,500	600	200	7,300	3,700
ESE	10,400	700	6,800	7,500	3,700
SE	6,900	800	13,000	11,700	4,400
SSE	5,800	11,500	10,900	9,800	6,400
S	5,800	11,200	10,700	9,000	6,300
SSW	5,600	4,900	5,600	4,500	6,400
SW	3,700	5,100	4,700	3,500	7,300
WSW	3,100	4,800	5,000	4,100	6,200
W	3,100	2,600	3,300	4,100	6,000
WNW	3,100	2,700	3,200	2,800	8,100
NW	5,500	2,300	3,000	3,100	7,700
NNW	6,100	2,100	2,800	3,600	5,200

Source: Bleakly 1998b, c
Note: Distances are rounded to the nearest 100 meters.

Fractions for Nonreactor Nuclear Facilities, DOE-HDBK-3010-94, page 4-49 (DOE 1994b), as shown in Table F.2–6. (DOE-HDBK-3010-94 indicates that these data are "release fractions." In the sources that are referenced, these data are described as fractions released in the respirable range, which correlates to ARFxRF.)

Two sets of data are provided in DOE-HDBK-3010-94. In addition to the ARFxRF fractions for melting fuel (shown in Table F.2–6), gap activity ARFxRF fractions are given. The gap activity represents the fission products that have accumulated in the gap between the fuel matrix and the fuel element cladding. The gap fractions are much less than the melting fuel fractions, indicating that most of the fission products remain in the fuel matrix during operations. The fraction of the fission products released during an accident involving the reactor core would depend on the damage mechanism. The melting fuel data are appropriate for severe accidents that might involve fuel melt. The gap activity data are appropriate for accidents that might puncture the cladding without damaging the fuel matrix. Not all the accidents postulated in this appendix, however, are represented by one of these two categories. Some of the postulated accidents involve mechanical damage caused by very violent, energetic events. One example is the collapse of the bridge crane, which is postulated to fall on top of the reactor superstructure. This event could cause violent buckling of tubes and rods that extend down into the reactor core, which in turn could cause severe damage to adjacent fuel elements. The ARFxRF release from this scenario would

Table F.2–6. Airborne Release Fraction/Respirable Fraction by Radionuclide Group

RADIONUCLIDE RELEASE GROUP	ARFxRF FRACTION	GAP ACTIVITY FRACTION
Noble Gases	0.95	0.05
Iodine	0.22	0.05
Cesium	0.15	0.05
Tellurium	0.11	0.00
Strontium	0.03	0.00
Ruthenium	0.007	0.00
Lanthanum	0.002	0.00
Cerium	0.009	0.00
Barium	0.03	0.00

Source: DOE 1994b
ARFxRF: mathematical product of airborne release fraction and respirable fraction

be somewhere between the gap activity data and the melting fuel data. The analysis in this appendix used the data for melting fuel, which bounds the releases. It is acknowledged that this assumption results in calculated consequences that are higher than expected for the mechanical damage scenarios.

Each of the postulated accident scenarios explicitly identies the material form for the MAR (such as powder or solid) and the energy stress that creates the postulated release condition (such as fire, explosion, spill). Using this information, bounding values of ARFxRF were obtained from DOE-HDBK-3010-94.

For accidents described as plutonium-239 (metal) fire scenarios, ARFxRF fractions were specified from DOE-HDBK-3010-94, page 4-2 (self-sustained oxidation–molten oxidized metal), as ARF=$5x10^{-4}$ and RF=0.5. For accidents described as uranium-235 (metal) fire scenarios, ARFxRF fractions were specified based on information in DOE-HDBK-3010-94, page 4-3 (complete oxidation of metal mass), as ARF=$1x10^{-3}$ and RF=1.0. It is recognized that complete oxidation of the metal mass would not be likely during the postulated accident scenarios involving a fire. The oxidation process during an accident is a complex event that depends (among other parameters) on the configuration of the metal and surrounding components; the spatial relationship of the metal to the fire; and the size, location, intensity, and duration of the fire. These parameters are very difficult to predict for an initiating event such as an airplane crash. Calculating an actual oxidation percentage is beyond the scope of this analysis. The assumption of complete or 100 percent oxidation bounds the calculated consequences for these scenarios; the reported consequences are higher than expected.

ARFxRF and pool DF values were implemented in *MACCS2* by adjusting the radionuclide release group fraction input values. Three general accident types were handled this way.

- For accidents where molten fuel or damaged cladding released fission products through a pool, thus preventing some of the fission products from being released to the atmosphere, the ARFxRF and pool DF factors were multiplied together to arrive at a release group fraction equivalent to be used in the *MACCS2* input file.
- For accidents where molten fuel or damaged cladding released fission products external to a pool, DOE-HDBK-3010-94 release fractions were used directly as the *MACCS2* group release fractions.

- For fire accident scenarios, the group release fractions were adjusted to reflect the ARFxRF values for either plutonium-239 or uranium-235, as applicable.

Specific modeling characteristics and parameters for each accident scenario are provided below in the individual TA sections.

F.2.4 Frequency of Occurrence Estimates

Existing safety documents for SNL/NM facilities do not include estimates of frequencies for all scenarios. In many instances, frequencies are discussed qualitatively; quantitative estimates are not developed. For some types of accidents, the bases for frequency estimates varied from facility to facility or used data that were not current. It was necessary, therefore, to evaluate existing estimates of accident scenario frequencies to ensure that the frequency estimates are consistent and reasonable.

Quantitative estimates were generally used in this SWEIS when provided in an existing safety document. Often a qualitative frequency category, or bin, was selected based on the description of the scenario in the safety document. Frequency categories recommended in the *Preparation Guide for U.S. DOE Nonreactor Nuclear Facility Safety Analysis Reports*, DOE-STD-3009 (DOE 1994c) are shown in Table F.2–7.

When a new accident scenario was postulated for this SWEIS, engineering judgement was used to estimate the frequency category of the accident scenario. The frequency estimates were based on an assessment of the likelihood of the initiating event and the number and potential effectiveness (availability) of the preventive and existing mitigative controls that are required to fail in order for the scenario to occur. Quantitative evaluations (such as event or fault tree analysis) were not performed.

It was recognized that airplane crash scenarios were an important consideration because of the proximity of the SNL/NM site relative to KAFB and the Albuquerque International Sunport. An analysis of airplane crash frequencies for the SNL/NM facilities of interest was performed for the SWEIS and is provided in Section F.5. This analysis used recent data and the methodology of DOE-STD-3014 (DOE 1996f). For practical purposes, the Sandia Pulsed Reactor (SPR) Facility was used to represent all TA-V facilities for the calculation of airplane crash frequencies. Similarly, representative facilities were used for the other TAs. In one case, more than one facility was used to represent a TA (TA-I). In all cases, the frequency of occurrence of an airplane crash into an SNL/NM facility was determined to be in the frequency category of extremely unlikely (that is, between $1x10^{-4}$ and $1x10^{-6}$ per year). For all airplane crash scenarios, the damage ratio was assumed to be 1.0.

The airplane crash probability was calculated assuming a crash into one building. For multiple facilities to be damaged from an airplane crash, a very specific flight pattern and aircraft would have to be evaluated. This would result in a very small probability of occurrence.

The frequency categories shown in Table F.2–7 differ from the categories shown in Section F.6. The reason for the difference is that the input data used to produce the matrices in Section F.6 are taken from source documents prepared by SNL/NM, which used different category definitions.

Table F.2–7. Frequency Categories by Frequency

FREQUENCY CATEGORY SCENARIO	FREQUENCY DESCRIPTION	FREQUENCY (per year)
I	Likely	Greater than $1x10^{-2}$
II	Unlikely	$1x10^{-2}$ to $1x10^{-4}$
III	Extremely Unlikely	$1x10^{-4}$ to $1x10^{-6}$
IV	Beyond Extremely Unlikely (Incredible)	Less than $1x10^{-6}$

Source: DOE 1994c

F.2.5 Technical Areas-I and -II

F.2.5.1 Selection of Representative Accident Scenarios

Safety documentation and other information for TA-I and TA-II facilities were reviewed to identify facilities that contain radioactive material. The Neutron Generator Facility (NGF) in TA-I and the Explosive Components Facility (ECF) in TA-II are the only facilities with amounts of radioactive material that present a potential risk to the public, environment, or workers outside the facility.

For both facilities, tritium is the radioactive material that is present in quantities sufficient to warrant analysis. The radiological accident analysis for TAs-I and -II considers accident scenarios at the NGF and the ECF involving tritium.

The SNL/NM SWEIS source documents (SNL/NM 1998a) contain descriptions of the operations conducted at these facilities, potential accidents, and the amounts of tritium present for each alternative. The accident scenario that is postulated for analysis for each facility is a catastrophic, unspecified event that causes all the tritium present in the facility to be released in the form of tritiated water. This assumption bounds the consequences and simplifies the analysis.

One accident scenario (NG-1) was selected for the NGF, representing a total release of the tritium inventory present in the facility. The SNL/NM SWEIS source documents provide the MAR for the scenario in the form of facility tritium inventories of 836 Ci for each alternative (SNL/NM 1998a).

Likewise, only one accident scenario (ECF-1) is necessary for the ECF. The source documents indicate that the expected tritium inventory present at the ECF is 49 Ci. The tritium inventory is based on the amount involved in the shelf-life test, which is constant under each alternative.

The frequencies for all the accident scenarios established for TAs-I and -II facilities were estimated to be less than $1x10^{-3}$ per year. This estimate is based on the necessity of a catastrophic event, such as an airplane crash or earthquake, to cause release of the entire inventory of the facility. In both the NGF and the ECF, the tritium locations are dispersed throughout each facility and are contained in many devices, and they are not vulnerable to total release from operational events.

F.2.5.2 Consequence Analysis Modeling Characteristics and Parameters

Table F.2–8 provides the key modeling assumptions and input parameters for the *MACCS2* consequence analysis of TAs-I and -II accidents.

F.2.5.3 Results

The impacts of accidents are described in three tables for the MEI and noninvolved worker, the 50-mile population, and the set of core receptors.

Table F.2–9 provides the consequence estimates for the MEI and the maximally exposed noninvolved worker. A distance of 100 m from the release point was used to estimate the dose to noninvolved workers. Table F.2–10 provides consequence and risk estimates for the population present within the surrounding 50-mi radius.

Table F.2–11 provides consequence estimates for all core receptors. Because some core receptor locations cover a large area (for example, golf course), they could be located in more than one direction shown in the table. The results show that the consequences of radiological accidents in TAs-I and -II are very low.

Table F.2–8. Consequence Analysis Modeling Characteristics and Parameters Technical Areas-I and II

FACILITY	ACCIDENT ID[a]	ACCIDENT DESCRIPTION	ACCIDENT MODELING CHARACTERISTICS			
			PLUME RELEASE HEIGHT	PLUME BUOYANCY	POOL DF	ARFxRF
TECHNICAL AREA-I						
Neutron Generator Facility	NG-1	Catastrophic release of building's tritium	Ground	No	NA	1.0
TECHNICAL AREA-II						
Explosive Components Facility	ECF-1	Catastrophic release of building's tritium	Ground	No	NA	1.0

Source: Original
ARFxRF: mathematical product of airborne release fraction and respirable fraction
DF: decontamination factor; see Section F.2.2.1
NA: not applicable

[a] Facility Accident Descriptors:
Explosive Components Facility: ECF-1
Neutron Generator Facility: NG-1

Table F.2–9. Technical Areas-I and -II Radiological Accident Frequencies and Consequences to Maximally Exposed Individual and Noninvolved Worker

ACCIDENT ID[a]	ACCIDENT SCENARIO DESCRIPTION	ACCIDENT FREQUENCY (per year)	APPLICABLE ALTERNATIVE[b]	MAXIMALLY EXPOSED INDIVIDUAL		NONINVOLVED WORKER	
				DOSE (rem)	INCREASED PROBABILITY OF LATENT CANCER FATALITY	DOSE (rem)	INCREASED PROBABILITY OF LATENT CANCER FATALITY
NG-1	Catastrophic release of building's tritium	$1.0x10^{-3}$ to $1.0x10^{-6}$	All	$8.4x10^{-5}$	$4.2x10^{-8}$	$7.9x10^{-3}$	$3.2x10^{-6}$
ECF-1	Catastrophic release of building's tritium	$1.0x10^{-3}$ to $1.0x10^{-6}$	All	$7.8x10^{-5}$	$3.9x10^{-8}$	$4.6x10^{-4}$	$1.9x10^{-7}$

Source: Original
[a] Facility Accident Descriptors:
Explosive Components Facility: ECF-1
Neutron Generator Facility: NG-1

[b] Applicable Alternative:
All–Accident scenario is applicable to all three alternatives

Table F.2–10. Technical Areas-I and -II Radiological Accident Frequencies and Consequences to the 50-Mile Population

ACCIDENT ID[a]	ACCIDENT SCENARIO DESCRIPTION	ACCIDENT FREQUENCY (per year)	APPLICABLE ALTERNATIVE[b]	DOSE (person-rem)	ADDITIONAL LATENT CANCER FATALITY
NG-1	Catastrophic release of building's tritium	$1.0x10^{-3}$ to $1.0x10^{-6}$	All	$1.0x10^{-1}$	$5.1x10^{-5}$
ECF-1	Catastrophic release of building's tritium	$1.0x10^{-3}$ to $1.0x10^{-6}$	All	$5.9x10^{-3}$	$3.0x10^{-6}$

Source: Original
[a] Facility Accident Descriptors:
Explosive Components Facility: ECF-1
Neutron Generator Facility: NG-1

[b] Applicable Alternative:
All–Accident scenario is applicable to all three alternatives

Table F.2–11. Technical Areas-I and -II Radiological Accident Frequencies and Consequences to Core Receptor Locations

ACCIDENT ID[a]	ACCIDENT SCENARIO DESCRIPTION	ACCIDENT FREQUENCY (per year)	APPLICABLE ALTERNATIVE[b]	DOSE (rem)	INCREASED PROBABILITY OF LATENT CANCER FATALITY	DOSE (rem)	INCREASED PROBABILITY OF LATENT CANCER FATALITY
ECF-1	Catastrophic release of building's tritium	$1.0x10^{-3}$ to $1.0x10^{-6}$	All	*Golf Course (1.6-2.4 km to SSE)*		*Golf Course (1.6-2.4 km to S)*	
				$3.1x10^{-7}$	$1.5x10^{-10}$	$2.5x10^{-7}$	$1.3x10^{-10}$
				National Atomic Museum, Base Housing, Shandiin Day Care Center (1.6-2.4 km to WNW)		*Sandia Base Elementary School, Coronado Club (1.6-2.4 km to NW)*	
				$1.4x10^{-7}$	$7.0x10^{-11}$	$1.5x10^{-7}$	$7.6x10^{-11}$
				Sandia Base Elementary School, Coronado Club (1.6-2.4 km to NNW)		*Wherry Elementary School (2.4-3.2 km to WNW)*	
				$2.0x10^{-7}$	$9.8x10^{-11}$	$7.5x10^{-8}$	$3.7x10^{-11}$
				Wherry Elementary School, Child Development Center-East (2.4-3.2 km to NW)		*Kirtland Underground Munitions and Maintenance Storage Complex (KUMMSC) (3.2-4.0 km to SSW)*	
				$8.3x10^{-8}$	$4.2x10^{-11}$	$7.1x10^{-8}$	$3.5x10^{-11}$
				Riding Stables (4.0-4.8 km to SSE)		*Veterans Affairs Medical Center, Lovelace Hospital (4.0-4.8 km to WNW)*	
				$7.9x10^{-8}$	$4.0x10^{-11}$	$3.3x10^{-8}$	$1.7x10^{-11}$
				Child Development Center-West (5.6-6.4 km to WNW)		*Kirtland Elementary School (6.4-7.2 km to WNW)*	
				$1.9x10^{-8}$	$9.4x10^{-12}$	$1.5x10^{-8}$	$7.6x10^{-12}$
NG-1	Catastrophic release of building's tritium	$1.0x10^{-3}$ to $1.0x10^{-6}$	All	*National Atomic Museum (0.8-1.6 km to WNW)*		*Coronado Club (0.8-1.6 km to NW)*	
				$5.7x10^{-6}$	$2.8x10^{-9}$	$6.2x10^{-6}$	$3.1x10^{-9}$

Table F.2–11. Technical Areas-I and -II Radiological Accident Frequencies and Consequences to Core Receptor Locations (concluded)

ACCIDENT ID[a]	ACCIDENT SCENARIO DESCRIPTION	ACCIDENT FREQUENCY (per year)	APPLICABLE ALTERNATIVE[b]	DOSE (rem)	INCREASED PROBABILITY OF LATENT CANCER FATALITY	DOSE (rem)	INCREASED PROBABILITY OF LATENT CANCER FATALITY
				Sandia Base Elementary School (0.8-1.6 km to NNW)		*Base Housing, Shandiin Day Care Center (1.6-2.4 km to W)*	
				$7.8x10^{-6}$	$3.9x10^{-9}$	$2.5x10^{-6}$	$1.2x10^{-9}$
				Wherry Elementary School, Base Housing, Shandiin Day Care Center (1.6-2.4 km to WNW)		*Child Development Center-East (1.6-2.4 km to NW)*	
				$2.4x10^{-6}$	$1.2x10^{-9}$	$2.6x10^{-6}$	$1.3x10^{-9}$
				Golf Course (2.4-3.2 km to SSE)		*Veterans Affairs Medical Center (3.2-4.0 km to W)*	
				$2.9x10^{-6}$	$1.4x10^{-9}$	$8.2x10^{-7}$	$4.1x10^{-10}$
				Kirtland Elementary School (5.6-6.4 km to W)		*Veterans Affairs Medical Center, Lovelace Hospital (3.2-4.0 km to WNW)*	
				$3.3x10^{-7}$	$1.7x10^{-10}$	$8.1x10^{-7}$	$4.0x10^{-10}$
				Kirtland Underground Munitions and Maintenance Storage Complex (KUMMSC) (3.2-4.0 km to S)		*Riding Stables (4.0-4.8 km to SSE)*	
				$1.1x10^{-6}$	$5.6x10^{-10}$	$1.4x10^{-6}$	$6.8x10^{-10}$
				Child Development Center-West (4.8-5.6 km to WNW)			
				$4.3x10^{-7}$	$2.1x10^{-10}$		

Source: Original
KAFB: Kirtland Air Force Base
km: kilometer

[a] Facility Accident Descriptors:
Explosive Components Facility: ECF-1
Neutron Generator Facility: NG-1
[b] Applicable Alternative: All–Scenarios applicable to all three alternatives

F.2.6 Technical Area-IV

F.2.6.1 Selection of Representative Accident Scenarios

Safety documentation and other information for TA-IV facilities were reviewed to identify facilities that contain radioactive material. The SNL/NM SWEIS source documents contain descriptions of the operations conducted at these facilities and provide estimates of radioactive material inventory (SNL/NM 1998a). The Z-Machine is the only facility in TA-IV with amounts of radioactive material that present a potential consequence to the public, environment, or workers outside the facility. Tritium and plutonium are the radioactive materials that are present in quantities sufficient to be of concern.

Based on the amounts and form of radioactive material involved, the consequences from the greatest possible release would be small. The accident scenario that is postulated for analysis is a catastrophic, unspecified event that causes all the tritium (in the form of tritiated water) and/or all the plutonium present in the facility to be released. This assumption bounds the consequences and simplifies the analysis.

A tritium accident scenario and a plutonium accident scenario were postulated for two alternatives. Accident scenario ZPu-1, catastrophic release of plutonium inventory, would be the same under both the No Action and Expanded Operations Alternatives, resulting in a total of three accident scenarios (radioactive material would not be present in the Z-Machine under the Reduced Operations Alternative). The accident identifiers and MAR for each scenario are shown in Table F.2–12.

For both the No Action and the Expanded Operations Alternatives, because the accidental release is assumed to be a catastrophic release, both tritium consequences and plutonium consequences would occur at the same time and would be additive. The frequencies for all the accident scenarios established for the Z-Machine were estimated to be extremely unlikely ($1x10^{-4}$ to $1x10^{-6}$ per year). This estimate is based on the need for a catastrophic event, such as an airplane crash or earthquake, to cause release of the entire inventory of the facility.

F.2.6.2 Consequence Analysis Modeling Characteristics and Parameters

Table F.2–13 provides the key modeling assumptions and input parameters for the *MACCS2* consequence analysis of TA-IV accidents.

F.2.6.3 Results

Table F.2–14 provides the consequence estimates for the MEI and the noninvolved worker. A distance of 100 m from the release point was used to estimate the dose to noninvolved workers. Table F.2–15 provides consequence for the population within the surrounding 50-mi radius. Table F.2–16 provides consequence estimates for all core receptors. Because some core receptor locations are large (for example, golf course), the receptor could be located in more than one direction.

F.2.7 Technical Area-V

F.2.7.1 Selection of Representative Accident Scenarios

This section describes the selection of the representative radiological accident scenarios to characterize the accident impacts for TA-V in the SWEIS. This section also develops or references source-term data for the accidents selected for consequence analysis.

F.2.7.2 Scenario Selection Approach

A systematic approach was used to select a representative set of radiological accident scenarios at TA-V for analysis of consequences. Types of accidents selected included earthquakes, fires, criticalities, high-frequency accidents, and high-consequence accidents. The accidents selected cover the spectrum from low-consequences–high-frequency to high-consequences–low-frequency accidents. The complete set of accidents postulated in existing safety documents and Environmental Impact Statements (EISs) was the primary basis for selection. The SWEIS accident analysis team supplemented this set with several additional accident scenarios based on facility walk-throughs and review of the operations and associated hazards. Generally, existing accident scenarios were used as-is.

The first step in identifying the set of representative accident scenarios for further analysis in the SWEIS was to review existing safety documents and EISs and identify the accident scenarios postulated in these documents. Scenario frequencies, if available, were also noted. Accident frequencies are not estimated for many

Table F.2–12. Accident Scenarios for Z-Machine

ACCIDENT ID[a]	ACCIDENT SCENARIO DESCRIPTION	RELEASE
NO ACTION ALTERNATIVE		
ZH3-1	Catastrophic release of tritium inventory	1,000 curies tritium
ZPu-1	Catastrophic release of plutonium inventory	200 milligrams plutonium
EXPANDED OPERATIONS ALTERNATIVE		
ZH3-2	Catastrophic release of tritium inventory	50,000 curies tritium
ZPu-1	Catastrophic release of plutonium inventory	200 milligrams plutonium

Source: Original
[a] Facility Accident Descriptors:
Z-Machine-tritium: ZH3-1, ZH3-2
Z-Machine-plutonium: ZPu-1
Note: For Reduced Operations Alternative, the Z-Machine will not operate.

Table F.2–13. Technical Areas-IV Consequence Analysis Modeling Characteristics and Parameters

FACILITY	ACCIDENT ID[a]	ACCIDENT SCENARIO	ACCIDENT MODELING CHARACTERISTICS			
			PLUME RELEASE HEIGHT	PLUME BUOYANCY	POOL DF	ARFxRF
TECHNICAL AREA-IV						
Z-Machine	ZH3-1 ZH3-2	Catastrophic release of building's tritium	Ground-level	No	NA	1.0
	ZPu-1	Catastrophic release of building's plutonium	Ground-level	No	NA	1.0

Source: Original
ARFxRF: mathematical product of airborne release fraction and respirable fraction
DF: decontamination factor; see Section F.2.2.1
NA: Not applicable

[a] Facility Accident Descriptors:
Z-Machine-tritium: ZH3-1, ZH3-2
Z-Machine-plutonium: ZPu-1

Table F.2–14. Technical Area-IV Radiological Accident Frequencies and Consequences to the Maximally Exposed Individual and Noninvolved Worker

Accident ID[a]	Accident Scenario Description	Accident Frequency (per year)	Applicable Alternative[b]	Maximally Exposed Individual		Noninvolved Worker	
				Dose (rem)	Increased Probability of Latent Cancer Fatality	Dose (rem)	Increased Probability of Latent Cancer Fatality
ZH3-1	Catastrophic release of building's tritium	$1.0x10^{-4}$ to $1.0x10^{-6}$	N	$1.92x10^{-5}$	$9.6x10^{-9}$	$9.7x10^{-3}$	$3.9x10^{-6}$
ZH3-2	Catastrophic release of building's tritium	$1.0x10^{-4}$ to $1.0x10^{-6}$	E	$9.6x10^{-4}$	$4.8x10^{-7}$	$4.9x10^{-1}$	$1.9x10^{-4}$
ZPu-1	Catastrophic release of building's plutonium	$1.0x10^{-4}$ to $1.0x10^{-6}$	N,E	$8.85x10^{-4}$	$4.4x10^{-7}$	$5.4x10^{-1}$	$2.2x10^{-4}$

Source: Original
[a] Facility Accident Descriptors:
Z-Machine-tritium: ZH3-1, ZH3-2
Z-Machine-plutonium: ZPu-1

[b] Applicable Alternative:
N–Scenario is applicable to No Action Alternative
E–Scenario is applicable to Expanded Operations Alternative

Table F.2–15. Technical Area-IV Radiological Accident Frequencies and Consequences to 50-Mile Population

Accident ID[a]	Accident Scenario Description	Accident Frequency (per year)	Applicable Alternative[b]	50-Mile Population	
				Dose (person-rem)	Additional Latent Cancer Fatality
ZH3-1	Catastrophic release of building's tritium	$1.0x10^{-4}$ to $1.0x10^{-6}$	N	$5.4x10^{-2}$	$2.7x10^{-5}$
ZH3-2	Catastrophic release of building's tritium	$1.0x10^{-4}$ to $1.0x10^{-6}$	N	2.7	$1.4x10^{-3}$
ZPu-1	Catastrophic release of building's plutonium	$1.0x10^{-4}$ to $1.0x10^{-6}$	N,E	1.8	$9.2x10^{-4}$

Source: Original
[a] Facility Accident Descriptors:
Z-Machine-tritium: ZH3-1, ZH3-2
Z-Machine-plutonium: ZPu-1

[b] Applicable Alternative:
N–Scenario is applicable to No Action Alternative
E–Scenario is applicable to Expanded Operations Alternative

Table F.2–16. Technical Area-IV Radiological Accident Frequencies and Consequences to Core Receptor Locations

Accident ID	Accident Scenario Description	Accident Frequency (per Year)	Applicable Alternative	Dose (rem)	Increased Probability of Latent Cancer Fatality	Dose (rem)	Increased Probability of Latent Cancer Fatality
				Golf Course (0.8-1.6 km to ESE)		Golf Course (0.8-1.6 km to SE)	
ZH3-1	Catastrophic release of building's tritium	$1.0x10^{-4}$ to $1.0x10^{-6}$	N	$1.7x10^{-5}$	$8.7x10^{-9}$	$1.9x10^{-5}$	$9.6x10^{-9}$
ZH3-2	Catastrophic release of building's tritium	$1.0x10^{-4}$ to $1.0x10^{-6}$	E	$8.7x10^{-4}$	$4.4x10^{-7}$	$9.6x10^{-4}$	$4.8x10^{-7}$
ZPu-1	Catastrophic release of building's plutonium	$1.0x10^{-4}$ to $1.0x10^{-6}$	N, E	$8.2x10^{-4}$	$4.1x10^{-7}$	$8.8x10^{-4}$	$4.4x10^{-7}$
				Golf Course (0.8-1.6 km to SSE)		Shandiin Day Care (1.6-2.4 km to NW)	
ZH3-1	Catastrophic release of building's tritium	$1.0x10^{-4}$ to $1.0x10^{-6}$	N	$1.4x10^{-5}$	$6.9x10^{-9}$	$4.1x10^{-6}$	$2.1x10^{-9}$
ZH3-2	Catastrophic release of building's tritium	$1.0x10^{-4}$ to $1.0x10^{-6}$	E	$6.9x10^{-4}$	$3.4x10^{-7}$	$2.1x10^{-4}$	$1.0x10^{-7}$
ZPu-1	Catastrophic release of building's plutonium	$1.0x10^{-4}$ to $1.0x10^{-6}$	N, E	$6.3x10^{-4}$	$3.1x10^{-7}$	$1.6x10^{-4}$	$7.8x10^{-8}$
				National Atomic Museum, Base Housing (1.6-2.4 km to NNW)		KAFB Underground Munitions and Maintenance Storage Complex (KUMMSC) (2.4-3.2 km to SSW)	
ZH3-1	Catastrophic release of building's tritium	$1.0x10^{-4}$ to $1.0x10^{-6}$	N	$4.2x10^{-6}$	$2.1x10^{-9}$	$2.5x10^{-6}$	$1.3x10^{-9}$
ZH3-2	Catastrophic release of building's tritium	$1.0x10^{-4}$ to $1.0x10^{-6}$	E	$2.1x10^{-4}$	$1.1x10^{-7}$	$1.3x10^{-4}$	$6.3x10^{-8}$
ZPu-1	Catastrophic release of building's plutonium	$1.0x10^{-4}$ to $1.0x10^{-6}$	N, E	$1.7x10^{-4}$	$8.5x10^{-8}$	$1.0x10^{-4}$	$5.0x10^{-8}$
				Wherry Elementary (2.4-3.2 km to NW)		Sandia Base Elementary, Wherry Elementary, Coronado Club, Child Development Center-East (2.4-3.2 km to NNW)	
ZH3-1	Catastrophic release of building's tritium	$1.0x10^{-4}$ to $1.0x10^{-6}$	N	$2.2x10^{-6}$	$1.1x10^{-9}$	$2.3x10^{-6}$	$1.1x10^{-9}$
ZH3-2	Catastrophic release of building's tritium	$1.0x10^{-4}$ to $1.0x10^{-6}$	E	$1.1x10^{-4}$	$5.6x10^{-8}$	$1.1x10^{-4}$	$5.7x10^{-8}$

Table F.2–16. Technical Area-IV Radiological Accident Frequencies and Consequences to Core Receptor Locations (concluded)

Accident ID	Accident Scenario Description	Accident Frequency (per Year)	Applicable Alternative	Dose (rem)	Increased Probability of Latent Cancer Fatality	Dose (rem)	Increased Probability of Latent Cancer Fatality
ZPu-1	Catastrophic release of building's plutonium	$1.0x10^{-4}$ to $1.0x10^{-6}$	N, E	$8.2x10^{-5}$	$4.1x10^{-8}$	$8.9x10^{-5}$	$4.4x10^{-8}$
				Riding Stables (3.2-4.0 km to SE)		**Veterans Affairs Medical Center (3.2-4.0 km to WNW)**	
ZH3-1	Catastrophic release of building's tritium	$1.0x10^{-4}$ to $1.0x10^{-6}$	N	$3.0x10^{-6}$	$1.5x10^{-9}$	$1.0x10^{-6}$	$5.1x10^{-10}$
ZH3-2	Catastrophic release of building's tritium	$1.0x10^{-4}$ to $1.0x10^{-6}$	E	$1.5x10^{-4}$	$7.5x10^{-8}$	$5.1x10^{-5}$	$2.5x10^{-8}$
ZPu-1	Catastrophic release of building's plutonium	$1.0x10^{-4}$ to $1.0x10^{-6}$	N, E	$1.2x10^{-4}$	$6.2x10^{-8}$	$4.1x10^{-5}$	$2.0x10^{-8}$
				Veterans Affairs Medical Center (3.2-4.0 km to NW)		**Lovelace Hospital (4.0-4.8 km to NW)**	
ZH3-1	Catastrophic release of building's tritium	$1.0x10^{-4}$ to $1.0x10^{-6}$	N	$1.5x10^{-6}$	$7.3x10^{-10}$	$1.0x10^{-6}$	$5.2x10^{-10}$
ZH3-2	Catastrophic release of building's tritium	$1.0x10^{-4}$ to $1.0x10^{-6}$	E	$7.3x10^{-5}$	$3.6x10^{-8}$	$5.2x10^{-5}$	$2.6x10^{-8}$
ZPu-1	Catastrophic release of building's plutonium	$1.0x10^{-4}$ to $1.0x10^{-6}$	N, E	$5.1x10^{-5}$	$2.5x10^{-8}$	$3.5x10^{-5}$	$1.7x10^{-8}$
				KAFB Elementary School, Child Development Center-West (5.6-6.4 km to WNW)			
ZH3-1	Catastrophic release of building's tritium	$1.0x10^{-4}$ to $1.0x10^{-6}$	N	$4.2x10^{-7}$	$2.1x10^{-10}$		
ZH3-2	Catastrophic release of building's tritium	$1.0x10^{-4}$ to $1.0x10^{-6}$	E	$2.1x10^{-4}$	$1.0x10^{-7}$		
ZPu-1	Catastrophic release of building's plutonium	$1.0x10^{-4}$ to $1.0x10^{-6}$	N,E	$1.6x10^{-5}$	$8.0x10^{-9}$		

Source: Original
km: kilometer
[a] Facility Accident Descriptors:
Z-Machine-tritium: ZH3-1, ZH3-2
Z-Machine-plutonium: ZPu-1
[b] Applicable Alternative:
N–Scenario is applicable to No Action Alternative
E–Scenario is applicable to Expanded Operations Alternative

Notes: 1) Under the Reduced Operations Alternative, the Z-Machine does not use tritium or plutonium.
2) Depending on the exact accident scenario, the consequences for the Expanded Operations Alternative may or may not be additive.

scenarios postulated in SARs. The SWEIS accident analysis team estimated frequency bins for these scenarios ,based on descriptions in the SARs. (Due to uncertainties and the randomness of events that cause accidents, scenario frequencies are typically categorized into frequency bins, as described above in Section F.2.4.)

The following TA-V nuclear facilities were considered in the first step of this selection process:

- ACRR (Defense Programs [DP] configuration)
- ACRR (medical isotopes production configuration)
- Hot Cell Facility (HCF) (medical isotopes production configuration)
- SPR Facility
- Gamma Irradiation Facility (GIF)
- New Gamma Irradiation Facility (NGIF)

Additional accident scenarios were identified by the SWEIS accident analysis team.

A two-step screening process was then used to select the set of accident scenarios for SWEIS consequence analysis. The first step was to review the complete set of accidents for potentially high-consequence and high-risk accidents as well as accident types of interest. The following types of accidents were selected for further consideration:

- High-consequence accidents
- High-frequency accidents
- Airplane crash accidents
- Earthquakes
- Criticality events
- Fires

The accident scenarios selected during this first screening step are summarized in Table F.2–17. Identification codes have been assigned to each scenario, as indicated in Table F.2–17, and in the scenario descriptions in following sections.

The second screening step eliminated several scenarios from those listed in Table F.2–17. The objective of this second screening step was to identify a reasonable number of accidents that would characterize the consequences from radiological accidents at TA-V facilities. Scenarios eliminated from consideration by this second screening step are those that are clearly bounded by other scenarios or those that lead to essentially the same consequences and risk. Both the frequency (as it affects the risk) and the severity of the consequences of scenarios were considered in the screen. Table F.2–17 identifies those scenarios that were and were not selected for analysis by the final screening process.

Accident frequencies shown in Table F.2–17 are based on source documents such as SARs. Some of these documents present frequency in a semi-quantitative form or as a range (for example $<1x10^{-6}$ or IV). The range reflects the degree of uncertainty in the event's occurrence.

Note that no scenarios for the GIF are included in Table F.2–17. The first screening step eliminated the scenarios for this facility because they were determined to be bounded by the accidents that might occur at the other TA-V facilities.

F.2.7.3 Description of Accident Scenarios

The following sections discuss in detail each of the accident scenarios listed on Table F.2–17. A discussion of the second screening step is included for each scenario, providing an explanation for scenarios eliminated from further analysis. For scenarios that were selected for analysis, information is provided describing the scenario frequency, the radioactive MAR, and the basis for the radioactive source term for the consequence analysis.

ACRR/Medical Isotopes Production (AM Scenarios)

AM-1 Airplane Crash—Collapse of Bridge Crane

Source Scenario Description—This scenario is discussed in paragraph 5.15.1.3 of the *Medical Isotopes Production Project Environmental Impact Statement* (MIPP EIS) (DOE 1996b). To bound the risks of an airplane crash, it was assumed that the airplane crash would cause the bridge crane to fall into the reactor pool, impact the reactor superstructure, and result in the rupture of four fuel elements in the reactor core.

The frequency of $5x10^{-5}$ per year used in the MIPP EIS is that of the crash, and does not factor in the likelihood of the crane being over the reactor pool at the time of the crash. The frequency of this scenario would be one or two orders of magnitude less than the frequency of the crash itself. Massey, et al. (SNL 1995e), concluded that other than the fatalities that result from the crash, the consequences to the ACRR would not exceed those from a seismic event causing a similar accident (collapse of bridge crane).

Table F.2–17. Technical Area-V Radiological Accident Scenarios for the No Action, Reduced Operations, and Expanded Operations Alternatives

FACILITY/ MODE	ACCIDENT ID	ACCIDENT SCENARIO	FREQUENCY (per year or bin)	MATERIALS AT RISK	ANALYZE IN SWEIS (Y/N)	JUSTIFICATION
Annular Core Research Reactor/Medical Isotopes Production Configuration	AM-1	Airplane crash - collapse of bridge crane	6.3×10^{-6}	FPs in 4 fuel elements	Y	Airplane crash
	AM-2	Earthquake - collapse of bridge crane	$<1 \times 10^{-6}$	FPs in 4 fuel elements	Y	Earthquake
	AM-3	Fuel element rupture	III	FPs in 1 fuel element	Y	High frequency could result in highest risk
	AM-4	Rupture of one molybdenum-99 target	1.0×10^{-4}	One irradiated target	Y	Unique from core-related accidents
	AM-5	Fuel handling accident (irradiated element)	III	One irradiated fuel element	Y	Occurs outside of pool; no mitigation by pool water
	AM-6	Airplane crash and/or fire in reactor room with unirradiated fuel and targets present	III	57 new fuel elements + 38 targets	Y	Occurs outside of pool; no mitigation by pool water
	AM-7	Target rupture during transfer from Annular Core Research Reactor to Hot Cell Facility	$<1 \times 10^{-6}$	One irradiated target	Y	Occurs outside of pool and might be outside of building; no mitigation
Hot Cell Facility/ Medical Isotopes Production Configuration	HM-1	Operator error during molybdenum-99 target processing	1.0	Cold trap gases	Y	Highest risk from MIPP EIS
	HM-2	Operator error during iodine-125 target processing	0.1	Cold trap gases	Y	Highest consequences from MIPP EIS
	HM-3	Airplane crash, penetrates building into hot cell in basement	$<1 \times 10^{-7}$	Cold trap gases + irradiated targets	N	Airplane crash

Table F.2–17. Technical Area-V Radiological Accident Scenarios for the No Action, Reduced Operations, and Expanded Operations Alternatives (continued)

FACILITY/ MODE	ACCIDENT ID	ACCIDENT SCENARIO	FREQUENCY (per year or bin)	MATERIALS AT RISK	ANALYZE IN SWEIS (Y/N)	JUSTIFICATION
	HM-4	Fire in steel containment box	II	One irradiated target + cold trap gases	Y	Higher consequences than scenarios analyzed in MIPP EIS
	HC-1	Earthquake – building collapse	7.0×10^{-4}	HM-4 + HS-2	Y	Consequences as summation of HM-4 + HS-2 as ground level release
Hot Cell Facility/ Room 108 Storage	HS-1	Fire in Room 108, #3	3.3×10^{-5}	SAR Table 3.4-11 (average) + MIPP waste	Y	Fire
	HS-2	Fire in Room 108, #4	2.0×10^{-7}	SAR Table 3.4-11 (maximum) + MIPP waste	Y	Fire – Highest consequence scenario for hot cell storage rooms
	HS-3	Criticality in Room 108, 50 kg of plutonium-239	$<1 \times 10^{-7}$	SAR Table 3.4-83	N	Criticality
Sandia Pulsed Reactor Facility	S3M-1	Fire in the reactor building	III	2.469×10^{5}g uranium-235 + FPs	N	Fire
	S3M-2	Control element misadjustment before pulse-element insertion	III	2.469×10^{5}g uranium-235 + FPs	Y	High-risk SAR scenario
	S3M-3	Failure of a fissionable experiment	III	Experiment plutonium-239 7.0×10^{3}gram	Y	Highest consequence scenario in SAR
	SCA-1	Critical assembly – anticipated transient without scram accident	III	Assembly FPs	N	Low likelihood; potential releases similar to limiting S3M accidents
	SS-1	Airplane crash into North Vault storage vault	6.3×10^{-6}	Plutonium experiment	Y	No mitigation; occurs outside building

Table F.2–17. Technical Area-V Radiological Accident Scenarios for the No Action, Reduced Operations, and Expanded Operations Alternatives (concluded)

FACILITY/ MODE	ACCIDENT ID	ACCIDENT SCENARIO	FREQUENCY (per year or bin)	MATERIALS AT RISK	ANALYZE IN SWEIS (Y/N)	JUSTIFICATION
	SP-1	Earthquake–building collapse	$7x10^{-4}$	SS-1	Y	Earthquake
	S4-1	Control element misadjustment before pulse-element insertion	III	$4.6035x10^{5}$g uranium-235 + FPs	Y	Highest risk scenario in No Action Alternative that will be more severe in Expanded Operations Alternative
Annular Core Research Reactor/ Defense Programs Configuration	AR-1	Uncontrolled addition of reactivity	IV	SAR Tables 14A-2 & 14A-3	Y	Highest consequence event in SAR
	AR-2	Fuel element rupture	I	FPs in 4 fuel elements	Y	High frequency could result in highest risk
	AR-3	Failure of experiment containing Annular Core Research Reactor fuel pins	III	Uranium dioxide experiment (20% enriched)	N	Consequences and risk bounded by other events
	AR-4	Fire in reactor room with experiment present	III	Plutonium Experiment	Y	Fire
	AR-5	Earthquake - collapse of bridge crane	$7x10^{-4}$	10% core FP inventory	Y	Earthquakes
	AR-6	Airplane crash - collapse of bridge crane	$6.3x10^{-6}$	10% core FP inventory	Y	Airplane crash

Sources: DOE 1996f; SNL/NM 1995c, 1995e, 1995v; Appendix F.4; SNL 1996d; Schmidt 1998
EIS: environmental impact statement
FP: fission products
g: gram
MIPP: Medical Isotopes Production Project
SAR: safety analysis report
SWEIS: Site-Wide Environmental Impact Statement
Y/N: yes/no
Note: Shaded scenarios were added by SWEIS Accident Analysis Team.

SWEIS Screen—This scenario was selected for SWEIS analysis because it is a potentially high-risk scenario.

SWEIS Scenario Description—The SWEIS analysis postulated the same scenario as the MIPP EIS. The consequences are based on the rupture of four fuel elements in the reactor core.

SWEIS Frequency—The airplane crash frequency for TA-V was updated for the SWEIS. It was calculated to be $6.3x10^{-6}$ per year. The SWEIS used this frequency for the scenario frequency, although it is recognized that the frequency will be lower because the bridge crane is seldom over the reactor. However, this scenario is assumed to bound the effect an airplane crash into the ACRR building might have on the reactor core.

SWEIS Source Term:

MAR—The release was based on a rupture of four fuel elements. The fission product inventory in one element is given in the "Total Inventory" column of Table 1 of Attachment 2 to the April 13, 1998 memo from T. R. Schmidt to L. S. Bayliss (Schmidt 1998). This fuel element inventory times four (for four elements) is used rather than the building releases from the MIPP EIS to allow the SWEIS analysis to use consistent assumptions for existing or known mitigative features. (SNL/NM personnel noted that the Attachment 2 data were the basis for the MIPP EIS analysis.)

Release Assumptions—Fission products from the four ruptured elements were assumed to be released into the reactor pool (with consideration for the appropriate release fraction). The airplane crash was assumed to breach the reactor building, resulting in a ground-level release of the fission products, which pass through the reactor pool. Table F.2–18 summarizes the source-term release characteristics (such as release height and buoyancy considerations) and the values for the source-term factors used in the determination of the source terms from this postulated accident scenario.

AM-2 Earthquake—Collapse of Bridge Crane

Source Scenario Description—This scenario is discussed in paragraph 5.15.1.3 of the MIPP EIS (DOE 1996b). The MIPP EIS assumed that the earthquake would cause the crane to fall onto the reactor superstructure with resultant rupture of four fuel elements. The releases for this scenario were assumed to be the same as those for the airplane crash scenario (scenario AM-1).

SWEIS Screen—As discussed below under the SWEIS Frequency paragraph, recent site-specific data indicate the frequency of an earthquake large enough to cause collapse of the bridge crane is approximately $7x10^{-4}$ per year (See section F.7.2). This is higher than the frequency of less than $1x10^{-6}$ per year that was previously estimated in Massey, et al. (SNL 1995e). This scenario was analyzed for the SWEIS using the recent frequency data. At this frequency, this is a high-risk scenario.

SWEIS Scenario Description—A large earthquake occurs at TA-V (0.22 *g*), causing ACRR building damage that results in collapse of the bridge crane. The bridge crane falls into the reactor pool, impacts the reactor superstructure, and results in the rupture of four fuel elements in the reactor core. Other than the initiating event, this scenario is the same as the airplane crash, Scenario AM-1. No additional releases are postulated because the reactor is located at the bottom of the pool and protected from other debris that may result from failure of the building structure.

SWEIS Frequency—Section F.7 discusses earthquake frequencies and facility responses for TA-V. A Uniform Building Code (UBC)-level earthquake (0.22 *g*) with a frequency of $7x10^{-4}$ per year could result in collapse of the ACRR building.

SWEIS Source Term:

MAR—The MAR is the same as that discussed above for Scenario AM-1.

Release Assumptions—The release assumptions were the same as for Scenario AM-1, above. Table F.2–18 summarizes the source-term release characteristics (such as release height and buoyancy considerations) and the values for the source-term factors used in the determination of the source terms from this postulated accident scenario.

AM-3 Fuel Element Rupture

Source Scenario Description—The ACRR SAR (SNL/NM 1996d), in paragraph 14.4.8, postulates a waterlogged fuel element rupture accident. This scenario would be initiated by a pinhole leak in the cladding of a fuel element through which water is drawn by heat-up/cool-down cycles. Steam generation during a pulse might build up internal pressure and rupture the cladding. The rupture of the waterlogged element could damage adjacent fuel elements. The SAR analysis assumes failure of a total of four fuel elements, with ejection of the fuel from all four elements into the pool water. Based on the SAR discussion, the frequency of this accident was estimated to be 0.1 per year.

Table F.2–18. Consequence Analysis Modeling Characteristics and Parameters for Technical Area-V

FACILITY/MODE	ACCIDENT ID	ACCIDENT SCENARIO	PLUME RELEASE HEIGHT (meters)	PLUME BUOYANCY	POOL DF	ARFxRF
Annular Core Research Reactor/ Medical Isotopes Production Configuration	AM-1	Airplane crash - collapse of bridge crane	Ground	No	See Note	See Table F.2–6
	AM-2	Earthquake - collapse of bridge crane	Ground	No	See Note	See Table F.2–6
	AM-3	Fuel element rupture	14.3	No	See Note	See Table F.2–6
	AM-4	Rupture of one molybdenum -99 target	14.3	No	See Note	See Table F.2–6
	AM-5	Fuel handling accident - irradiated element	14.3	No	NA	See Table F.2–6
	AM-6	Airplane crash and fire in reactor room with unirradiated fuel and targets present	Ground	Yes	NA	For uranium-235, $1.0x10^{-3}$ x 1.0
	AM-7	Target rupture during Annular Core Research Reactor to Hot Cell Facility transfer	Ground	No	NA	See Table F.2–6
Hot Cell Facility/ Medical Isotopes Production Configuration	HM-1	Operator error – molybdenum-99 target processing	38.1	No	NA	1.0
	HM-2	Operator error – iodine-125 target processing	38.1	No	NA	1.0
	HM-4	Fire in steel containment box	38.1	No	NA	See Table F.2–6 for target releases ARFxRF=1.0 for cold trap releases
	HM-4G	Fire in steel containment box	Ground	No	NA	See Table F.2–6 for target releases ARFxRF=1.0 for cold trap releases
Hot Cell Facility– Room 108 Storage	HS-1	Fire in room 108, average inventories	38.1	No	NA	For uranium-235, $1.0x10^{-3}$ x 1.0 For plutonium-239, $5.0x10^{-4}$ x 0.5

Table F.2–18. Consequence Analysis Modeling Characteristics and Parameters for Technical Area-V (continued)

FACILITY/MODE	ACCIDENT ID	ACCIDENT SCENARIO	PLUME RELEASE HEIGHT (meters)	PLUME BUOYANCY	POOL DF	ARFxRF
Hot Cell Facility–Room 108 Storage (continued)	HS-2	Fire in room 108, maximum inventories	38.1	No	NA	For uranium-235, $1.0 \times 10^{-3} \times 1.0$ For plutonium-239, $5.0 \times 10^{-4} \times 0.5$
	HS-2G	Fire in room 108, maximum inventories	Ground	No	NA	For uranium-235, $1.0 \times 10^{-3} \times 1.0$ For plutonium-239, $5.0 \times 10^{-4} \times 0.5$
	HC-1	Earthquake - building collapse	Ground	No	NA	For uranium-235, $1.0 \times 10^{-3} \times 1.0$ For plutonium-239, $5.0 \times 10^{-4} \times 0.5$ See Table F.2–6 for target releases ARFxRF=1.0 for cold trap releases
Sandia Pulsed Reactor	S3M-2	Control element misadjustment before insert	Ground	No	NA	For core fission products, see Table F.2–6 For uranium-235, $1.0 \times 10^{-3} \times 1.0$
	S3M-3	Failure of a fissionable experiment	Ground	No	NA	For core fission products, see Table F.2–6 For plutonium-239, $5.0 \times 10^{-4} \times 0.5$
	SS-1	Airplane crash into North Vault storage vault	Ground	Yes	NA	For core fission products, see Table F.2–6 For plutonium-239, $5.0 \times 10^{-4} \times 0.5$
	SP-1	Earthquake – building collapse	Ground	Yes for SS-1	NA	For core fission products, see Table F.2–6 For plutonium-239, $5.0 \times 10^{-4} \times 0.5$
	S4-1	Control element misadjustment before insert	Ground	No	NA	For core fission products, see Table F.2–6 For uranium-235, $1.0 \times 10^{-3} \times 1.0$
Annular Core Research Reactor/ Defense Programs Configuration	AR-1	Uncontrolled addition of reactivity	14.3	No	NA	See Table F.2–6

Table F.2–18. Consequence Analysis Modeling Characteristics and Parameters for Technical Area-V (concluded)

FACILITY/MODE	ACCIDENT ID	ACCIDENT SCENARIO	PLUME RELEASE HEIGHT (meters)	PLUME BUOYANCY	POOL DF	ARFxRF
Annular Core Research Reactor/ Defense Programs Configuration (continued)	AR-2	Rupture of waterlogged fuel element	14.3	No	See Note	See Table F.2–6
	AR-4	Fire in reactor room with experiment present	14.3	No	NA	For plutonium-239, $5.0x10^{-4}$x 0.5
	AR-5	Earthquake – collapse of bridge crane	Ground	No	See Note	See Table F.2–6
	AR-6	Airplane crash - collapse of bridge crane	Ground	No	See Note	See Table F.2–6

Sources: DOE 1994b; SNL/NM 1995e, 1995v; SNL 1992b, 1996d
ARFxRF: mathematical product of airborne release fraction and respirable fraction
DF: decontamination factor; see Section F.2.2.1
NA: not applicable
Note : Pool DF values used are 1.0 for noble gases, 100 for halogens, and 1,400 for all other radionuclides.

SWEIS Screen—The mechanism for the fuel element rupture that is described in the SAR is dependent on the reactor operating in a pulse mode. Massey, et al. (SNL 1995e), screened out this accident by estimating that the frequency of this type of fuel element failure is likely to be less than $1x10^{-6}$ per year in the medical isotopes production configuration (that is steady-state operation). The SWEIS Accident Analysis Team agrees that the failure mechanism described in the SAR might not be physically possible in steady-state operation. However, other failure mechanisms exist for reactor fuel elements operating in a steady-state mode. Accident analyses for power reactors operating in the steady-state mode typically include a fuel element rupture scenario (NRC 1996). The SWEIS therefore includes a fuel element rupture scenario that releases the fission product inventory of one fuel element. While the consequences of this scenario are bounded by other accidents, its frequency is estimated to be greater than some of the higher consequence accidents. Including this scenario contributes to a larger spectrum of accidents considered in the SWEIS accident analysis.

SWEIS Scenario Description—The SWEIS analysis postulated a rupture of one fuel element in the reactor core during steady-state operation. The exact mechanism is not specified, but a number are possible. Potential mechanisms include overheating of a fuel element or mechanical damage to an element during handling that causes a failure during operation. An insertion of excess reactivity is also possible, even in the steady-state mode, due to a number of unplanned operational transients. This is another potential cause of a fuel element rupture.

SWEIS Frequency—The rupture of a fuel element when the reactor is operating in the steady-state is estimated to be unlikely (10^{-2} to 10^{-4} per year). Fuel element ruptures are not a common occurrence, but a number of power reactor fuel element failures have occurred to some degree.

SWEIS Source Term:

MAR—The release was based on the fission product inventory of one fuel element, which is given in the "Total Inventory" column of Table 1 of Attachment 2 to the April 13, 1998, memo from T. R. Schmidt to L. S. Bayliss (Schmidt 1998). These data are discussed above under scenario AM-1.

Release Assumptions—Fission products from the ruptured element were assumed to be released into the reactor pool (with consideration for the appropriate release fraction). An elevated release through the stack was assumed for the fission products that pass through the reactor pool. Table F.2–18 summarizes the source-term release characteristics (such as release height and buoyancy considerations) and the values for the source-term factors used in the determination of the source terms from this postulated accident scenario.

AM-4 Rupture of One Molybdenum-99 Target

Source Scenario Description—This scenario is discussed in paragraph 5.15.1.3 of the MIPP EIS (DOE 1996b). The MIPP EIS assumed that one target would rupture in the core. This accident was postulated to bound accidents involving targets that might take place during irradiation.

SWEIS Screen—This scenario was analyzed for the SWEIS because it represents a scenario different from the fuel-related accidents and is a potentially high-risk scenario.

SWEIS Scenario Description—The SWEIS analysis postulated the same scenario as the MIPP EIS. The consequences were based on the rupture of one irradiated target in the target grid assembly in the reactor core.

SWEIS Frequency—A feasibility study of MIPP estimates the frequency of this event at $1x10^{-4}$ to $1x10^{-6}$ per year (SNL 1995e).

SWEIS Source Term:

MAR—The release was based on the "Total Inventory" column of Table 2 of Attachment 2 to the April 13, 1998, memo from T. R. Schmidt to L. S. Bayliss (Schmidt 1998). These target inventories were used rather than the MIPP EIS releases to allow the SWEIS analysis to use consistent assumptions for existing or known mitigative features.

Release Assumptions—Fission products from the ruptured target were assumed to be released into the reactor pool (with consideration for the appropriate release fraction). An elevated release through the stack was assumed. Table F.2–18 summarizes the source-term release characteristics (such as release height and buoyancy considerations) and the values for the source-term factors used in the determination of the source terms from this postulated accident scenario.

AM-5 Fuel Handling Accident—One Irradiated Fuel Element Ruptures

Source Scenario Description—This scenario is discussed in paragraph 5.15.1.3 of the MIPP EIS (DOE 1996b). The MIPP EIS states that fuel-handling accidents were evaluated and not considered to have as great a risk as those chosen for analysis in the EIS. This appears to be based on the assumption that fuel handling will be performed under water until the fission products have decayed to where they are no longer a significant hazard.

SWEIS Screen—This scenario was analyzed for the SWEIS because it is a potentially high-consequence scenario. The accident was assumed to occur outside of the reactor pool, so there would be no pool influence.

SWEIS Scenario Description—The scenario under the SWEIS is that, while being transferred from the ACRR pool to the GIF pool, an irradiated fuel element is dropped, impacts a hard surface, and ruptures. Although plans are to transfer the fuel to the GIF pool under water, the analysis assumes that for some reason the transfer has to be made by lifting the element out of the ACRR pool and up through the air into the GIF pool. The facility operators indicated that fuel elements have been transferred this way in the past.

SWEIS Frequency—Based on the plans to normally transfer fuel under water, the high radiation level posed by such irradiated fuel if removed from the pool, and the large number of administrative controls that will have to be overridden, the frequency of this event was estimated to be extremely unlikely, $1x10^{-4}$ to $1x10^{-6}$ per year.

SWEIS Source Term:

MAR—The release was based on the fission product inventory of one irradiated fuel element. Table 3 of Attachment 2 to the April 13, 1998, memo from T. R. Schmidt to L. S. Bayliss (Schmidt 1998) provides the inventory of one fuel element for worst-case power history immediately after shutdown. Fuel elements will be allowed to decay prior to transfer, resulting in lower fission product inventories. The inventories in Table 3 were used for the SWEIS source term because data are not available for decayed elements and it is uncertain how long the elements will be allowed to decay. This assumption results in higher consequences than if a decay period was accounted for in the source term.

Release Assumptions—Fission products from the ruptured element were assumed to be released directly into the reactor building (with consideration for the appropriate release fraction). An elevated release through the stack was assumed. Table F.2–18 summarizes the source-term release characteristics (such as release height and buoyancy considerations) and the values for the source-term factors used in the determination of the source terms from this postulated accident scenario.

AM-6 Airplane Crash and Fire in Reactor Room with Unirradiated Fuel and Targets Present

Source Scenario Description—An airplane crash was considered in the MIPP EIS (DOE 1996b), but only its impact on the core was evaluated. There was no consideration of the potential impact of an airplane crash on material that might be on the operating floor.

SWEIS Screen—This scenario was analyzed for the SWEIS because it represents a different type of accident than those that have been postulated. In addition, there would be no pool influence because the release would occur outside the reactor pool.

SWEIS Scenario Description—The scenario postulates an airplane crash into the reactor building while the reactor is shut down in preparation for refueling. New fuel elements would be present in the reactor room awaiting insertion into the core. In addition, fresh targets would also be present awaiting insertion after refueling. The airplane would penetrate the building and cause a large fire in the reactor room.

SWEIS Frequency—The airplane crash frequency for TA-V was updated for the SWEIS. It was calculated to be $6.3x10^{-6}$ per year. This frequency was used for this scenario, recognizing that this is an overestimate because it does not account for the limited amount of time that new fuel and fresh targets would be present on the operating floor.

SWEIS Source Term:

MAR—The MIPP EIS projects 57 spent fuel elements would require replacement per year. Assuming one refueling per year, 57 fresh fuel elements could be present on the operating floor just prior to refueling. In addition, it was assumed that two fresh target loads would also be present on the operating floor. This is based on two loads of 19 targets each, which would be the initial target configuration. This is a conservative, bounding assumption, because it is unlikely that two loads would be present on the operating floor. Two loads of the initial design load of 19 targets also bounds one load at the higher load size of 38 targets. The MAR equals 22.37 kg of uranium-235 (57 fuel elements x 380 *g* of uranium-235 per fuel element + 38 targets x 18.6 *g* of uranium-235 per target) (Schmidt 1998). The dose contribution from the uranium-238 in the fuel elements is less than 1 percent, based on a comparison of relative amounts, their specific activity, and dose conversion factors.

Release Assumptions—The release was assumed to be a ground-level release because the airplane crash was assumed to breach the reactor building. Table F.2–18 summarizes the source-term release characteristics (such as release height and buoyancy considerations) and the values for the source-term factors used in the determination of the source terms from this postulated accident scenario.

AM-7 Target Rupture During Transfer from ACRR to HCF

Source Scenario Description—This scenario is discussed in paragraph 5.15.1.4 of the MIPP EIS (DOE 1996b). A target rupture would occur in transit between the ACRR and the HCF as a result of an unspecified incident involving the transport equipment or operation.

SWEIS Screen—This scenario was analyzed in the SWEIS because it is the worst-case scenario involving an irradiated target and is a potentially high-consequence scenario.

SWEIS Scenario Description—The same scenario was postulated for the SWEIS.

SWEIS Frequency—The MIPP EIS estimates this frequency to be beyond extremely unlikely, less than $1x10^{-6}$ per year. The targets are transported in a cask designed to protect the target in the event of most potential transport accidents. The SWEIS assumes a frequency at the high end of the estimate, $1x10^{-6}$ per year.

SWEIS Source Term:

MAR—The source term is the fission product inventory listed in Table 5–24 of the MIPP EIS. The MIPP EIS data were used directly for this scenario because neither the MIPP EIS nor the SWEIS assumes any mitigation.

Release Assumptions—The Table 5–24 inventory was assumed to be released directly into the atmosphere, because this scenario can occur between the reactor building and the HCF. The release was assumed to be a ground-level release. Table F.2–18 summarizes the source-term release characteristics (such as release height and buoyancy considerations) and the values for the source-term factors used in the determination of the source terms from this postulated accident scenario.

HCF—Medical Isotopes Production Configuration (HM Scenarios)

HM-1 Operator Error During Molybdenum-99 Target Processing

Source Scenario Description—This scenario is discussed in paragraph 5.15.1.5 of the MIPP EIS (DOE 1996b). An operator could inadvertently open the wrong valve or open the correct valve at the wrong time. Mechanical failures of valves or transfer lines could occur, releasing the waste gases from the decay tank (cold trap). The loss of fission products would be inside the hot cells and most of the fission products would be contained on the charcoal or high-efficiency particulate air (HEPA) filters. Noble gases, however, would be vented to the HCF stack. It was assumed that the targets were irradiated for 7 days at 20 kw of power and had cooled for 16 hours before the release. A total of 1,550 Ci of noble gases would be released; their proportions were assigned based on the above power rating of the targets. The estimated release is shown in Table 5–26 of the MIPP EIS.

SWEIS Screen—This scenario was analyzed in the SWEIS because it is the highest risk scenario in the MIPP EIS.

SWEIS Scenario Description—The same scenario was postulated for the SWEIS.

SWEIS Frequency—The MIPP EIS estimated a frequency of 1.0×10^{-2} to 1.0×10^{-1} per year. The SWEIS used this estimate, recognizing that the frequency would likely be lowered as design development continues, especially if this event is identified as having a high risk. Design features or operational controls could be added to reduce the frequency of this scenario.

SWEIS Source Term:

MAR—The content of the decay cold trap would be available for release. The gas that would be released is given in Table 5–26 of the MIPP EIS.

Release Assumptions—The gas inventories in Table 5–26 were assumed to be released as an elevated stack release. Table F.2–18 summarizes the source-term release characteristics (such as release height and buoyancy considerations) and the values for the source-term factors used in the determination of the source terms from this postulated accident scenario.

HM-2 Operator Error During Iodine-125 Target Processing

Source Scenario Description—This scenario is discussed in paragraph 5.15.1.5 of the MIPP EIS (DOE 1996b). This scenario is similar to HM-1, but would occur while iodine-125 targets, rather than molybdenum-99 targets, are being processed. This scenario was assumed to occur 72 hours after irradiation. Cold trap valves would be left open when the gas is being transferred between decay storage tanks. The estimated release would consist of 31 Ci of xenon-125. The MIPP EIS assumes that other radionuclides (such as iodine-125) would be present, but filters would capture all the halogens. The dose would be dominated by the xenon-125.

SWEIS Screen—This scenario was analyzed in the SWEIS because it was the highest consequence scenario in the MIPP EIS.

SWEIS Scenario Description—The same scenario was postulated for the SWEIS.

SWEIS Frequency—The MIPP EIS estimated a frequency of 1.0 x 10^{-2} to 1.0 x 10^{-1} per year, which was used for the SWEIS. This is essentially the same event as HM-1, but the frequency is an order of magnitude less because iodine-125 targets would be processed much less frequently than molybdenum-99 targets.

SWEIS Source Term:

MAR—The MAR is the content of the decay tank (cold trap). The MIPP EIS determined that the 31 Ci of xenon-125 in the tank would dominate the dose calculations. The SWEIS analysis used this inventory.

Release Assumptions—The gas inventory of 31 Ci of xenon-125 was assumed to be released as an elevated stack release. Table F.2–18 summarizes the source-term release characteristics (such as release height and buoyancy considerations) and the values for the source-term factors used in the determination of the source terms from this postulated accident scenario.

HM-3 Airplane Crash, Penetrates Building into HCF Basement

Source Scenario Description—This scenario is discussed in paragraph 5.15.1.5 of the MIPP EIS (DOE 1996b). The MIPP EIS qualitatively concludes that the probability of an airplane crash into the HCF, as well as the potential dose, would be much smaller than the probability and consequences from an operator error scenario (HM-1 or HM-2).

SWEIS Screen—This scenario was not analyzed for the SWEIS. Its consequences and risks would be less than other HCF scenarios.

HM-4 Fire in Steel Containment Box Used for Processing Targets

Source Scenario Description—The MIPP EIS (DOE 1996b) states that a fire was considered but not analyzed because the potential dose was much smaller than the consequences from the HM-1 and HM-2 scenarios.

SWEIS Screen—This scenario was analyzed for the SWEIS because it would result in higher consequences than the other scenarios for target processing that were taken from the MIPP EIS.

SWEIS Scenario Description—Lacking design and operational details, a bounding scenario was postulated for the SWEIS. It was assumed that a large fire in the steel containment box would result in the release of the gases in the decay tank (cold trap), as in scenario HM-1, plus the fission products from one irradiated target being processed.

SWEIS Frequency—Based on the frequency of occurrence of similar fire accident scenarios postulated in the existing HCF SAR, this scenario was estimated to be unlikely (frequency of 1x10^{-2} to 1x10^{-4} per year).

SWEIS Source Term:

MAR—The release from one target is based on the "Total Inventory" column of Table 2 of Attachment 2 to the April 13, 1998, memo from T. R. Schmidt to L. S. Bayliss (Schmidt 1998). The inventory of gases in the cold trap is given in the MIPP EIS, Table 5–26.

Release Assumptions—The release would be the sum of the cold trap gases and the fission products released from the target and was assumed to be an elevated stack release. The cold trap gas inventories were taken directly from Table 5–26. The target release was assumed to be the fission product inventories from Table 2, accounting for the appropriate release fraction. The fission products from the target were assumed to be released without mitigation. Table F.2–18 summarizes the source-term release characteristics (such as release height and buoyancy considerations) and the values for the source-term factors used in the determination of the source terms from this postulated accident scenario.

HCF (HC Scenario)

HC-1 Earthquake - Building Collapse

Source Scenario Description—The HCF SAR (SNL/NM 1995e) discusses seismic analyses that show that earthquakes up to the UBC-level in magnitude (0.22 *g*) are not expected to cause any major damage to the facility. The SAR indicates the event would pose no radiological or toxicological consequences to workers or the public. However, a recent study (Paragon 1997 and 1998) found that the HCF would fail the 0.22 *g* earthquake.

SWEIS Screen—Section F.7 discusses earthquake frequencies and facility responses for TA-V. A UBC-level earthquake (0.22 *g*) with a frequency of 7x10^{-4}

per year could result in collapse of the HCF building. This scenario was analyzed for the SWEIS because it is a high-risk scenario.

SWEIS Scenario Description—A large earthquake (0.22 *g*) occurs at TA-V, causing significant damage to the HCF building. The collapse causes multiple effects on radioactive material in the facility. The gases in the cold trap from processing medical isotopes production targets are postulated to be released. A fire is postulated in the steel containment box where a target is being processed, resulting in the release of the fission products from that target. A fire is also postulated in Room 108, assuming the maximum inventory of fissionable material is being stored there in addition to waste material from medical isotopes production. These effects and the resultant releases are the same as the combination of Scenarios HM-4 and HS-2, above.

SWEIS Frequency—Section F.7 discusses earthquake frequencies and facility responses for TA-V. A UBC-level earthquake (0.22 *g*) with a frequency of 7×10^{-4} per year could result in collapse of the ACRR building.

SWEIS Source Term:

MAR—The MAR is the sum of the MAR in Scenarios HM-4 and HS-2, above.

Release Assumptions—The release assumptions were the same as for Scenarios HM-4 and HS-2, above, for the respective MAR. Table F.2–18 summarizes the source-term release characteristics (such as release height and buoyancy considerations) and the values for the source-term factors used in the determination of the source terms from this postulated accident scenario.

HCF—Room 108 Storage (HS Scenarios)

HS-1 Fire in Room 108 (SAR Scenario #3)

Source Scenario Description—This scenario is discussed in Section 3.4.2.1 of the HCF SAR (SNL/NM 1995e). A general combustible fire would be ignited by an event such as an electrical short, forklift incident, or other unspecified circumstance. Various radioactive materials ranging from fissile material to fission products in various forms are stored in Room 108. The inventory of such materials changes from time to time. Although the combustible loading in Room 108 is low on average, the nature of the radioactive material stored there limits the type of mitigating systems and actions. The limit on the maximum quantity of fissile material in Room 108 is 500 kg, with 350 kg allocated for the SPR. Table 3.4–11 of the HCF SAR shows the types and amounts of radioactive material typically stored in Room 108, both average and maximum estimates. The SAR analysis considered both average and maximum quantities, but the frequency of having the maximum material amount in the room was very low. The likelihood of a medium-size fire with maximum quantities present (Scenario #4) was, therefore, determined to be very low, less than 1×10^{-6}. Scenario #3 is a medium-size fire with the average material quantities available. The total of the average quantities would be 13.5 kg (from Table 3.4–11). Scenario #3 is more likely than Scenario #4, but its consequences are lower. The consequence analysis in the SAR simplified the calculations by choosing plutonium-239 as the surrogate material representing all radionuclides present. This simplification eliminated the need to consider different materials with their different properties. With this assumption, the SAR analysis postulated 13.5 kg of plutonium-239 as the MAR for a fire.

SWEIS Screen—HCF SAR scenarios #3 and #4 were both analyzed for the SWEIS because they are potentially high-risk and high-consequence scenarios, respectively. The two scenarios are similar events: SAR Scenario #3 (SWEIS Scenario HS-1) is a medium-size fire with average material inventories, and SAR Scenario #4 (SWEIS Scenario HS-2) is a medium-size fire with maximum material inventories.

SWEIS Scenario Description— Although the mission of the HCF is changing with the conversion to medical isotopes production, SNL/NM indicated that Room 108 will continue to be used to store nuclear material related to the facility's previous mission, at least for a while. Additional radioactive materials related to the new mission may also be present in Room 108. While radioactive waste from the medical isotopes production process will be stored in barrels in Room 109 (adjacent to Room 108), Room 108 will be used to stage barrels prior to shipping. The same fire scenario analyzed in the SAR is postulated in the SWEIS, with the additional radioactive material from the isotopes production waste barrels that may be staged in Room 108.

Medical isotopes production waste (which includes fission products, uranium oxide, and contaminated equipment) will be managed in a solidified cement form in the barrels. Up to 180 barrels of waste in solidified cement may be stored in Room 109. In this form, however, the radioactive material is not susceptible to dispersal by fire. An accident scenario in Room 109, such as a large fire, is not, therefore, postulated for the SWEIS. The consequences of such an event are bounded by the postulated fire in Room 108, which contains nuclear material in a dispersible form.

SWEIS Frequency—The SAR frequency of 3.3x10^{-5} for Scenario #3 was used for the SWEIS.

SWEIS Source Term:

MAR— This scenario represents average material inventories, HS-2 represents maximum inventories. The historic material quantities for this scenario are given in the "average" column of Table 3.4–11 of the HCF SAR. TA-V management has indicated that existing nuclear material will continue to be stored in Room 108, at least for a while, in addition to using the room to stage waste from medical isotopes production (Schmidt 1998). The accident scenario from the HCF SAR would still apply during medical isotopes production, but the medical isotopes production waste must be considered in addition to the historical inventories in the SAR.

Up to eight barrels of medical isotopes production waste are estimated to be staged in Room 108. Each barrel could contain up to 1,200 Ci of mixed fission products in the form of solidified cement within vented stainless steel containers and up to 400 g of fully enriched uranium dioxide. While all the material will be in solidified cement and not susceptible to dispersal, some material (uranium oxide) is assumed to be available for dispersal to bound the accident consequences. For this average inventory scenario, half the barrels are postulated to be present with half the maximum content of radioactive material. This assumption results in a MAR of 800 g of enriched uranium dioxide for the medical isotopes production waste.

Release Assumptions—The release was based on applying the release fractions for plutonium and uranium exposed to a large fire to the inventories present. Table 3.4–11 of the HCF SAR describes the forms of plutonium and uranium present. Separate releases for plutonium and uranium were calculated and modeled. An elevated stack release was assumed. As discussed above, the uranium in the isotopes production waste was assumed to be in a dispersible form (that is, exposed metal) even though it is planned to be placed in solidified cement inside barrels. Table F.2–18 summarizes the source-term release characteristics (such as release height and buoyancy considerations) and the values for the source-term factors used in the determination of the source terms from this postulated accident scenario.

HS-2 Fire in Room 108 (SAR Scenario #4)

Source Scenario Description—This scenario, discussed above under the HS-1 scenario, is a larger consequence, lower frequency fire scenario than SAR Scenario #3 (SNL/NM 1995e).

SWEIS Screen—This scenario was analyzed for the SWEIS. See the discussion above for scenario HS-1.

SWEIS Scenario Description—The same scenario was postulated for the SWEIS. The material inventories in the SAR were supplemented by the staging nuclear material related to medical isotopes production (waste) in Room 108 (see the discussion below under MAR).

SWEIS Frequency—The frequency in the HCF SAR of 2.0x10^{-7} for Scenario #4 was used for the SWEIS.

SWEIS Source Term:

MAR—This scenario represents maximum material inventories. The maximum historic quantities are given in the "maximum" column of Table 3.4–11 of the HCF SAR. The maximum medical isotopes production waste quantity was added to this. As noted above under the discussion for Scenario HS-1, medical isotopes production waste is planned to be in solidified cement and not susceptible to dispersal. The addition of some of this waste to the MAR in a dispersible form is postulated to bound the consequences of the accident scenario. The maximum MAR from isotopes production waste for HS-2 was postulated to be the total uranium oxide inventory of eight barrels with each barrel containing the maximum inventory of 400 Ci per barrel. This results in a total of 3.2 kg of uranium oxide.

Release Assumptions—The release was based on applying the release fractions for plutonium and uranium exposed to a large fire to the inventories present. Table 3.4–11 of the HCF SAR describes the forms of plutonium and uranium present. Separate releases for plutonium and uranium were calculated and modeled. An elevated stack release was assumed. As discussed above, the uranium in the isotopes production waste was assumed to be in a dispersible form (that is exposed metal) even though it is planned to be placed in solidified cement inside barrels.

HS-3 Criticality in Room 108, 50 kg of Plutonium-239

Scenario Description—This scenario is discussed in Section 3.4.2.4 of the HCF SAR (SNL/NM 1995e). A violation of an administrative control related to fissile material quantity or storage configuration would cause an inadvertent criticality.

SWEIS Screen—This scenario was not analyzed for the SWEIS. Consequences to onsite workers and the public would be small (although the consequences to a worker in the immediate vicinity could be lethal). The frequency was estimated in the SAR to be very small (at least extremely unlikely, if not incredible). Other HCF accident scenarios bound the risk and consequences of this scenario outside the facility.

SPR Facility—SPR IIIM Reactor (S3M Scenarios)

S3M-1 Fire in the Reactor Building

Source Scenario Description—This scenario is discussed in Section 15.3.1 of the SPR Facility SAR (SNL/NM 1995v). The amount of combustible materials in the reactor building has been purposely minimized, but three general sources of fires could be identified: 1) combustion of the reactor fuel itself; 2) a hazardous experiment, perhaps involving flammable materials; and 3) typical fire sources not specifically related to the reactor, such as electrical shorts, spontaneous combustion, and others. Based on bounding assumptions, the worst-case effects of a fire would be a breach of the filter system, a release to the environment of 15 g of (respirable) uranium, and a release to the environment of all fission products from an approximate $0.25 superprompt critical pulse that would melt approximately 10 percent of the core fuel (the melt would contain approximately $1.8x10^{17}$ fissions).

SWEIS Screen—This scenario was not analyzed for the SWEIS because its consequences and risk are both bounded by the following scenario, S3M-2.

S3M-2 Control Element Misadjustment Before Pulse-Element Insertion

Source Scenario Description—This scenario is discussed in Section 15.4.2 of the SPR Facility SAR (SNL/NM 1995v). Control element positions are set for each operation to produce the desired pulse size. The adjustment process requires the operators to calculate the desired control element positions and then place the elements in these positions from the control room. Control element misadjustment before pulse element insertion could result in a larger than anticipated superprompt critical pulse. The estimated upper limit total worth insertion of approximately

> **Unit of Reactivity – The Dollar ($)**
>
> When a reactor is operational, it can be critical in either of two states: critical with delayed neutrons or critical with prompt neutrons. The amount of reactivity in the core when the core becomes critical with prompt neutrons is defined as a dollar's worth of reactivity. When a reactor is "prompt critical," very small changes in the amount of reactivity in the core can create very large, sudden, and rapid changes in reactor "power."

$1.40 would result in the nearly complete destruction of the core and subsequent release of an abnormal amount of fission products to the reactor room and to the environment. The result of a $1.40 insertion event, discussed in Section 15.3.2 of the SPR Facility SAR, would be an unplanned superprompt critical pulse with a fission yield of approximately $4.1x10^{18}$. The analysis assumes that all the fission products from the $4.1x10^{18}$ fissions would be released to the reactor building from the reactor fuel. The 100 percent release from the fuel and then out the building is very conservative. While the analysis did not include the contribution from the uranium-235 in the core, conservative assumptions for the fission products released from the melt region are sufficient to encompass any added downwind dose from the uranium.

SWEIS Screen—This scenario was analyzed for the SWEIS because it was a high-risk scenario.

SWEIS Scenario Description—The scenario in the SPR Facility SAR is for the SPR III reactor. The same scenario was postulated for the SWEIS for the SPR IIIM reactor.

SWEIS Frequency—Based on the discussion in the SAR, the frequency of this scenario was estimated to be extremely unlikely ($1x10^{-4}$ to $1x10^{-6}$ per year).

SWEIS Source Term:

MAR—This scenario assumes that the worst case would be vaporization of the entire core. The MAR would be the uranium in the core plus any fission products present at the time of the accident. The SAR analysis only included the release of fission products, noting that the contribution of the uranium in the core to the consequence calculations would be small. The SWEIS analysis included the contribution from the uranium in the core, although this resulted in a small contribution to the consequences.

The SAR indicates that with worst-case assumptions, this accident scenario could result in a $4.1x10^{18}$ fission pulse (for the SPR III reactor). Fission product data for this size pulse were not available. Table 11–1 of the SPR SAR, however, presents fission product data for a $3x10^{17}$ fission pulse after an operating history that is equivalent to infinite operation at the highest expected operating power level. Inspection of the data indicates that the pulse would add little to the fission products that would build up over the assumed long-term operation. The inventories of several short-lived isotopes would be substantially greater, but these would decay quickly and the incremental inventories would not contribute much to the resultant dose. Therefore, the difference between imposing a $4.1x10^{18}$ pulse rather than a $3x10^{17}$ pulse on the core with this assumed operating history would be negligible.

The data from SPR SAR Table 11–1 were used to develop the fission product MAR for this scenario. To account for the larger SPR IIIM core, it was assumed the number of fissions and resultant fission product inventories would be greater by a direct ratio of core masses. This is a reasonable estimate because the SPR IIIM core would have the same composition as the SPR III core. The total mass of the SPR IIIM core is 295 kg (Kaczor 1998); the total mass of the SPR III core is 258 kg (SAR). The SPR SAR Table 11–1 data were scaled up for SPR IIIM by a factor of 295/258=1.1434.

To determine the contribution of the uranium in the SPR IIIM core, the mass of uranium-235 must be determined. With a core composition of 90 percent uranium with an enrichment of 93 percent, the core would have 246.9 kg of uranium-235.

Release Assumptions—The releases would be based on appropriate release fractions for a melt scenario. The release calculation considers all the fission products and the uranium-235 present in the SPR IIIM core. Although the release would flow through the SPR Facility stack, a ground-level release was assumed because of the low stack height. Table F.2–18 summarizes the source-term release characteristics (such as release height and buoyancy considerations) and the values for the source-term factors used in the determination of the source terms from this postulated accident scenario.

S3M-3 Failure of a Fissionable Experiment

Scenario Description—This scenario is discussed in Section 15.4.3 of the SPR Facility SAR (SNL/NM 1995v). The so-called shock rod experiments are typical of the historic experiments involving fissionable material. These experiments involve the rapid heating of uranium or plutonium rods to excite the fundamental oscillation modes of the material. The tests are routinely carried to experiment failure, generally due to high-stress cracking at elevated temperature. The purpose of these experiments is to study basic properties of the material and its dynamic response. Plutonium experiments are required to incorporate two levels of containment; however, to encompass the worst case, the scenario assumes failure of all containment and the complete melt of 7,000 g of plutonium.

SWEIS Screen—This scenario was analyzed for the SWEIS because it is a high-consequence scenario.

SWEIS Scenario Description—This scenario was postulated for the SWEIS. The difference in reactors (SPR IIIM versus SPR III) would have no impact on this scenario because the experiment is independent of the reactor used.

SWEIS Frequency—Based on the discussion in the SAR, the frequency of this scenario was estimated to be extremely unlikely ($1x10^{-4}$ to $1x10^{-6}$ per year).

SWEIS Source Term:

MAR—This scenario assumes that the worst case would be a complete melt of all the plutonium. The MAR would be the plutonium mass plus the fission products that are present in the plutonium from the pulse. The SAR indicates the pulse for this scenario would involve $5x10^{16}$ plutonium fissions, but the fission product data for this number of plutonium fissions are not available. Fission product data available for $1x10^{18}$ plutonium fissions (*Rocky Flats Risk Assessment Guide, 1985,* Table 4.3–1) were used for the SWEIS analysis (Rockwell International 1985). This resulted in conservatively high consequences.

Release Assumptions—The releases would be based on appropriate release fractions for a melt scenario. The release calculation would consider all the fission products and the plutonium-239. Although the release would flow through the SPR Facility stack, a ground-level release was assumed because of the low stack height. Table F.2–18 summarizes the source-term release characteristics (such as release height and buoyancy considerations) and the values for the source-term factors used in the determination of the source terms from this postulated accident scenario.

SPR Facility—Critical Assembly (SCA Scenario)

SCA-1 Anticipated Transient Without Scram Accident

Scenario Description**—**This scenario is discussed in Section 13.8 of the *Critical Assembly SAR* (SNL/NM 1995c). "Anticipated Transients Without Scram" accidents are initiated by reactivity anomalies sufficient to challenge the automatic protection system and are exacerbated by total failure of this system. The worst-case consequences are caused by an unmitigated fast ramp reactivity insertion accident. The frequency of accident scenarios leading to the fast ramp rate regime is exceedingly small because of the number of independent hardware failures and operator errors required. The consequence analysis was based on an upper bound estimate of 8.6×10^{18} fissions.

SWEIS Screen**—**The Particle Bed Critical Assembly (PBCA) is currently not present at SNL/NM, and there are no plans to return it. TA-V management did indicate that it is possible for the assembly to be returned in the future and operated at the SPR Facility. This accident scenario, which is the highest consequence scenario for the PBCA, yields an upper bound estimate of 8.6×10^{18} fissions, slightly greater than the yield from the SPR IIIM reactor in scenario S3M-2. These two scenarios are estimated to be in the same frequency bin (1×10^{-4} to 1×10^{-6} per year), but the PBCA scenario is less likely than scenario S3M-2. The conservative assumptions in developing the SCA scenario are discussed in the *Critical Assembly SAR*. Considering that the PBCA will be operated much less frequently than SPR IIIM, if at all, the risk of scenario S3M-2 was considered greater than the risk of scenario SCA-1. Scenario S3M-3 represents the highest consequence scenario for SPR Facility operations. Scenario SCA-1, therefore, is considered bounded by scenarios S3M-2 and S3M-3 and was not analyzed for the SWEIS.

SPR Facility—Storage (SS Scenario)

SS-1 Airplane Crash into North Vault (NOVA) Storage Vault

Source Scenario Description**—**This scenario was not postulated in the SPR Facility SAR (SNL/NM 1995v). SNL/NM TA-V personnel indicated that this vault is now used infrequently (Schmidt 1998).

SWEIS Screen**—**This scenario was analyzed in the SWEIS because it is a potentially high-consequence scenario.

SWEIS Scenario Description**—**The SWEIS analysis postulated an airplane crash into the vault, causing a large fire that releases stored radioactive material. An experiment containing plutonium-239, similar to the experiment used in scenario S3M-3 and representative of other plutonium components tested at TA-V, was assumed to be stored in the NOVA.

The SPR Facility has other vaults within the primary facility structure that are used more frequently for storing radioactive material. The structure's thick concrete walls offer protection from an airplane crash. The NOVA vault also offers some protection, but its walls are not as robust structurally as the main building. An airplane crash into the NOVA vault would have a greater impact on the vault's contents than a crash into the building structure in the vicinity of one of the other vaults.

SWEIS Frequency**—**The frequency of an airplane crash at the SPR Facility was calculated for the SWEIS to be 6.3×10^{-6} per year (Appendix F.4). This will be used for the scenario frequency, even though the scenario frequency will be somewhat lower because a plutonium experiment is not always stored in the vault. Discussions with TA-V personnel, however, indicated that some experiments have in the past been kept in storage onsite for long periods of time (TtNUS 1998k). The scenario frequency will also be lower because 6.3×10^{-6} per year represents a crash anywhere into the SPR Facility. The frequency of a crash directly into the North Vault will be less because the vault is a fraction of the overall facility profile (that is, it is a smaller target than the entire facility).

SWEIS Source Term:

MAR**—**The MAR for this scenario is 7 kg of plutonium-239. While more material could be present at times, the likelihood of an airplane crash during these short periods of time would be extremely low. The one plutonium experiment is a reasonable assumption for the MAR.

Release Assumptions**—**The releases would be based on appropriate release fractions for a large fire scenario. A ground-level release is assumed because the crash would open the vault to atmosphere. Table F.2–18 summarizes the source-term release characteristics (such as release height and buoyancy considerations) and the values for the source-term factors used in the determination of the source terms from this postulated accident scenario.

SPR Facility (SP Scenario)

SP-1 Earthquake - Building Collapse

***Source Scenario Description*—**The SPR SAR (SNL/NM 1995v) dismisses seismic events due to the assumption that earthquakes up to the UBC-level in magnitude (0.22 *g*) are not expected to cause any major damage to the facility. The SAR indicates the event would pose no radiological consequences to workers or the public.

***SWEIS Screen*—**Section F.7 discusses earthquake frequencies and facility responses for TA-V. A UBC-level earthquake (0.22 *g*) with a frequency of $7x10^{-4}$ per year could result in collapse of the SPR NOVA. The reactor building would remain intact. This scenario was analyzed for the SWEIS because it is a high-risk scenario.

***SWEIS Scenario Description*—**A large earthquake (0.22 *g*) occurs at TA-V, causing collapse of the SPR NOVA. It is assumed that the building collapse causes a seismically induced fire within the NOVA. Scenario SS-1, which is a postulated airplane crash into the NOVA, could be used as a representative bounding release scenario for the vault fire.

***SWEIS Frequency*—**Section F.7 discusses earthquake frequencies and facility responses for TA-V. A UBC-level earthquake (0.22 *g*) with a frequency of $7x10^{-4}$ per year could result in collapse of the SPR facility including the reactor building. However, the vault is not expected to be damaged or collapse due to this postulated seismic event.

SWEIS Source Term:

***MAR*—**The MAR for this new postulated accident scenario is bounded by the source terms from Scenario SS-1. Since the SPR NOVA must be considered as a radiological contaminated building, dust and suspension of building particles would contribute only a minor source term.

***Release Assumptions*—**The release assumptions were the same as for Scenario SS-1 (airplane crash into the NOVA). Table F.2–18 summarizes the source-term release characteristics (such as release height and buoyancy considerations) and the values for the source-term factors used in the determination of the source terms from this postulated accident scenario.

SPR Facility—SPR IV Reactor (S4 Scenario)

S4-1 Control Element Misadjustment Before Pulse-Element Insertion

***Scenario Description*—**This is the same scenario as S3M-2, except that the accident would occur during operation of the SPR IV reactor rather than the SPR IIIM reactor.

***SWEIS Screen*—**This scenario was analyzed for the SWEIS because it is a high-risk scenario in the SAR.

***SWEIS Scenario Description*—**The scenario analyzed in the SPR Facility SAR (SNL/NM 1995v) is for the SPR III reactor. The same scenario is postulated in the SWEIS for the SPR IV reactor.

***SWEIS Frequency*—**Based on the discussion in the SPR Facility SAR, the frequency of this scenario was estimated to be extremely unlikely ($1x10^{-4}$ to $1x10^{-6}$ per year).

SWEIS Source Term:

***MAR*—**The MAR was based on the same assumptions as Scenario S3M-2, except that material quantities and fission products would be scaled up for the larger SPR IV reactor core. The total core mass for SPR IV would be 550 kg (Schmidt 1998). With a core composition of 90 percent uranium with an enrichment of 93 percent, the core would have 460.35 kg of uranium-235. SAR fission product data would be scaled up by a factor of 550/258=2.1318.

***Release Assumptions*—**The releases were based on applicable fractions for a melt scenario. Although the release would flow through the SPR Facility stack, a ground-level release was assumed because of the low stack height. Table F.2–18 summarizes the source-term release characteristics (such as release height and buoyancy considerations) and the values for the source-term factors used in the determination of the source terms from this postulated accident scenario.

ACRR-DP Configuration (AR Scenarios)

AR-1 Uncontrolled Addition of Reactivity (Insertion of $10.25)

***Source Scenario Description*—**This scenario is discussed in Section 14.3.1 of the ACRR SAR (SNL/NM 1996d). A total reactivity worth of $10.25 is inserted into the core over a time frame of 80 milliseconds. This accident is assumed to occur without regard to some initiating event or failure of a reactivity control system or violation of prescribed procedures. The absolute magnitude of the reactivity change could be caused by the addition of reactivity from either the removal of negative reactivity (control rods, transient rods, or a negative worth experiment) or positive reactivity (positive worth experiment). In terms of operational capabilities, the reactivity would represent the total available in the transient bank coupled to an unplanned removal of a large negative worth experiment in the same time frame.

SWEIS Screen—This scenario was analyzed in the SWEIS because it is the highest consequence event in the ACRR SAR.

SWEIS Scenario Description—The same scenario was postulated for the SWEIS.

SWEIS Frequency—This scenario would require the occurrence of several events, some of which would negate inherent safety features. Based on the discussion in the ACRR SAR, the frequency of this scenario would be beyond extremely unlikely, or less than $1x10^{-6}$. A frequency of $1x10^{-6}$ was estimated for the SWEIS.

SWEIS Source Term:

MAR—Core fission product and actinide inventories at the time of the event, including consideration of the insertion, are provided in Tables 11A–1 and 11A–3 in the ACRR SAR (and are repeated in Tables 14A–2 and 14A–3). The SAR estimates that 2 percent of the core material would be available for release as "liquid" fuel.

Release Assumptions—The fission product inventory from 2 percent of the fuel would be released after considering appropriate release fractions. This scenario was assumed to be such an energetic event that the fission products would be driven up through the pool without the full decontamination that is assumed for other pool accidents. No pool decontamination was assumed. The release was assumed to be an elevated stack release. Table F.2–18 summarizes the source-term release characteristics (such as release height and buoyancy considerations) and the values for the source-term factors used in the determination of the source terms from this postulated accident scenario.

AR-2 Waterlogged Fuel Element Ruptures

Source Scenario Description—This scenario is discussed in Section 14.4.8 of the ACRR SAR (SNL/NM 1996d). This event would be initiated by failure of a single waterlogged fuel element during a pulse from low initial power and subsequent damage to adjacent elements. The pulse would be assumed to occur when the maximum fission product inventories have built up in the core. Adjacent elements would be assumed to be damaged by the rupture of the waterlogged element. The analysis assumes failure of a total of four fuel elements, with ejection of the fuel from all four elements into the pool water.

SWEIS Screen—This scenario was analyzed for the SWEIS because it represents a potentially high-risk scenario. Although the release for this scenario would be less than the releases for other scenarios, its risk could be greater because of its higher frequency.

SWEIS Scenario Description—The same scenario was postulated for the SWEIS.

SWEIS Frequency—Based on the discussion in the ACRR SAR and the ACRR's operating history, the frequency of this scenario was estimated to be $1x10^{-1}$ to $1x10^{-2}$ per year (that is, once every 10 to 100 years). The SAR characterizes the potential for waterlogged fuel elements as "likely," but states that the presence of leaking fuel elements would be identified by an increase in the radioactivity in the reactor coolant. The cause of the increased radioactivity would be investigated and corrected, most likely prior to the heat-up and cool-down cycles that are needed to fill the fuel element void space and cause the cladding to burst during a pulse. In addition, the SAR discusses operating history data for small research reactors like the ACRR. A few leaking fuel elements have been observed, but they are rare, and there have been no incidents of explosive failures. The ACRR has operated for over 30 years with no leaking fuel elements.

SWEIS Source Term:

MAR—The fission product inventories would be based on the conservative, long-term operating history described in Chapter 11 of the ACRR SAR. The applicable fission product inventories would be the prepulse numbers in Tables 11A–1 and 11A–3 (repeated in Tables 14A–2 and 14A–3 of the ACRR SAR). This accident could occur during steady-state or pulse operations. If it were to occur during a normal pulse imposed on the inventories from the assumed operating history, inventories slightly higher than the prepulse inventories would be present. The data for an incremental increase due to a normal pulse are not available, but it is evident from the referenced tables that a pulse would not increase the fission product inventories of interest by very much. The conservatism in the assumed operating history more than compensates for a slight increase that a pulse would cause, and the prepulse inventories would be adequate for this analysis. The SAR estimates the upper bound of fission product inventory released by this event to be 2.3 percent of total core inventory. This estimate was used for the SWEIS analysis.

Release Assumptions**—**The fission products from 2.3 percent of the fuel were assumed to be released into the pool with consideration for the appropriate release fraction. The release from the reactor building was assumed to be an elevated stack release. Table F.2–18 summarizes the source-term release characteristics (that is release height and buoyancy considerations) and the values for the source-term factors used in the determination of the source terms from this postulated accident scenario.

AR-3 Failure of Experiment Containing ACRR Fuel Pins

Scenario Description**—**This scenario is discussed in Section 14.4.10.4 of the ACRR SAR (SNL/NM 1996d). The experiment would comprise fresh ACRR fuel pins (uranium dioxide at 20 percent enrichment) with fission products from the ACRR pulse experiment only. The test fuel pins would rupture during a pulse that deposits a total energy of 3 MW-seconds.

SWEIS Screen**—**This scenario was not analyzed for the SWEIS because its consequences and risk are bounded by other scenarios. In addition, future experiments involving reactor fuel would not be likely, given the new mission for the ACRR and the limited scope of any pulse-mode operations.

AR-4 Fire in Reactor Room with Experiment Present

Source Scenario Description**—**This scenario is discussed in Section 14.4.11.1 of the ACRR SAR (SNL/NM 1996d). This scenario is postulated in the SAR, but it is not analyzed quantitatively. The SAR stated that fissionable material in an experiment could be affected by a fire, and small quantities of uranium oxide and other contaminants could be released into the local atmosphere. The SAR states that the consequences would not exceed those calculated for the limiting event.

SWEIS Screen**—**This scenario was analyzed for the SWEIS because it is a potentially high-consequence and high-risk scenario.

SWEIS Scenario Description**—**To bound the potential consequences of this type of scenario, the SWEIS conservatively assumed a large fire in the reactor room without specific analysis of combustible loading and ignition sources. Also, to bound the potential consequences, an experiment containing plutonium was assumed to be present in the reactor room.

SWEIS Frequency**—**The frequency is based on a Category II frequency bin (unlikely) for a large fire in the reactor room. The scenario frequency was assumed to be one lower category to account for the limited amount of time a plutonium experiment would be present in the reactor room when the fire occurs. This results in a Category III frequency bin estimate (extremely unlikely) for this scenario ($1x10^{-4}$ to $1x10^{-6}$ per year).

SWEIS Source Term:

MAR**—**The ACRR SAR does not quantify the MAR or the release from this scenario. Scenario S3M-3 indicates 7 kg of plutonium-239 could be present in an experiment in the SPR Facility. Assuming that a similar experiment could be present in the ACRR, the MAR for this scenario would be 7 kg of plutonium-239.

Release Assumptions**—**The release was based on the release fraction for a plutonium component in a large fire. The release from the reactor building was assumed to be an elevated stack release. Table F.2–18 summarizes the source-term release characteristics (such as release height and buoyancy considerations) and the values for the source-term factors used in the determination of the source terms from this postulated accident scenario.

AR-5 Earthquake - Collapse of Bridge Crane

Source Scenario Description**—**The ACRR SAR (SNL/NM 1996d) evaluates the collapse of the bridge crane; however, such an event was not expected to cause any major damage to the facility. The SAR indicated that such an event would pose no radiological consequences to workers or the public.

SWEIS Screen**—**As discussed under the SWEIS frequency paragraph below, recent site-specific data indicate the frequency of an earthquake large enough to cause collapse of the bridge crane is approximately $7x10^{-4}$ per year. This is higher than the frequency of less than $1x10^{-6}$ per year that was previously estimated in Massey, et al. (SNL 1995e). This scenario was analyzed for the SWEIS using the recent frequency data. At this frequency, this scenario is a high-risk scenario.

SWEIS Scenario Description**—**A large earthquake occurs at TA-V (0.22 *g*), causing ACRR building damage that results in collapse of the bridge crane. The bridge crane falls into the reactor pool, impacts the reactor superstructure, and results in the rupture of 10 percent of the core or 24 fuel elements in the reactor core. Other than the initiating event, this scenario is the same as the airplane crash, Scenario AM-1. No additional releases are postulated because the reactor is located at the bottom of the pool and protected from other debris that may result from failure of the building structure.

SWEIS Frequency—Section F.7 discusses earthquake frequencies and facility responses for TA-V. A UBC-level earthquake (0.22 *g*) with a frequency of $7x10^{-4}$ per year, could result in collapse of the ACRR facility. This scenario will be analyzed for the SWEIS because it is a high-risk scenario.

SWEIS Source Term:

MAR— The fission product inventories would be based on the conservative, long-term operating history described in Chapter 11 of the ACRR SAR. The applicable fission product inventories would be the prepulse numbers in Tables 11A–1 and 11A–3 (repeated in Tables 14A–2 and 14A–3). The SAR estimates the upper bound of fission product inventory released by this event to be 10 percent of total core inventory. This estimate was used for the SWEIS analysis.

Release Assumptions—The release assumptions were the same as for Scenario AR-6. Table F.2–18 summarizes the source-term release characteristics (such as release height and buoyancy considerations) and the values for the source-term factors used in the determination of the source terms from this postulated accident scenario.

AR-6 Airplane Crash—Collapse of Bridge Crane

Scenario Description—This scenario is discussed in Section 14.4.11.4 of the ACRR SAR (SNL/NM 1996d). The SAR discusses the probability of an aircraft crash into the reactor building, but does not evaluate the potential consequences.

SWEIS Screen—This scenario was analyzed in the SWEIS because it is a potentially high-risk scenario.

SWEIS Scenario Description—In order to bound the consequences of an airplane crash, the MIPP EIS (DOE 1996b) assumed the crash would knock the bridge crane off its rails onto the reactor superstructure. This would be the same scenario as AR-5, except for a different initiating event. The SWEIS analysis postulated an airplane crash would cause collapse of the bridge crane, which would be assumed to fall directly on to the reactor superstructure and damage 24 fuel elements (approximately 10 percent of the core).

SWEIS Frequency—The airplane crash frequency for TA-V was updated for the SWEIS. It was calculated to be $6.3x10^{-6}$ per year (Section F.4). The SWEIS used this frequency for the scenario frequency, although it is recognized that the frequency would be lower because the bridge crane would seldom be over the reactor. However, this scenario is assumed to bound the effect an airplane crash into the ACRR building could have on the reactor core.

SWEIS Source Term:

MAR—The fission product inventories would be based on the conservative, long-term operating history described in Chapter 11 of the ACRR SAR. The applicable fission product inventories would be the prepulse numbers in Tables 11A–1 and 11A–3 (repeated in Tables 14A–2 and 14A–3 of the ACRR SAR). The SAR estimates the upper bound of fission product inventory released by this event to be 10 percent of total core inventory. This estimate was used for the SWEIS analysis.

Release Assumptions—The fission products from 10 percent of the fuel were assumed to be released into the pool with consideration for the appropriate release fraction. The airplane crash was assumed to breach the reactor building, resulting in a ground-level release. Table F.2–18 summarizes the source-term release characteristics (such as release height and buoyancy considerations) and the values for the source-term factors used in the determination of the source terms from this postulated accident scenario.

F.2.7.4 Consequence Analysis Modeling Characteristics and Parameters

Table F.2–18 provides a summary of the scenario-specific modeling characteristics and parameters for the scenarios described in the previous sections. These characteristics and parameters were used in the consequence analyses by incorporation into the *MACCS2* input files.

F.2.7.5 Technical Area-V Results

Results from the *MACCS2* runs have been used to provide consequence estimates for TA-V for each of the accident scenarios. Three sets of results tables are presented for each alternative containing accident consequences for each accident scenario. Table F.2–19 provides the consequence estimates for the MEI and the maximally exposed noninvolved worker for each scenario. A distance of 100 m from the release point was used to estimate the dose to noninvolved workers. Table F.2–20 provides consequence estimates for the 50-mi population. Table F.2–21 provides consequence estimates for the core receptor locations.

Of all the credible (having a frequency >10^{-6} per year) accidents for TA-V, accident AR-4 yields the largest dose to the MEI and the largest dose to the population within 50 mi. This accident involves the ACRR and applies in the No Action and Expanded Operations Alternatives only. Those doses (0.002 rem and 18 person-rem) are about the same as those from accident S3M-3 (0.0017 rem and 16 person-rem). The latter applies to all three alternatives.

Those accidents have a probability of 10^{-4} to 10^{-6} per year, and could produce about 0.009 excess latent cancer fatalities in the surrounding populations, were they to occur. The MEI for those accidents is located at the Golf Course and has only a $1x10^{-6}$ chance of a latent fatal cancer resulting from the accident.

F.2.8 Manzano Waste Storage Facilities

The Manzano Waste Storage Facilities are located in the Manzano Area southeast of TA-I. Four structures, each a one-story bunker made of concrete and covered with dirt, are designated as nuclear facilities. These bunkers are authorized to store nuclear waste in the form of low-level mixed waste (LLMW), low-level waste (LLW), and transuranic (TRU) waste. Storage of surplus special nuclear material is also authorized. Quantities are controlled to limit the amount of nuclear material in each bunker to Hazard Category 3 limits (that is, less than Hazard Category 2 thresholds), as defined by DOE-STD-1027-92 (DOE 1992c).

A SAR documents the safety basis for these facilities (SNL/NM 1997q). An HA identifies the hazards and develops potential accident scenarios. A major finding of the HA is that the accident scenarios that pose the greatest risk are fire-related, especially vehicle and forklift-initiated fire events. Based on this finding, the SAR concludes that the limiting accident scenario is a vehicle fire occurring while packages are being transported into, out of, or around the Manzano Area. The frequency of this accident scenario was estimated to be in the range of $1x10^{-4}$ to $1x10^{-2}$ per year.

The fire event discussed in the SAR is assumed to be initiated by a vehicle malfunction or fuel leak. The waste package is assumed to be fully involved in the fire. The SAR analysis assumes, for bounding purposes, that the maximum activity authorized to be stored in one bunker, represented by plutonium-239, is in the waste package and is involved in the fire. Typical package shipments contain much lower quantities and materials other than plutonium.

The radioactive source term from the accident was determined using the standard source-term equation, which is given in Eq. F.2–1 of this Appendix. The following parameter values were used in the SWEIS analysis:

- MAR = 900 grams (55.2 Ci) of plutonium-239
- DR = 1.0
- ARF = $5x10^{-4}$
- RF = 1.0
- LPF = 1.0

Tables F.2–22 through F.2–24 present the results of modeling this accident using the *MACCS2* computer code. The population distribution surrounding the release point is shown in Table F.2–3, while the distance and direction to core receptors and the KAFB boundary are given in Tables F.2–4 and F.2–5.

Although the doses to the MEI (at the Riding Stables) and the 50-mi population are lower, because of the higher frequency of MZ-1, it poses a greater risk to the public than AR-4 and S3M-3 (Section F.2.7.5).

The consequences of this accident will not differ noticeably for the three alternatives because the accident release is based on the authorized quantity and not estimated quantity. SNL/NM has indicated that the quantity of material stored for the Reduced Operations Alternative would decrease by 50 percent from the No Action Alternative, and increase by 30 percent for the Expanded Operations Alternative (SNL/NM 1998a). The maximum authorized quantities would not change due to these variations. However, the frequency of the accident scenario might change due to more shipments or fewer shipments, but such variation would not change the range of the estimated frequency. The consequences of this accident are, therefore, assumed to be the same for all three alternatives.

Table F.2–19. Technical Area-V Radiological Accident Frequencies and Consequences to Maximally Exposed Individual and Noninvolved Worker

Accident ID[a]	Accident Scenario Description	Accident Frequency (per year)	Applicable Alternative[b]	Maximally Exposed Individual		Noninvolved Worker	
				Dose (rem)	Increased Probability of Latent Cancer Fatality	Dose (rem)	Increased Probability of Latent Cancer Fatality
AM-1	Airplane crash - collapse of bridge crane	6.3×10^{-6}	All	4.8×10^{-4}	2.4×10^{-7}	1.9×10^{-1}	7.4×10^{-5}
AM-3	Rupture of waterlogged fuel element	1.0×10^{-2} to 1.0×10^{-4}	All	1.1×10^{-4}	5.4×10^{-8}	9.6×10^{-3}	3.8×10^{-6}
AM-4	Rupture of one molybdenum-99 target	1.0×10^{-4} to 1.0×10^{-6}	All	8.5×10^{-5}	4.3×10^{-8}	7.5×10^{-3}	3.0×10^{-6}
AM-5	Fuel handling accident - irradiated element	1.0×10^{-4} to 1.0×10^{-6}	All	1.2×10^{-3}	6.1×10^{-7}	1.9×10^{-1}	7.6×10^{-5}
AM-6	Airplane crash and fire in reactor room with unirradiated fuel and targets present	6.3×10^{-6}	All	2.1×10^{-7}	1.0×10^{-10}	1.2×10^{-4}	4.9×10^{-8}
AM-7	Target rupture during Annular Core Research Reactor to Hot Cell Facility transfer	$<1.0 \times 10^{-6}$	All	9.7×10^{-5}	4.9×10^{-8}	3.4×10^{-2}	1.4×10^{-5}
HM-1	Operator error - molybdenum-99 target processing	1.0×10^{-1} to 1.0×10^{-2}	All	6.5×10^{-6}	3.3×10^{-9}	4.0×10^{-4}	1.6×10^{-7}
HM-2	Operator error - iodine-125 target processing	1.0×10^{-1} to 1.0×10^{-2}	All	2.1×10^{-7}	1.0×10^{-10}	1.0×10^{-5}	4.2×10^{-9}
HM-4	Fire in steel containment box	1.0×10^{-2} to 1.0×10^{-4}	All	4.8×10^{-4}	2.4×10^{-7}	5.7×10^{-3}	2.3×10^{-6}
HS-1	Fire in room 108, average inventories	3.3×10^{-5}	All	3.6×10^{-4}	1.8×10^{-7}	5.0×10^{-4}	2.0×10^{-7}

Table F.2–19. Technical Area-V Radiological Accident Frequencies and Consequences to MEI and Noninvolved Worker (concluded)

Accident ID[a]	Accident Scenario Description	Accident Frequency (per year)	Applicable Alternative[b]	Maximally Exposed Individual		Noninvolved Worker	
				Dose (rem)	Increased Probability of Latent Cancer Fatality	Dose (rem)	Increased Probability of Latent Cancer Fatality
HS-2	Fire in room 108, maximum inventories	$2.0x10^{-7}$	All	$1.3x10^{-2}$	$6.6x10^{-6}$	$1.8x10^{-2}$	$7.4x10^{-6}$
S3M-2	Control element misadjustment before insert	$1.0x10^{-4}$ to $1.0x10^{-6}$	All	$2.9x10^{-4}$	$1.5x10^{-7}$	$6.3x10^{-1}$	$2.5x10^{-4}$
S3M-3	Failure of a fissionable experiment	$1.0x10^{-4}$ to $1.0x10^{-6}$	All	$1.7x10^{-3}$	$8.4x10^{-7}$	4.8	$3.8x10^{-3}$
SS-1	Airplane crash into North Vault storage vault	$6.3x10^{-6}$	All	$1.2x10^{-3}$	$5.8x10^{-7}$	$6.9x10^{-1}$	$5.5x10^{-4}$
S4-1	Control element misadjustment before insert	$1.0x10^{-4}$ to $1.0x10^{-6}$	E	$5.5x10^{-4}$	$2.7x10^{-7}$	1.2	$4.7x10^{-4}$
AR-1	Uncontrolled addition of reactivity	$<1.0x10^{-6}$	N, E	$1.9x10^{-3}$	$9.3x10^{-7}$	$2.9x10^{-1}$	$1.2x10^{-4}$
AR-2	Rupture of waterlogged fuel element	$1.0x10^{-1}$ to $1.0x10^{-2}$	N, E	$3.5x10^{-4}$	$1.7x10^{-7}$	$3.0x10^{-2}$	$1.2x10^{-5}$
AR-4	Fire in reactor room with experiment present	$1.0x10^{-4}$ to $1.0x10^{-6}$	N, E	$2.0x10^{-3}$	$1.0x10^{-6}$	$3.4x10^{-1}$	$1.4x10^{-4}$
AR-6	Airplane crash - collapse of bridge crane	$6.3x10^{-6}$	N, E	$1.7x10^{-3}$	$8.4x10^{-7}$	$5.6x10^{-1}$	$2.2x10^{-4}$

Source: Original
TA: technical area
[a] Technical Area-V Facility Accident Descriptors:
Annular Core Research Reactor: DP Configuration: AR-1, AR-2, AR-4, AR-6
Annular Core Research Reactor: Medical Isotopes Production Configuration: AM-1, AM-3, AM-4, AM-5, AM-6, AM-7
Hot Cell: Medical Isotopes Production Configuration: HM-1, HM-2, HM-4
Hot Cell: Room 108 Storage: HS-1, HS-2
Sandia Pulsed Reactor: S3M-2, S3M-3, SS-1, S4-1

[b] Applicable Alternative:
All–Scenarios applicable to all three alternatives
N–Scenario applicable to No Action Alternative
E–Scenario is applicable to Expanded Operations Alternative

Table F.2–20. Technical Area-V Radiological Accident Frequencies and Consequences to 50-Mile Population

Accident ID[a]	Accident Scenario Description	Accident Frequency (per year)	Applicable Alternative[b]	Dose (person-rem)	Additional Latent Cancer Fatality
AM-1	Airplane crash - collapse of bridge crane	6.3×10^{-6}	All	3.9	2.0×10^{-3}
AM-3	Rupture of waterlogged fuel element	1.0×10^{-2} to 1.0×10^{-4}	All	9.8×10^{-1}	4.9×10^{-4}
AM-4	Rupture of one molybdenum-99 target	1.0×10^{-4} to 1.0x10¯6	All	7.8×10^{-1}	3.9×10^{-4}
AM-5	Fuel handling accident - irradiated element	1.0×10^{-4} to 1.0×10^{-6}	All	9.9	4.9×10^{-3}
AM-6	Airplane crash and fire in reactor room with unirradiated fuel and targets present	6.3×10^{-6}	All	3.3×10^{-3}	1.6×10^{-6}
AM-7	Target rupture during Annular Core Research Reactor to Hot Cell Facility transfer	$<1.0\times10^{-6}$	All	7.9×10^{-1}	3.9×10^{-4}
HM-1	Operator error - molybdenum-99 target processing	1.0×10^{-1} to 1.0×10^{-2}	All	7.6×10^{-2}	3.8×10^{-5}
HM-2	Operator error - iodine-125 target processing	1.0×10^{-1} to 1.0×10^{-2}	All	3.1×10^{-3}	1.6×10^{-6}
HM-4	Fire in steel containment box	1.0×10^{-2} to 1.0×10^{-4}	All	5.2	2.6×10^{-3}
HS-1	Fire in room 108, average inventories	3.3×10^{-5}	All	4.3	2.1×10^{-3}
HS-2	Fire in room 108, maximum inventories	2.0×10^{-7}	All	1.6×10^{2}	7.9×10^{-2}
S3M-2	Control element misadjustment before insert	1.0×10^{-4} to 1.0×10^{-6}	All	2.4	1.2×10^{-3}
S3M-3	Failure of a fissionable experiment	1.0×10^{-4} to 1.0×10^{-6}	All	1.6×10^{1}	7.9×10^{-3}
SS-1	Airplane crash into North Vault storage vault	6.3×10^{-6}	All	1.8×10^{1}	9.2×10^{-3}
S4-1	Control element misadjustment before insert	1.0×10^{-4} to 1.0×10^{-6}	E	4.5	2.2×10^{-3}

Table F.2–20. Technical Area-V Radiological Accident Frequencies and Consequences to 50-Mile Population (concluded)

Accident ID[a]	Accident Scenario Description	Accident Frequency (per year)	Applicable Alternative[b]	Dose (person-rem)	Additional Latent Cancer Fatality
AR-1	Uncontrolled addition of reactivity	$<1.0 \times 10^{-6}$	N,E	1.5×10^{1}	7.3×10^{-3}
AR-2	Rupture of waterlogged fuel element	1.0×10^{-1} to 1.0×10^{-2}	N,E	2.7	1.3×10^{-3}
AR-4	Fire in reactor room with experiment present	1.0×10^{-4} to 1.0×10^{-6}	N,E	1.8×10^{1}	9.0×10^{-3}
AR-6	Airplane crash - collapse of bridge crane	6.3×10^{-6}	N,E	1.2×10^{1}	5.9×10^{-3}

Source: Original

[a] Technical Area-V Facility Accident Descriptors:
Annular Core Research Reactor-DP Configuration: AR-1, AR-2, AR-4, AR-6
Annular Core Research Reactor-Medical Isotopes Production Configuration: AM-1, AM-3, AM-4, AM-5, AM-6, AM-7
Hot Cell Facility: Medical Isotopes Production Configuration: HM-1, HM-2, HM-4
Hot Cell Facility: Room 108 Storage: HS-1, HS-2
Sandia Pulsed Reactor: S3M-2, S3M-3, SS-1, S4-1

[b] Applicable Alternative:
All–Scenarios applicable to all three alternatives
N–Scenario applicable to No Action Alternative
E–Scenario applicable to Expanded Operations Alternative

Table F.2–21. Technical Area-V Radiological Accident Frequencies and Consequences to Core Receptor Locations

Accident ID[a]	Accident Scenario Description	Accident Frequency (per year)	Applicable Alternative[b]	Dose (rem)	Increased Probability of Latent Cancer Fatality	Dose (rem)	Increased Probability of Latent Cancer Fatality
				Golf Course (1.6-2.4 km to N)		*Golf Course (1.6-2.4 km to NNE)*	
AM-1	Airplane crash - collapse of bridge crane	$6.3x10^{-6}$	All	$4.5x10^{-4}$	$2.2x10^{-7}$	$4.8x10^{-4}$	$2.4x10^{-7}$
AM-3	Rupture of waterlogged fuel element	$1.0x10^{-2}$ to $1.0x10^{-4}$	All	$9.8x10^{-5}$	$4.9x10^{-8}$	$1.1x10^{-4}$	$5.4x10^{-8}$
AM-4	Rupture of one molybdenum-99 target	$1.0x10^{-4}$ to $1.0x10^{-6}$	All	$7.8x10^{-5}$	$3.9x10^{-8}$	$8.5x10^{-5}$	$4.3x10^{-8}$
AM-5	Fuel handling accident - irradiated element	$1.0x10^{-4}$ to $1.0x10^{-6}$	All	$1.2x10^{-3}$	$5.9x10^{-7}$	$1.2x10^{-3}$	$6.1x10^{-7}$
AM-6	Airplane crash and fire in reactor room with unirradiated fuel and targets present	$6.3x10^{-6}$	All	$2.1x10^{-7}$	$1.0x10^{-10}$	$2.0x10^{-7}$	$9.8x10^{-11}$
AM-7	Target rupture during Annular Core Research Reactor to Hot Cell Facility transfer	$<1.0x10^{-6}$	All	$9.0x10^{-5}$	$4.5x10^{-8}$	$9.7x10^{-5}$	$4.9x10^{-8}$
HM-1	Operator error - molybdenum-99 target processing	$1.0x10^{-1}$ to $1.0x10^{-2}$	All	$6.2x10^{-7}$	$3.1x10^{-10}$	$6.5x10^{-6}$	$3.3x10^{-9}$
HM-2	Operator error - iodine-125 target processing	$1.0x10^{-1}$ to $1.0x10^{-2}$	All	$1.9x10^{-7}$	$9.7x10^{-11}$	$2.1x10^{-7}$	$1.0x10^{-10}$
HM-4	Fire in steel containment box	$1.0x10^{-2}$ to $1.0x10^{-4}$	All	$4.6x10^{-4}$	$2.3x10^{-7}$	$4.8x10^{-4}$	$2.4x10^{-7}$
HS-1	Fire in room 108, average inventories	$3.3x10^{-5}$	All	$3.4x10^{-4}$	$1.7x10^{-7}$	$3.6x10^{-4}$	$1.8x10^{-7}$
HS-2	Fire in room 108, maximum inventories	$2.0x10^{-7}$	All	$1.3x10^{-2}$	$6.3x10^{-6}$	$1.3x10^{-2}$	$6.6x10^{-6}$
S3M-2	Control element misadjustment before insert	$1.0x10^{-4}$ to $1.0x10^{-6}$	All	$2.8x10^{-4}$	$1.4x10^{-7}$	$2.9x10^{-4}$	$1.5x10^{-7}$

Table F.2–21. Technical Area-V Radiological Accident Frequencies and Consequences to Core Receptor Locations (continued)

Accident ID[a]	Accident Scenario Description	Accident Frequency (per year)	Applicable Alternative[b]	Dose (rem)	Increased Probability of Latent Cancer Fatality	Dose (rem)	Increased Probability of Latent Cancer Fatality
S3M-3	Failure of a fissionable experiment	$1.0x10^{-4}$ to $1.0x10^{-6}$	All	$1.6x10^{-3}$	$8.1x10^{-7}$	$1.7x10^{-3}$	$8.4x10^{-7}$
SS-1	Airplane crash into North Vault storage vault	$6.3x10^{-6}$	All	$1.2x10^{-3}$	$5.8x10^{-7}$	$1.1x10^{-3}$	$5.5x10^{-7}$
S4-1	Control element misadjustment before insert	$1.0x10^{-4}$ to $1.0x10^{-6}$	E	$5.3x10^{-4}$	$2.6x10^{-7}$	$5.5x10^{-4}$	$2.7x10^{-7}$
AR-1	Uncontrolled addition of reactivity	$<1.0x10^{-6}$	N, E	$1.8x10^{-3}$	$8.9x10^{-7}$	$1.9x10^{-3}$	$9.3x10^{-7}$
AR-2	Rupture of waterlogged fuel element	$1.0x10^{-1}$ to $1.0x10^{-2}$	N, E	$3.2x10^{-4}$	$1.6x10^{-7}$	$3.5x10^{-4}$	$1.7x10^{-7}$
AR-4	Fire in reactor room with experiment present	$1.0x10^{-4}$ to $1.0x10^{-6}$	N, E	$2.0x10^{-3}$	$9.8x10^{-7}$	$2.0x10^{-3}$	$1.0x10^{-6}$
AR-6	Airplane crash – collapse of bridge crane	$6.3x10^{-6}$	N, E	$1.6x10^{-3}$	$7.8x10^{-7}$	$1.7x10^{-3}$	$8.4x10^{-7}$
				Kirtland Underground Munitions and Maintenance Storage Complex (KUMMSC) (1.6-2.4 km to NW)		***National Atomic Museum, Base Housing, Shandiin Day Care Center (5.6-6.4 to NNW)***	
AM-1	Airplane crash – collapse of bridge crane	$6.3x10^{-6}$	All	$3.7x10^{-4}$	$1.9x10^{-7}$	$7.7x10^{-5}$	$3.9x10^{-8}$
AM-3	Rupture of waterlogged fuel element	$1.0x10^{-2}$ to $1.0x10^{-4}$	All	$8.2x10^{-5}$	$4.1x10^{-8}$	$1.9x10^{-5}$	$9.3x10^{-9}$
AM-4	Rupture of one molybdenum-99 target	$1.0x10^{-4}$ to $1.0x10^{-6}$	All	$6.5x10^{-5}$	$3.3x10^{-8}$	$1.5x10^{-5}$	$7.5x10^{-9}$
AM-5	Fuel handling accident – irradiated element	$1.0x10^{-4}$ to $1.0x10^{-6}$	All	$9.7x10^{-4}$	$4.8x10^{-7}$	$1.4x10^{-4}$	$7.0x10^{-8}$

Table F.2–21. Technical Area-V Radiological Accident Frequencies and Consequences to Core Receptor Locations (continued)

Accident ID[a]	Accident Scenario Description	Accident Frequency (per year)	Applicable Alternative[b]	Dose (rem)	Increased Probability of Latent Cancer Fatality	Dose (rem)	Increased Probability of Latent Cancer Fatality
AM-6	Airplane crash and fire in reactor room with unirradiated fuel and targets present	$6.3x10^{-6}$	All	$1.7x10^{-7}$	$8.6x10^{-11}$	$3.7x10^{-8}$	$1.9x10^{-11}$
AM-7	Target rupture during Annular Core Research Reactor to Hot Cell Facility transfer	$<1.0x10^{-6}$	All	$7.5x10^{-5}$	$3.7x10^{-8}$	$1.6x10^{-5}$	$7.8x10^{-9}$
HM-1	Operator error – molybdenum-99 target processing	$1.0x10^{-1}$ to $1.0x10^{-2}$	All	$5.3x10^{-6}$	$2.7x10^{-9}$	$1.4x10^{-6}$	$7.2x10^{-10}$
HM-2	Operator error - iodine-125 target processing	$1.0x10^{-1}$ to $1.0x10^{-2}$	All	$1.7x10^{-7}$	$8.4x10^{-11}$	$5.1x10^{-8}$	$2.6x10^{-11}$
HM-4	Fire in glove box	$1.0x10^{-2}$ to $1.0x10^{-4}$	All	$3.8x10^{-4}$	$1.9x10^{-7}$	$7.3x10^{-5}$	$3.6x10^{-8}$
HS-1	Fire in room 108, average inventories	$3.3x10^{-5}$	All	$2.8x10^{-4}$	$1.4x10^{-7}$	$5.1x10^{-5}$	$2.6x10^{-8}$
HS-2	Fire in room 108, maximum inventories	$2.0x10^{-7}$	All	$1.0x10^{-2}$	$5.2x10^{-6}$	$1.9x10^{-3}$	$9.4x10^{-7}$
S3M-2	Control element misadjustment before insert	$1.0x10^{-4}$ to $1.0x10^{-6}$	All	$2.3x10^{-4}$	$1.2x10^{-7}$	$3.6x10^{-5}$	$1.8x10^{-8}$
S3M-3	Failure of a fissionable experiment	$1.0x10^{-4}$ to $1.0x10^{-6}$	All	$1.3x10^{-3}$	$6.7x10^{-7}$	$1.9x10^{-4}$	$9.4x10^{-8}$
SS-1	Airplane crash into North Vault storage vault	$6.3x10^{-6}$	All	$9.7x10^{-4}$	$4.8x10^{-7}$	$2.1x10^{-4}$	$1.1x10^{-7}$
S4-1	Control element misadjustment before insert	$1.0x10^{-4}$ to $1.0x10^{-6}$	E	$4.3x10^{-4}$	$2.2x10^{-7}$	$6.7x10^{-5}$	$3.4x10^{-8}$
AR-1	Uncontrolled addition of reactivity	$<1.0x10^{-6}$	N,E	$1.5x10^{-3}$	$7.4x10^{-7}$	$2.1x10^{-4}$	$1.1x10^{-7}$
AR-2	Rupture of waterlogged fuel element	$1.0x10^{-1}$ to $1.0x10^{-2}$	N,E	$2.7x10^{-4}$	$1.3x10^{-7}$	$5.3x10^{-5}$	$2.7x10^{-8}$

Table F.2–21. Technical Area-V Radiological Accident Frequencies and Consequences to Core Receptor Locations (continued)

Accident ID[a]	Accident Scenario Description	Accident Frequency (per year)	Applicable Alternative[b]	Dose (rem)	Increased Probability of Latent Cancer Fatality	Dose (rem)	Increased Probability of Latent Cancer Fatality
AR-4	Fire in reactor room with experiment present	$1.0x10^{-4}$ to $1.0x10^{-6}$	N, E	$1.6x10^{-3}$	$8.0x10^{-7}$	$2.2x10^{-4}$	$1.1x10^{-7}$
AR-6	Airplane crash – collapse of bridge crane	$6.3x10^{-6}$	N, E	$1.3x10^{-3}$	$6.5x10^{-7}$	$2.4x10^{-4}$	$1.2x10^{-7}$
				Veterans Affairs Medical Center, Wherry Elementary School, Coronado Club, Child Development Center-East (6.4-7.2 km to NNW)		***Veterans Affairs Medical Center (7.2-8.1 km to NW)***	
AM-1	Airplane crash – collapse of bridge crane	$6.3x10^{-6}$	All	$6.4x10^{-5}$	$3.2x10^{-8}$	$4.9x10^{-5}$	$2.5x10^{-8}$
AM-3	Rupture of waterlogged fuel element	$1.0x10^{-2}$ to $1.0x10^{-4}$	All	$1.6x10^{-5}$	$7.8x10^{-9}$	$1.2x10^{-5}$	$6.0x10^{-9}$
AM-4	Rupture of one molybdenum-99 target	$1.0x10^{-4}$ to $1.0x10^{-6}$	All	$1.2x10^{-5}$	$6.2x10^{-9}$	$9.5x10^{-6}$	$4.7x10^{-9}$
AM-5	Fuel handling accident - irradiated element	$1.0x10^{-4}$ to $1.0x10^{-6}$	All	$1.1x10^{-4}$	$5.7x10^{-8}$	$8.2x10^{-5}$	$4.1x10^{-8}$
AM-6	Airplane crash and fire in reactor room with unirradiated fuel and targets present	$6.3x10^{-6}$	All	$3.2x10^{-8}$	$1.6x10^{-11}$	$2.4x10^{-8}$	$1.2x10^{-11}$
AM-7	Target rupture during Annular Core Research Reactor to Hot Cell Facility transfer	$<1.0x10^{-6}$	All	$1.3x10^{-5}$	$6.5x10^{-9}$	$9.8x10^{-6}$	$4.9x10^{-9}$
HM-1	Operator error – molybdenum-99 target processing	$1.0x10^{-1}$ to $1.0x10^{-2}$	All	$1.2x10^{-6}$	$6.1x10^{-10}$	$9.2x10^{-7}$	$4.6x10^{-10}$
HM-2	Operator error – iodine-125 target processing	$1.0x10^{-1}$ to $1.0x10^{-2}$	All	$4.4x10^{-8}$	$2.2x10^{-11}$	$3.5x10^{-8}$	$1.7x10^{-11}$

Table F.2–21. Technical Area-V Radiological Accident Frequencies and Consequences to Core Receptor Locations (continued)

Accident ID[a]	Accident Scenario Description	Accident Frequency (per year)	Applicable Alternative[b]	Dose (rem)	Increased Probability of Latent Cancer Fatality	Dose (rem)	Increased Probability of Latent Cancer Fatality
HM-4	Fire in steel containment box	1.0×10^{-2} to 1.0×10^{-4}	All	6.0×10^{-5}	3.0×10^{-8}	4.5×10^{-5}	2.2×10^{-8}
HS-1	Fire in room 108, average inventories	3.3×10^{-5}	All	4.2×10^{-5}	2.1×10^{-8}	3.2×10^{-5}	1.6×10^{-8}
HS-2	Fire in room 108, maximum inventories	2.0×10^{-7}	All	1.5×10^{-3}	7.7×10^{-7}	1.2×10^{-3}	5.9×10^{-7}
S3M-2	Control element misadjustment before insert	1.0×10^{-4} to 1.0×10^{-6}	All	2.9×10^{-5}	1.5×10^{-8}	2.1×10^{-5}	1.0×10^{-8}
S3M-3	Failure of a fissionable experiment	1.0×10^{-4} to 1.0×10^{-6}	All	1.5×10^{-4}	7.6×10^{-8}	1.1×10^{-4}	5.4×10^{-8}
SS-1	Airplane crash into North Vault storage vault	6.3×10^{-6}	All	1.8×10^{-4}	8.9×10^{-8}	1.4×10^{-4}	6.8×10^{-8}
S4-1	Control element misadjustment before insert	1.0×10^{-4} to 1.0×10^{-6}	E	5.5×10^{-5}	2.7×10^{-8}	3.9×10^{-5}	2.0×10^{-8}
AR-1	Uncontrolled addition of reactivity	$<1.0 \times 10^{-6}$	N, E	1.7×10^{-4}	8.6×10^{-8}	1.2×10^{-4}	6.2×10^{-8}
AR-2	Rupture of waterlogged fuel element	1.0×10^{-1} to 1.0×10^{-2}	N, E	4.4×10^{-5}	2.2×10^{-8}	3.2×10^{-5}	1.6×10^{-8}
AR-4	Fire in reactor room with experiment present	1.0×10^{-4} to 1.0×10^{-6}	N, E	1.8×10^{-4}	8.9×10^{-8}	1.3×10^{-4}	6.5×10^{-8}
AR-6	Airplane crash – collapse of bridge crane	6.3×10^{-6}	N, E	1.9×10^{-4}	9.7×10^{-8}	1.4×10^{-4}	7.1×10^{-8}
				Kirtland Elementary School, Child Development Center-West (8.1-12.1 km to NW)		***Riding Stables (1.6-2.4 km to NE)***	
AM-1	Airplane crash – collapse of bridge crane	6.3×10^{-6}	All	3.0×10^{-5}	1.5×10^{-8}	4.7×10^{-4}	2.4×10^{-7}
AM-3	Rupture of waterlogged fuel element	1.0×10^{-2} to 1.0×10^{-4}	All	7.3×10^{-6}	3.7×10^{-9}	1.0×10^{-4}	5.2×10^{-8}

Table F.2–21. Technical Area-V Radiological Accident Frequencies and Consequences to Core Receptor Locations (continued)

Accident ID[a]	Accident Scenario Description	Accident Frequency (per year)	Applicable Alternative[b]	Dose (rem)	Increased Probability of Latent Cancer Fatality	Dose (rem)	Increased Probability of Latent Cancer Fatality
AM-4	Rupture of one molybdenum-99 target	$1.0x10^{-4}$ to $1.0x10^{-6}$	All	$5.8x10^{-6}$	$2.9x10^{-9}$	$8.2x10^{-5}$	$4.1x10^{-8}$
AM-5	Fuel handling accident - irradiated element	$1.0x10^{-4}$ to $1.0x10^{-6}$	All	$4.7x10^{9}$	$2.4x10^{6}$	$1.2x10^{-3}$	$5.8x10^{-7}$
AM-6	Airplane crash and fire in reactor room with unirradiated fuel and targets present	$6.3x10^{-6}$	All	$1.4x10^{-8}$	$7.1x10^{-12}$	$1.9x10^{-7}$	$9.4x10^{-11}$
AM-7	Target rupture during Annular Core Research Reactor to Hot Cell Facility transfer	$<1.0x10^{-6}$	All	$6.0x10^{-6}$	$3.0x10^{-9}$	$9.4x10^{-5}$	$4.7x10^{-8}$
HM-1	Operator error – molybdenum-99 target processing	$1.0x10^{-1}$ to $1.0x10^{-2}$	All	$6.1x10^{-7}$	$3.0x10^{-10}$	$6.1x10^{-6}$	$3.1x10^{-9}$
HM-2	Operator error - iodine-125 target processing	1.0x10-1 to $1.0x10^{-2}$	All	$2.4x10^{-8}$	$1.2x10^{-11}$	$2.0x10^{-7}$	$9.9x10^{-11}$
HM-4	Fire in glove box	$1.0x10^{-2}$ to $1.0x10^{-4}$	All	$2.6x10^{-5}$	$1.3x10^{-8}$	$4.6x10^{-4}$	$2.3x10^{-7}$
HS-1	Fire in room 108, average inventories	$3.3x10^{-5}$	All	$1.9x10^{-5}$	$9.4x10^{-9}$	$3.4x10^{-4}$	$1.7x10^{-7}$
HS-2	Fire in room 108, maximum inventories	$2.0x10^{-7}$	All	$6.9x10^{-4}$	$3.4x10^{-7}$	$1.3x10^{-2}$	$6.3x10^{-6}$
S3M-2	Control element misadjustment before insert	$1.0x10^{-4}$ to $1.0x10^{-6}$	All	$1.2x10^{-5}$	$6.2x10^{-9}$	$2.7x10^{-5}$	$1.4x10^{-8}$
S3M-3	Failure of a fissionable experiment	$1.0x10^{-4}$ to $1.0x10^{-6}$	All	$6.3x10^{-5}$	$3.2x10^{-8}$	$1.5x10^{-3}$	$7.7x10^{-7}$
SS-1	Airplane crash into North Vault storage vault	$6.3x10^{-6}$	All	$8.0x10^{-5}$	$4.0x10^{-8}$	$1.1x10^{-3}$	$5.3x10^{-7}$
S4-1	Control element misadjustment before insert	$1.0x10^{-4}$ to $1.0x10^{-6}$	E	$2.3x10^{-5}$	$1.1x10^{-8}$	$5.1x10^{-4}$	$2.5x10^{-7}$

Table F.2–21. Technical Area-V Radiological Accident Frequencies and Consequences to Core Receptor Locations (continued)

Accident ID[a]	Accident Scenario Description	Accident Frequency (per year)	Applicable Alternative[b]	Dose (rem)	Increased Probability of Latent Cancer Fatality	Dose (rem)	Increased Probability of Latent Cancer Fatality
AR-1	Uncontrolled addition of reactivity	$<1.0x10^{-6}$	N, E	$7.0x10^{-5}$	$3.5x10^{-8}$	$1.8x10^{-3}$	$8.8x10^{-7}$
AR-2	Rupture of waterlogged fuel element	$1.0x10^{-1}$ to $1.0x10^{-2}$	N, E	$1.9x10^{-5}$	$9.3x10^{-9}$	$3.3x10^{-4}$	$1.7x10^{-7}$
AR-4	Fire in reactor room with experiment present	$1.0x10^{-4}$ to $1.0x10^{-6}$	N, E	$7.5x10^{-5}$	$3.8x10^{-8}$	$1.9x10^{-3}$	$9.7x10^{-7}$
AR-6	Airplane crash – collapse of bridge crane	$6.3x10^{-6}$	N, E	$8.2x10^{-5}$	$4.1x10^{-8}$	$1.6x10^{-3}$	$8.1x10^{-7}$
				Sandia Base Elementary School (6.4-7.2 km to N)		***Lovelace Hospital (7.2-8.1 km to NNW)***	
AM-1	Airplane crash – collapse of bridge crane	$6.3x10^{-6}$	All	$7.5x10^{-5}$	$3.8x10^{-8}$	$5.4x10^{-5}$	$2.7x10^{-8}$
AM-3	Rupture of waterlogged fuel element	$1.0x10^{-2}$ to $1.0x10^{-4}$	All	$1.8x10^{-5}$	$9.1x10^{-9}$	$1.3x10^{-5}$	$6.6x10^{-9}$
AM-4	Rupture of one molybdenum-99 target	$1.0x10^{-4}$ to $1.0x10^{-6}$	All	$1.5x10^{-5}$	$7.3x10^{-9}$	$1.0x10^{-5}$	$5.2x10^{-9}$
AM-5	Fuel handling accident - irradiated element	$1.0x10^{-4}$ to $1.0x10^{-6}$	All	$1.3x10^{-4}$	$6.4x10^{-8}$	$9.2x10^{-5}$	$4.6x10^{-8}$
AM-6	Airplane crash and fire in reactor room with unirradiated fuel and targets present	$6.3x10^{-6}$	All	$3.7x10^{-8}$	$1.8x10^{-11}$	$2.6x10^{-8}$	$1.3x10^{-11}$
AM-7	Target rupture during Annular Core Research Reactor to Hot Cell Facility transfer	$<1.0x10^{-6}$	All	$1.5x10^{-5}$	$7.6x10^{-9}$	$1.1x10^{-5}$	$5.4x10^{-9}$
HM-1	Operator error – molybdenum-99 target processing	$1.0x10^{-1}$ to $1.0x10^{-2}$	All	$1.4x10^{-6}$	$6.9x10^{-10}$	$1.0x10^{-6}$	$5.2x10^{-10}$

Table F.2–21. Technical Area-V Radiological Accident Frequencies and Consequences to Core Receptor Locations (concluded)

Accident ID[a]	Accident Scenario Description	Accident Frequency (per year)	Applicable Alternative[b]	Dose (rem)	Increased Probability of Latent Cancer Fatality	Dose (rem)	Increased Probability of Latent Cancer Fatality
HM-2	Operator error - iodine-125 target processing	$1.0x10^{-1}$ to $1.0x10^{-2}$	All	$5.1x10^{-8}$	$2.5x10^{-11}$	$3.9x10^{-8}$	$1.9x10^{-11}$
HM-4	Fire in steel containment box	$1.0x10^{-2}$ to $1.0x10^{-4}$	All	$6.8x10^{-5}$	$3.4x10^{-8}$	$4.9x10^{-5}$	$2.5x10^{-8}$
HS-1	Fire in room 108, average inventories	$3.3x10^{-5}$	All	$4.9x10^{-5}$	$2.4x10^{-8}$	$3.4x10^{-5}$	$1.7x10^{-8}$
HS-2	Fire in room 108, maximum inventories	$2.0x10^{-7}$	All	$1.8x10^{-3}$	$8.9x10^{-7}$	$1.3x10^{-3}$	$6.3x10^{-7}$
S3M-2	Control element misadjustment before insert	$1.0x10^{-4}$ to $1.0x10^{-6}$	All	$3.3x10^{-5}$	$1.6x10^{-8}$	$2.4x10^{-5}$	$1.2x10^{-8}$
S3M-3	Failure of a fissionable experiment	$1.0x10^{-4}$ to $1.0x10^{-6}$	All	$1.7x10^{-4}$	$8.4x10^{-8}$	$1.2x10^{-4}$	$6.2x10^{-8}$
SS-1	Airplane crash into North Vault storage vault	$6.3x10^{-6}$	All	$2.1x10^{-4}$	$1.0x10^{-7}$	$1.5x10^{-4}$	$7.4x10^{-8}$
S4-1	Control element misadjustment before insert	$1.0x10^{-4}$ to $1.0x10^{-6}$	E	$6.1x10^{-5}$	$3.0x10^{-8}$	$4.5x10^{-5}$	$2.2x10^{-8}$
AR-1	Uncontrolled addition of reactivity	$<1.0x10^{-6}$	N, E	$1.9x10^{-4}$	$9.6x10^{-8}$	$1.4x10^{-4}$	$7.0x10^{-8}$
AR-2	Rupture of waterlogged fuel element	$1.0x10^{-1}$ to $1.0x10^{-2}$	N, E	$5.0x10^{-5}$	$2.5x10^{-8}$	$3.6x10^{-5}$	$1.8x10^{-8}$
AR-4	Fire in reactor room with experiment present	$1.0x10^{-4}$ to $1.0x10^{-6}$	N, E	$2.0x10^{-4}$	$1.0x10^{-7}$	$1.4x10^{-4}$	$7.1x10^{-8}$
AR-6	Airplane crash - collapse of bridge crane	$6.3x10^{-6}$	N, E	$2.2x10^{-4}$	$1.1x10^{-7}$	$1.6x10^{-4}$	$7.9x10^{-8}$

Source: Original

[a] Technical Area-V Facility Accident Descriptors:
Annular Core Research Reactor-Defense Program Configuration: AR-1, AR-2, AR-4, AR-6
Annular Core Research Reactor-Medical Isotopes Production Configuration: AM-1, AM-2, AM-3, AM-4, AM-5, AM-6, AM-7
Hot Cell Facility: Medical Isotopes Production: HM-1, HM-2, HM-4
Hot Cell Facility: Room 108 Storage: HS-1, HS-2
Sandia Pulsed Reactor: S3M-2, S3M-3, S4-1, SS-1

[b] Applicable Alternative:
All–Scenario applicable to all three alternatives
N–Scenario applicable to No Action Alternative
E–Scenario applicable to Expanded Operations Alternative

Table F.2–22. Manzano Waste Storage Facilities Radiological Accident Frequencies and Consequences to the Maximally Exposed Individual and Noninvolved Worker

Accident ID[a]	Accident Scenario Description	Accident Frequency (per year)	Applicable Alternative[b]	Maximally Exposed Individual		Noninvolved Worker	
				Dose (rem)	Increased Probability of Latent Cancer Fatality	Dose (rem)	Increased Probability of Latent Cancer Fatality
MZ-1	Waste package fire	$1.0x10^{-2}$ to $1.0x10^{-4}$	All	$4.9x10^{-4}$	$2.5x10^{-7}$	$3.2x10^{-1}$	$1.3x10^{-4}$

Source: Original
[a] Manzano Waste Storage Facilities Accident Descriptor: MZ-1
[b] Applicable Alternative:
All–Scenario is applicable to all three alternatives

Table F.2–23. Manzano Waste Storage Facilities Accident Frequencies and Consequences to 50-Mile Population

Accident ID[a]	Accident Scenario Descriptions	Accident Frequency (per year)	Applicable Alternative[b]	Dose (person-rem)	Additional Latent Cancer Fatality
MZ-1	Waste Package Fire	$1.0x10^{-2}$ to $1.0x10^{-4}$	All	3.7	$1.8x10^{-3}$

Source: Original
[a] Manzano Waste Storage Facilities Accident Descriptor: MZ-1
[b] Applicable Alternative:
All–Scenario is applicable to all three alternatives

Table F.2–24. Manzano Waste Storage Facilities Radiological Accident Frequencies and Consequences to Core Receptors

Accident ID[a]	Accident Scenario Description	Accident Frequency (per year)	Applicable Alternative[b]	Dose (rem)	Increased Probability of Latent Cancer Fatality	Dose (rem)	Increased Probability of Latent Cancer Fatality
MZ-1	Waste Package Fire	1.0×10^{-3}	All	*Riding Stables (0.8-1.6 km to WNW)*		*Golf Course (1.6-2.4 km to NW)*	
				4.9×10^{-4}	2.5×10^{-7}	3.1×10^{-4}	1.6×10^{-7}
				Golf Course (2.4-3.2 km to WNW)		*Kirtland Underground Munitions and Maintenance Storage Complex (4.0-4.8 km to W)*	
				1.4×10^{-4}	7.1×10^{-8}	9.1×10^{-5}	4.5×10^{-8}
				National Atomic Museum, Base Housing (6.4-7.2 km to NW)		*Sandia Base Elementary School, Wherry Elementary School, Coronado Club, Child Development Center-East, Shandiin Day Care Center (7.2-8.1 km to NW)*	
				4.4×10^{-5}	2.2×10^{-8}	3.6×10^{-5}	1.8×10^{-8}
				Sandia Base Elementary School (7.2-8.1 km to NNW)		*Kirtland Elementary School (8.1-12.1km to WNW)*	
				3.9×10^{-5}	2.0×10^{-8}	1.7×10^{-5}	8.5×10^{-9}
				Veterans Affairs Medical Center, Lovelace Hospital, Child Development Center-West (8.1-12.1 km to NW)			
				2.1×10^{-5}	1.1×10^{-8}		

Source: Original
[a] Manzano Waste Storage Facilities Accident Descriptor: MZ-1
[b] Applicable Alternative:
All–Scenario is applicable to all three alternatives

F.3 CHEMICAL ACCIDENTS

F.3.1 Introduction

The purpose of this section is to document the evaluation of the potential hazards from the accidental release of chemicals present at SNL/NM. The section discusses the potential impacts from catastrophic releases of chemicals to the environment and the potential impacts from small spills that could affect only a few involved workers within the area of the spill. There are more than 1,300 individual chemicals presently being used at SNL/NM in quantities ranging from a few milligrams to tanks containing upwards of 10,000 gal. For this evaluation, it is important to identify not only the "worst" hazardous or toxic chemical, but also that chemical's volatility and affected inventory.

F.3.2 Screening For Hazardous Chemicals

To assess the impacts of the "worst" hazardous or toxic chemicals, an existing screening tool was modified to account for the volume of the chemicals involved. The screening tool is based on the Vapor Hazard Ratio (VHR) (Restrepo 1993). The VHR is the equilibrium vapor pressure (in ppm) divided by the acceptable concentration (ppm). Because the VHR can range over several orders of magnitude, the Vapor Hazard Index (VHI) was developed, which is the logarithm of VHR and is used to identify and rank chemicals by their inherent properties. The VHI is calculated by using the following formula:

$$VHI = \log(VHR) = \log[(VP*1.0x10^{6})/(\text{acceptable concentration}*760\ \text{mmHg})]$$

(Eq. F.3–1)

Where: VP = vapor pressure in millimeters of mercury at standard temperature and pressure, acceptable concentration is in parts per million (ppm), and mmHg = millimeters of mercury.

The SWEIS uses the ERPG Level-2 (ERPG-2) as the acceptable concentration limit (AIHA 1997). The DOE and the U.S. Environmental Protection Agency (EPA) have accepted in the Risk Management Program Rule (40 Code of Federal Regulations (CFR) §68.112) that ERPG-2 limits would be the acceptable limits in emergency planning.

In order to include the effect of volume in the determination of the "worst" chemical, the screening methodology developed an additional index called the Risk Hazard Index (RHI), which is the log of VHR times the affected inventory. This reduces to the following equation:

$$RHI = \log(VHR * \text{inventory}) = \log(VHR) + \log(\text{inventory}) = VHI + \log(\text{inventory})$$

(Eq. F.3–2)

Where: Inventory is expressed in pounds.

The chemical with the highest RHI within a facility is the chemical that will have the worst potential impacts from an accident during which the entire building inventory is released. Chemicals with lower RHIs would have lesser impacts. The RHI is the tool used in this SWEIS to determine the chemical within a facility with the potential for the highest accident impacts from that facility. This approach assumes a total release of a building's chemical inventory. If smaller disproportionate releases are assumed, the ranking could change. Because the number of release scenarios is very large, the total release scenario was chosen to represent the maximum potential chemical impact.

Planning Guideline

- The ERPG-1 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor.
- The ERPG-2 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action.
- The ERPG-3 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing life threatening health effects.

American Industrial Hygiene Association (AIHA 1997)

Table F.3–1 illustrates this concept. Chlorine, with a higher VHI but only a 1-lb release, has an RHI of 5.5 with an *ALOHA* (NSC 1995) modeled distance of 324 ft to meet the chlorine ERPG-2 level. Methyl iodide, with a smaller VHI of 4.0 but with a 50-lb release, has an RHI of 5.7 and an *ALOHA* modeled distance of 390 ft to meet the methyl iodide ERPG-2 level. For a 1-lb release of methyl iodide, the RHI takes on a value less than the chlorine RHI of 5.5.

The VHI was calculated for a list of almost 190 hazardous/toxic chemicals that could be present at SNL/NM. The list was composed of chemicals from four sources: 1) chemicals that had an approved ERPG-2 level (DOE 1999b), 2) chemicals that the EPA determined should be considered in an accident assessment (40 CFR Part 68.130, Table 2), 3) chemicals that SNL/NM considered as their most hazardous or toxic materials (SNL/NM 1998n, 1999a), and 4) chemicals present at SNL/NM that had a Temporary Emergency Exposure Limit (TEEL)-2 value recommended by the DOE (DOE 1999c).

The vapor pressures were obtained from standard handbooks of chemicals such as the *Handbook of Chemistry and Physics* (Weast 1967) and the National Institute of Occupational Safety and Health (NIOSH) *Pocket Guide to Chemical Hazards* (CDC 1997), from material safety data sheets (UV 1998), and from the DOE (DOE 1999c). For those chemicals that are considered to be gases at room temperature, a value of 760 mm was entered. The ERPG-2 values were determined according to a strict hierarchy. The preferred source was the approved ERPG-2 from the DOE Subcommittee on Consequence Assessment and Protective Actions (DOE-SCAPA) (DOE 1998g). The second-ranked source was a Westinghouse Safety Management Solutions, Inc., document that compiled TEEL-2 levels (DOE 1999c). The third-ranked source was the level of concern from the EPA *Technical Guide of Hazards Analysis, Emergency Planning for Extremely Hazardous Substances* (EPA 1987). The fourth-ranked source used was one-tenth of the "Immediately Dangerous to Life and Health" (IDLH) guideline, as presented in the NIOSH document (CDC 1997). The fifth-ranked source used was the time-weighted average (TWA) times 5 (CDC 1997). If the referenced document contained a value, but the units were mg/m^3, the following equation was used to convert to ppm:

$$\text{ERPG-2 in ppm} = (24.5/\text{M.W.}) * C \quad \text{(Eq. F.3–3)}$$

Where: M.W. = molecular weight in grams, and
C = concentration in mg/m^3.

Table F.3–2 identifies the list of chemicals considered, sources for including the chemical, vapor pressure, ERPG-2, and VHI. For some chemicals, the VHI is listed as <10 mmHg vapor pressure, which is the lower limit for application of the VHI/RHI screening. Any chemical having a vapor pressure less than 10 mmHg will not be volatile enough to release any significant fraction of its inventory into the atmosphere. A "not calculated" indicates that vapor pressure for that chemical or ERPG-2 could not be found. Therefore, any chemical with either notation was not included in the screening.

There are four possible separate and distinct sources of chemical inventories identified by building and location at SNL/NM. The first, CheMaster (SNL/NM 1996n), is an

Table F.3–1. Example Comparisons of RHI Values from Chlorine and Methyl Iodide Releases

CHEMICAL	VAPOR PRESSURE (mmHg)	ERPG-2 (ppm)	VHI	WEIGHT (pounds)	RHI	DISTANCE TO MEET ERPG-2 LEVEL (ft)
Chlorine	760	3	5.52	1	5.5	324
				10	6.5	1,074
Methyl Iodide	400	50	4.02	1	4.0	48
				50	5.7	390

Source: Original
ERPG-2: Emergency Response Planning Guideline Level 2
ft: feet
mmHg: millimeters of mercury
ppm: parts per million
RHI: Risk Hazard Index
VHI: Vapor Hazard Index

Table F.3–2. List of Screening Chemicals and their Properties

SOURCE(S) OF CHEMICAL LISTING	CHEMICAL	VAPOR PRESSURE (mmHg)	ERPG-2 OR TEEL-2 (ppm)	VAPOR HAZARD INDEX
DOE-SCAPA	Acetaldehyde	740	200	3.69
SNL/NM	Acetic Acid	11.40	35	2.63
SNL/NM	Acetone	180	8,500	1.45
DOE-SCAPA, 40 CFR §68.130, SNL/NM	Acrolein	220.4	0.5	5.76
DOE-SCAPA	Acrylic Acid	3	50	<10 mmHg Vapor Pressure
DOE-SCAPA, 40 CFR §68.130, SNL/NM	Acrylonitrile	83.6	35	3.50
40 CFR §68.130, SNL/NM	Acrylyl Chloride	300	0.24	6.21
SNL/NM	Aluminum Oxide Anhydrous	0	15	<10 mmHg Vapor Pressure
40 CFR §68.130	Allyl Alcohol	19	15	3.22
40 CFR §68.130, SNL/NM	Allylamine	500	1.37	5.68
DOE-SCAPA	Allyl Chloride	298.68	40	3.99
DOE-SCAPA, 40 CFR §68.130 SNL/NM	Ammonia	760	200	3.70
SNL/NM	Ammonium Fluoride	0	12.5	<10 mmHg Vapor Pressure
SNL/NM	Ammonium Hydrogen Difluoride	N.F.	12.5	Not Calculated
DOE-SCAPA, 40 CFR §68.130, SNL/NM	Ammonium Hydroxide (<25%)	6.87	200	<10 mmHg Vapor Pressure
DOE-SCAPA, 40 CFR §68.130, SNL/NM	Ammonium Hydroxide (>25%)	23.84	200	2.20
SNL/NM	Antimony Pentafluoride	10.108	0.31	4.64
40 CFR §68.130	Arsenous Trichloride	8.892	0.5	<10 mmHg Vapor Pressure
40 CFR §68.130, SNL/NM	Arsine	760	0.5	6.3
DOE-SCAPA	Benzene	76	150	2.82
DOE-SCAPA	Benzyl Chloride	0.912	10	<10 mmHg Vapor Pressure
DOE-SCAPA	Beryllium	0	0.68	<10 mmHg Vapor Pressure
40 CFR §68.130, SNL/NM	Boron Trichloride	760	2.09	5.68
40 CFR §68.130, SNL/NM	Boron Trifluoride	760	2.5	5.60

Table F.3–2. List of Screening Chemicals and their Properties (continued)

SOURCE(S) OF CHEMICAL LISTING	CHEMICAL	VAPOR PRESSURE (mmHg)	ERPG-2 OR TEEL-2 (ppm)	VAPOR HAZARD INDEX
***DOE-SCAPA*, 40 CFR §68.130 SNL/NM**	Bromine	172	1	5.35
DOE-SCAPA	1,3 Butadiene	760	200	3.70
SNL/NM	N-Butyl Acetate	3.20	50	<10 mmHg Vapor Pressure
DOE-SCAPA	N-Butyl Acrylate	3.268	25	<10 mmHg Vapor Pressure
DOE-SCAPA	N-Butyl Isocyanate	N.F.	0.05	Not Calculated
***DOE-SCAPA*, 40 CFR §68.130, SNL/NM**	Carbon Disulfide	364.8	50	3.98
DOE-SCAPA	Carbon Monoxide	760	350	3.46
DOE-SCAPA	Carbon Tetrachloride	92.72	100	3.09
SNL/NM	Carbon Tetrafluoride	760	N.F.	Not Calculated
***DOE-SCAPA*, SNL/NM**	Chlorine	760	3	5.52
40 CFR §68.130	Chlorine Dioxide	760	0.5	6.30
DOE-SCAPA	Chlorine Trifluoride	760	1	6.00
DOE-SCAPA	1-Chloro-1, 1-Difluoroethane	760	15,000	1.82
DOE-SCAPA	Chloroacetyl Chloride	19	1	4.40
40 CFR §68.130	Chloroform	161.12	50	3.63
40 CFR §68.130, SNL/NM	Chloromethyl Ether	30	0.05	5.87
40 CFR §68.130, SNL/NM	Chloromethyl Methyl Ether	192.28	0.55	5.66
DOE-SCAPA	Chloropicrin	18	0.2	5.07
DOE-SCAPA	Chlorosulfonic Acid	1	2.1	<10mm Hg Vapor Pressure
DOE-SCAPA	Chlorotrifluroethylene	760	100	4.00
***DOE-SCAPA*, 40 CFR §68.130**	Crotonaldehyde	19	10	3.40
40 CFR §68.130	Crotonaldehyde, (E)-[2]Butenal	36	13.98	3.53
DOE-SCAPA	Cyanogen Chloride	760	0.4	6.40
SNL/NM	Cyanuric Fluoride	135	0.03	6.76
SNL/NM	Cyclohexane	100	1,300	2.01
40 CFR §68.130	Cyclohexylamine	9.12	50	<10 mmHg Vapor Pressure

Table F.3–2. List of Screening Chemicals and their Properties (continued)

SOURCE(S) OF CHEMICAL LISTING	CHEMICAL	VAPOR PRESSURE (mmHg)	ERPG-2 OR TEEL-2 (ppm)	VAPOR HAZARD INDEX
DOE-SCAPA*, 40 CFR §68.130, *SNL/NM	Diborane	760	1	6
SNL/NM	Dibromotetrafluoroethane	N.F.	N.F.	Not Calculated
SNL/NM	Dibutyl Phthalate	0.01	25	<10 mmHg Vapor Pressure
SNL/NM	Dichlorodifluoromethane	760	1,500	2.82
DOE-SCAPA	Diketene	10	5	3.42
DOE-SCAPA	Dimethylamine	760	100	4.00
***DOE-SCAPA*, 40 CFR §68.130**	Dimethyldichlorosilane	139	5	4.56
SNL/NM	Dimethyl Sulfate	4.94	0.7	<10 mmHg Vapor Pressure
DOE-SCAPA	Dimethyl Disulfide	28.6	50	2.88
DOE-SCAPA	N,N-Dimethylformamide Anhydrous	3	100	<10 mmHg Vapor Pressure
40 CFR §68.130	1,1-Dimethylhydrazine	157	5	4.62
DOE-SCAPA	Dimethyl Sulfide	520	500	3.14
SNL/NM	Dioxathion	0.01	0.18	<10 mmHg Vapor Pressure
SNL/NM	Disilane	760	25	4.60
***DOE-SCAPA*, 40 CFR §68.130**	Epichlorohydrin	12.16	20	2.90
SNL/NM	2-Ethoxyethyl Acetate	1.20	15	<10 mmHg Vapor Pressure
SNL/NM	Ethyl Alcohol	43.00	3,300	1.23
SNL/NM	Ethyl Silicate	1.00	50	<10 mmHg Vapor Pressure
SNL/NM	Ethylene Dichloride	64.00	50	3.23
SNL/NM	Ethylene Glycol	0.05	40	<10 mmHg Vapor Pressure
40 CFR §68.130	Ethylenediamine	11	10	3.16
40 CFR §68.130	Ethyleneimine	160	2.3	4.96
SNL/NM	Ethylene Fluorohydrin	50	0.03	6.39
DOE-SCAPA*, 40 CFR §68.130, *SNL/NM	Ethylene Oxide	760	50	4.30
***DOE-SCAPA*, 40 CFR §68.130**	Fluorine	760	5	5.30
***DOE-SCAPA*, 40 CFR §68.130**	Formaldehyde	760	10	5

Table F.3–2. List of Screening Chemicals and their Properties (continued)

SOURCE(S) OF CHEMICAL LISTING	CHEMICAL	VAPOR PRESSURE (mmHg)	ERPG-2 OR TEEL-2 (ppm)	VAPOR HAZARD INDEX
40 CFR §68.130, SNL/NM	Furan	700	0.43	6.33
DOE-SCAPA	Furfural	1.0944	10	<10 mmHg Vapor Pressure
SNL/NM	Gallium Trichloride	0.2	4.45	<10 mmHg Vapor Pressure
SNL/NM	Glycerin	0	50	<10 mmHg Vapor Pressure
DOE-SCAPA	Hexachlorobutadiene	0.2	10	<10 mmHg Vapor Pressure
DOE-SCAPA	Hexafluoroacetone And Hydrates	760	1	6
DOE-SCAPA	Hexafluoropropylene	760	50	4.30
SNL/NM	N-Hexane	100	250	2.72
40 CFR §68.130	Hydrazine	10.64	0.80	4.24
DOE-SCAPA, 40 CFR §68.130, SNL/NM	Hydrochloric Acid (< 28%)	4.9	20	<10 mmHg Vapor Pressure
DOE-SCAPA, 40 CFR §68.130, SNL/NM	Hydrochloric Acid (> 28%)	131	20	3.94
DOE-SCAPA, 40 CFR §68.130, SNL/NM	Hydrofluoric Acid	0	20	<10 mmHg Vapor Pressure
DOE-SCAPA, 40 CFR §68.130, SNL/NM	Hydrogen Chloride	760	20	4.70
DOE-SCAPA, 40 CFR §68.130, SNL/NM	Hydrogen Cyanide	760	10	5
DOE-SCAPA, 40 CFR §68.130, SNL/NM	Hydrogen Fluoride	760	20	4.70
DOE-SCAPA	Hydrogen Peroxide	5	50	<10 mmHg Vapor Pressure
40 CFR §68.130, SNL/NM	Hydrogen Selenide	760	0.20	6.70
DOE-SCAPA, 40 CFR §68.130, SNL/NM	Hydrogen Sulfide	760	30	4.52
DOE-SCAPA	Iodine	0.304	0.5	<10 mmHg Vapor Pressure
40 CFR §68.130, SNL/NM	Iron, Pentacarbonyl	35.72	0.1	5.67
DOE-SCAPA, 40 CFR §68.130	Isobutyronitrile	100	50	3.42
DOE-SCAPA	2-Isocyanatoethyl Methacrylate	80	0.1	6.02

Table F.3–2. List of Screening Chemicals and their Properties (continued)

SOURCE(S) OF CHEMICAL LISTING	CHEMICAL	VAPOR PRESSURE (mmHg)	ERPG-2 OR TEEL-2 (ppm)	VAPOR HAZARD INDEX
SNL/NM	Isophorone Diisocyanate	0.0003	0.14	<10 mmHg Vapor Pressure
SNL/NM	Isopropyl Alcohol	33	400	2.04
40 CFR §68.130	Isopropyl Chloroformate	50	19.98	3.52
DOE-SCAPA	Lithium Hydride	0	0.31	<10 mmHg Vapor Pressure
40 CFR §68.130	Methacrylonitrile	90	1.1	5.03
DOE-SCAPA	Methanol	93.48	1,000	2.09
DOE-SCAPA, SNL/NM	Methyl Bromide	760	50	4.30
DOE-SCAPA, 40 CFR §68.130	Methyl Chloride	760	400	3.40
40 CFR §68.130	Methyl Chloroformate	210	0.47	5.77
40 CFR §68.130	Methyl Hydrazine	49.6	2	4.51
DOE-SCAPA	Methyl Iodide	400	50	4.02
DOE-SCAPA, 40 CFR §68.130, SNL/NM	Methyl Isocyanate	352.64	0.5	5.97
SNL/NM	Methyl Isothiocyanate	15	0.3	4.82
DOE-SCAPA, 40 CFR §68.130	Methyl Mercaptan	760	25	4.60
DOE-SCAPA, SNL/NM	Methylene Chloride	360.24	750	2.80
DOE-SCAPA, 40 CFR §68.130, SNL/NM	Methyltrichlorosilane	136.04	3	4.78
40 CFR §68.130	Methyltricyanate	20	28.53	2.96
DOE-SCAPA	Methylene Diphenyl Diisocyanate	0.001	0.2	<10 mmHg Vapor Pressure
DOE-SCAPA, SNL/NM	Monomethylamine	760	100	4.00
SNL/NM	Naphtha	1	1,000	<10 mmHg Vapor Pressure
40 CFR §68.130, SNL/NM	Nickel Carbonyl	400	0.05	7.02
40 CFR §68.130, SNL/NM	Nitric Acid (</= 80%)	8	15	<10 mmHg Vapor Pressure
40 CFR §68.130, SNL/NM	Nitric Acid (> 80%)	20	15	3.24
40 CFR §68.130, SNL/NM	Nitric Oxide	760	25	4.60
40 CFR §68.130, SNL/NM	Nitrous Oxide	760	125	3.90
40 CFR §68.130, SNL/NM	Nitrogen Dioxide	760	5.01	5.30
SNL/NM	Osmium Tetroxide	11	0.01	6.18

Table F.3–2. List of Screening Chemicals and their Properties (continued)

SOURCE(S) OF CHEMICAL LISTING	CHEMICAL	VAPOR PRESSURE (mmHg)	ERPG-2 OR TEEL-2 (ppm)	VAPOR HAZARD INDEX
SNL/NM	Ozone	760	0.5	6.30
40 CFR §68.130	Peracetic Acid	60	1.45	4.74
DOE-SCAPA	Perchloroethylene	14.44	200	1.98
40 CFR §68.130	Perchloromethylmercaptan	3.04	1	<10 mmHg Vapor Pressure
DOE-SCAPA, SNL/NM	Perfluoroisobutylene	760	0.10	7.00
DOE-SCAPA, SNL/NM	Phenol	0.3572	50	<10 mmHg Vapor Pressure
DOE-SCAPA, 40 CFR §68.130, SNL/NM	Phosgene	760	0.2	6.70
DOE-SCAPA, 40 CFR §68.130, SNL/NM	Phosphine	760	0.5	6.30
SNL/NM	Phosphoric Acid	0.03	500	<10 mmHg Vapor Pressure
40 CFR §68.130, SNL/NM	Phosphorus Oxychloride	40	0.48	5.04
40 CFR §68.130, SNL/NM	Phosphorus Trichloride	135	2.5	4.85
DOE-SCAPA	Phosphorus Pentoxide	0.00001	4.32	<10 mmHg Vapor Pressure
40 CFR §68.130	Piperidine	40.28	6.34	3.92
40 CFR §68.130	Propionitrile	39.52	1.65	4.50
SNL/NM	1,2-Propanediol	0.08	75	<10 mmHg Vapor Pressure
SNL/NM	N-Propyl Alcohol	10	250	1.72
40 CFR §68.130	Propyl Chloroformate	24	1.99	4.20
40 CFR §68.130	Propyleneimine	112	51.5	3.46
DOE-SCAPA, 40 CFR §68.130	Propylene Oxide	445	250	3.37
SNL/NM	Pyrene	0.00001	0.21	<10 mmHg Vapor Pressure
SNL/NM	Sarin	2.9	0.01	<10 mmHg Vapor Pressure
SNL/NM	Silane	760	25	4.60
SNL/NM	A-187 Silane	N.F.	25	Not Calculated
SNL/NM	A-1100 Silane	N.F.	25	Not Calculated
SNL/NM	A-1120 Silane	N.F.	25	Not Calculated
SNL/NM	Y-9492 Silane	N.F.	25	Not Calculated

Table F.3–2. List of Screening Chemicals and their Properties (continued)

SOURCE(S) OF CHEMICAL LISTING	CHEMICAL	VAPOR PRESSURE (mmHg)	ERPG-2 OR TEEL-2 (ppm)	VAPOR HAZARD INDEX
SNL/NM	Dow Corning Z-6070 Silane	N.F.	25	Not Calculated
SNL/NM	Dow Corning Z-6020 Silane	N.F.	25	Not Calculated
SNL/NM	Dow Corning Z-6032 Silane	N.F.	25	Not Calculated
SNL/NM	Dow Corning Z-6040 Silane	N.F.	25	Not Calculated
SNL/NM	Silicon Tetrafluoride	760	0	<10 mmHg Vapor Pressure
SNL/NM	Sodium Hydroxide	0.988	0.61	<10 mmHg Vapor Pressure
DOE-SCAPA	Styrene	5.46	250	<10 mmHg Vapor Pressure
DOE-SCAPA, 40 CFR §68.130, SNL/NM	Sulfur Dioxide	760	3	5.52
DOE-SCAPA, SNL/NM	Sulfuric Acid	1	10	<10 mmHg Vapor Pressure
SNL/NM	Sulfur Hexafluoride	760	N.F.	Not Calculated
40 CFR §68.130	Sulfur Tetrafluoride	760	2.09	5.68
DOE-SCAPA, 40 CFR §68.130	Sulfur Trioxide	433	3.06	5.27
SNL/NM	Tellurium Hexafluoride	760	1	6
SNL/NM	Tetraethyl Telluride	N.F.	0.00	Not Calculated
DOE-SCAPA	Tetrafluoroethylene	760	1,000	3.00
DOE-SCAPA	Tetramethoxysilane	12	10	3.20
40 CFR §68.130, SNL/NM	Tetramethyl Lead	23.4	0.37	4.92
40 CFR §68.130, SNL/NM	Tetranitromethane	8	1	<10 mmHg Vapor Pressure
SNL/NM	Thionyl Chloride	100	5	4.42
DOE-SCAPA, 40 CFR §68.130	Titanium Tetrachloride	9.88	2.58	<10 mmHg Vapor Pressure
DOE-SCAPA	Toluene	22.91	300	2.00
40 CFR §68.130, SNL/NM	Tolyene 2,4-Diisocyanate	0.05	1	<10 mmHg Vapor Pressure
40 CFR §68.130	Tolyene 2,6-Diisocyanate	0.05	0.13	<10 mmHg Vapor Pressure
40 CFR §68.130	Tolyene Diisocyanate	1	1	<10 mmHg Vapor Pressure
SNL/NM	Trans-1,4-Dichlorobutene	6	0.03	<10 mmHg Vapor Pressure

Table F.3–2. List of Screening Chemicals and their Properties (concluded)

SOURCE(S) OF CHEMICAL LISTING	CHEMICAL	VAPOR PRESSURE (mmHg)	ERPG-2 OR TEEL-2 (ppm)	VAPOR HAZARD INDEX
SNL/NM	Chloromethyltrichlorosilane	30	0.04	5.99
DOE-SCAPA	1, 1, 1-trichloroethane	100	700	2.27
DOE-SCAPA	Trichloroethylene	59.28	500	2.19
DOE-SCAPA	Trichlorosilane	522.6	3	5.36
SNL/NM	Triethoxysilane	23	0.75	4.61
DOE-SCAPA	Trimethoxysilane	N.F.	2	Not Calculated
DOE-SCAPA	Trimethylamine	760	100	4.00
40 CFR §68.130	Trimethylchlorosilane	71	11.27	3.92
DOE-SCAPA	Uranium Hexafluoride	107.92	1.04	5.13
SNL/NM	Vanadium Pentoxide	0.0000001	4.71	<10 mmHg Vapor Pressure
DOE-SCAPA, 40 CFR §68.130	Vinyl Acetate	88.92	75	3.19
SNL/NM	Vinyl Chloride	760	75	4.12
SNL/NM	Xylene	7.90	200	<10 mmHg Vapor Pressure

Sources: 40 CFR §68.130; CDC 1997; DOE 1998g, 1999b, 1999c; EPA 1987; SNL/NM 1998a, 1999b; Weast 1967; UV 1998
DOE-SCAPA: DOE Subcommittee on Consequence Assessment and Protective Actions
ERPG-2: Emergency Response Planning Guideline Level 2
mmHg: millimeters of mercury
N.F.: not found
ppm: parts per million
TEEL-2: Temporary Emergency Exposure Limit

electronic database supporting SNL/NM source documents that contains chemical inventories by location for three separate buildings (Buildings 828, 858, 897) (SNL/NM 1996n). The second, HAs, which document the impact of release of hazardous materials for emergency planning purposes, were available for eight referenced facilities and identified the "worst" several chemicals for each facility (SNL/NM 1995i [Building 823], SNL 1994c [Building 878], SNL 1995d [Building 880], SNL 1995f [Building 883], SNL/NM 1994f [Building 884], SNL 1994d [Building 888]). The third source of data is the building profiles. Of the over 30 profiles reviewed, only one, Building 905 (SNL/NM 1996x), provided any information that was in addition to the CheMaster database and HA documents. The fourth source of data is the SNL/NM responses to questions about the Microsystems and Engineering Sciences Applications (MESA) Complex (SNL/NM 1999b). Quantities of chemicals from all four sources were then converted to pounds to be used in the RHI calculation.

The screening chemicals in Table F.3–2 were compared with the list of chemicals presented in the four sources of data. If a screening chemical was identified in the data sources, the amount of the chemical stored was combined with the VHI to calculate a RHI for that location. The volume of each chemical was accumulated to calculate an RHI for the entire building. The chemicals with the highest RHI values are identified in Table F.3–3. The inventories of the highlighted chemicals in Table F.3–3 were used for the dispersion models for each building.

In only one case, arsine in Building 893, data gained from a facility walk-through and meeting (TtNUS 1998k) were used to lower the building inventory from that shown on the CheMaster system. This was done after consulting with facility representatives to verify that inventories were rarely expected to exceed 65 lb and then verifying actual onsite storage. For those rare instances when the amount of arsine in the building exceeded 65 pounds, the combination of the probability of the instance and the probability of the accident would result in a total accident probability much less than 10^{-6} per year.

Table F.3–3. List of Chemicals and Risk Hazard Indexes by Facility

BUILDING		CHEMICAL NAME	BUILDING INVENTORY	BUILDING INVENTORY	VHI INDEX	RHI INDEX
NAME	NUMBER					
Systems Research and Development	823	***Ammonia***	6,236.4 L	10.4	3.7	4.72
		Carbon Disulfide	7.6 L	0.056	3.98	2.73
		Carbon Monoxide	19,487.9 L	53.6	3.46	5.19
		Hexane	45.1 L	65.2	3.17	4.98
		Hydrogen Sulfide	841 L	2.81	4.52	4.97
		Nitric Acid	13.375 L	43.75	3.62	5.26
		Nitric Oxide	85 L	0.25	4.6	4.00
		Nitrogen Dioxide	22 L	0.93	5.3	5.27
		Nitrous Oxide	7,461 L	32.17	3.9	5.41
		Sulfur Dioxide	85 L	0.53	5.52	5.24
Microelectronics Development Laboratory	858	***Chlorine***	540 ft^3	106.41	5.52	7.55
		Hydrogen Fluoride	0.6 ft^3	0.033	4.7	3.22
		Arsine 15%	62.8 ft^3	2	6	6.30
		Phosphine (Converted to 100%)	51.7 ft^3	4.84	6.3	7.00[a]
		Fluorine 5%	38 ft^3	0.16	5.3	4.50
		Diborane	100 ft^3	7.7	6	6.89
		Silane (Silicon Tetrahydride)	546.4 ft^3	47.1	4.6	6.27

Table F.3–3. List of Chemicals and Risk Hazard Indexes by Facility (continued)

BUILDING NAME	BUILDING NUMBER	CHEMICAL NAME	BUILDING INVENTORY	BUILDING INVENTORY	VHI INDEX	RHI INDEX
Microsystems and Engineering Sciences Applications Complex		***Ammonia***	100 lb	100	3.7	5.70
		Ammonia Auhydrous	140 lb	140	3.7	5.85
		Arsine	80 lb	80	6.3	8.20
		Boron Trichloride	32 lb	32	5.68	7.19
		Bromine	200 mL	1.37	5.35	5.49
		Hydrochloric Acid	114 L	300	3.94	6.41
		Nitric Acd	75.7 L	251	3.24	5.64
		Nitrous Oxide	100 lb	100	3.9	5.90
		Phosphine	60 lb[a]	60[a]	6.3	8.08
		Saline	8.3 lb	8.3	4.6	5.52
Industrial Hygiene Instrumentation Laboratory	869	***Carbon Disulfide***	3.8 L	0.03	3.98	2.46
		Nitric Acid	5.7 L	18.6	3.62	4.89
Advanced Manufacturing Process Laboratory	878	***Nitrous Oxide***	50 lb	50	3.9	5.60
Computing Building	880	***Hydrofluoric Acid 49%***	4 lb	2	4.7	5.00
Photovoltaic Device Fabrication Laboratory	883	***Ammonia***	6 lb	6	3.7	4.48
		Hydrofluoric Acid	12 L	0.02	4.7	3.00
		Nitric Acid	20 L	29.5	3.62	5.09

Table F.3–3. List of Chemicals and Risk Hazard Indexes by Facility (continued)

BUILDING		CHEMICAL NAME	BUILDING INVENTORY	BUILDING INVENTORY	VHI INDEX	RHI INDEX
NAME	NUMBER					
Photovoltaic Device Fabrication Laboratory (cont.)	883	***Phosphine***	72 ft^3	6.8	6.3	7.13
6-MeV Tandem Van Der Graaf Generator	884	***Ammonia***	34.2 lb	34.2	3.7	5.23
		Carbon Monoxide	10 ft^3	0.78	3.46	3.35
		Hydrofluoric Acid	10 lb	10	4.7	5.70
		Nitric Acid	3 L	9.8	3.62	4.61
Lightning Simulation Facility	888	***Fluorine 5%***	500 L	0.07	5.3	4.15
Compound Semiconductor Laboratory (CSRL)	893	***Ammonia Anhydrous***	400 lb	400	3.7	6.3
		Bromine	200 ml	1.37	5.35	5.49
		Hydrochloric Acid 37%	114 L	300.5	3.94	6.41
Compound Semiconductor Laboratory (CSRL)–Gas Storage Location	893 Gas Storage Location	***Arsine 100%***	99.5 lb	65	6.3	8.11
		Boron Trichloride	32 lb	32	5.68	7.19
		Boron Trifluoride	70 g	0.15	5.6	4.79
		Nitric Acid	75.7 L	250.9	3.24	5.64
		Nitrous Oxide	100 lb	100	3.9	5.9
		Phosphine 100%	99 lb	50	6.3	8.00
		Silane (Silicon Tetrahydride)	31.4 lb	8.3	4.6	5.52

Table F.3–3. List of Chemicals and Risk Hazard Indexes by Facility (concluded)

BUILDING NAME	BUILDING NUMBER	CHEMICAL NAME	BUILDING INVENTORY	BUILDING INVENTORY	VHI INDEX	RHI INDEX
Integrated Materials Research Laboratory	897	***Ammonia***	1.82 kg	4	3.7	4.30
		Bromine	900 g	2	5.35	5.65
		Chlorine	2 kg	4.4	5.52	6.16
		Fluorine	424.7 L	1.25	5.3	5.40
		Furan	500 ml	0.003	6.33	3.81
		Hydrofluoric Acid	2.54 kg	5.6	4.7	5.45
		Methylamine	800 ml	0.002	5	2.30
		Nitric Acid	13.4 L	43.8	3.62	5.26
		Nitric Oxide	158.2 g	0.35	4.6	4.14
		Thionyl Chloride	1 L	3.6	4.42	4.98
Explosive Components Facility	905	***Alcohols***	30 L	52.8	2.09	3.81
		Hydrogen Chloride 5%	15 L	0.054	4.7	3.43
		Thionyl Chloride	28 L	101.1	4.42	6.42

Source: Original
ft^3: cubic feet
g: gram
kg: kilogram
L: liter
lb: pound
ml: milliliter
RHI: Risk Hazard Index
VHI: Vapor Hazard Index
[a] Amounts of arsine and phosphine shown are the amounts if stored in one location. Two storage locations would result in each location containing half the amount.
Note: The highlighted chemicals were used for the dispersion model for each building.

F.3.3 Atmospheric Dispersion of Chemicals

The atmospheric concentration analysis uses the *ALOHA* computer program (NSC 1995). This program is capable of modeling release rates from various sources and the resultant hazardous gas cloud concentrations. The program does not account for wind shifts, terrain steering effect, fires, chemical reactions, or radioactive materials.

Each chemical release is assumed to be a ground-level dispersion, modeled as a point source, with a total release time of 10 minutes for the inventory. A neutral atmospheric stability (stability level "D") and a wind speed of 1.5 m/sec are used for all *ALOHA* simulations in this document.

The most frequent stability class at SNL/NM is D, occurring 44 percent of the time. Wind speeds of 3m/sec and greater usually accompany D stability. The use of D stability with 1.5 m/sec yields more conservative results (higher concentrations at distances further from the release point) than the corresponding meteorological conditions used in estimation of radiological impacts, which were evaluated using the equivalent of 50-percentile dispersion. The 50-percentile dispersion parameters are D stability and 4.3 m/sec.

The release time of 10 minutes was chosen to maximize the accident concentrations. The 10-minute release duration is recommended in the EPA risk management program (EPA 1999). It was assumed that the entire chemical would be released from its container. Because the release was not modeled by *ALOHA*, the temperature of the ambient conditions was not important.

Because the wind direction during an accident cannot be predicted, the SWEIS chemical analysis assumed dispersion of the chemicals in the predominant wind direction (from south-southwest to north-northeast), during daytime (7 am to 7 pm) (see Table F.3–3a). Daytime was chosen to maximize the number of people affected onsite because more people are working onsite during daytime than during nighttime periods. In addition, the predominant wind direction during the nighttime would disperse the chemicals toward the center of KAFB and minimize the offsite impacts.

Table F.3-3a shows the likelihood of a chemical plume migrating in a particular direction, should an accident occur.

Each chemical release assumes loss of the building's inventory due to some catastrophic event such as an earthquake or airplane crash. No attempt is made to model actual process release rates, which would probably be of greater duration or lesser quantity, resulting in a lower concentration. Atmospheric inversion is not considered. No credit is taken for existing process control features, storage practices, or containerization safety features that may slow or limit the releases. Even in a catastrophic event, release of the building's inventory is somewhat improbable due to the robust types of storage containers and the segregation of processes within the buildings.

Atmospheric Stability Categories

Meteorologists have divided the atmospheric stability into seven categories, ranging from A (extremely unstable) to D (neutral) to G (extremely stable). The stability categories can be determined either by the wind speed and change of temperature with height or by the standard deviation of the horizontal wind direction.

The effects of potential chemical interactions between different chemicals were not modeled because the results are not predictable to a degree of certainty appropriate for the SWEIS. Some chemicals, like phosphine and thionyl chloride, react with oxygen in the air, reducing the size of the plume described in the SWEIS. The dispersion results show only the chemical with the highest RHI. For those chemicals with lower RHIs, the plumes would be smaller.

Table F.3–4 provides a summary of the *ALOHA* chemical dispersion runs. The affected zones are plotted on Figures F.3–1 through F.3–12. In addition to showing a dispersion plume extending to the north-northeast, a circle is included to illustrate the areas that could be affected if the wind was blowing into another direction.

Table F.3-5 identifies receptors that could be exposed to a chemical release from a building. Only the arsine and phosphene plumes are long enough to reach any receptors. The likelihood of the plume migrating in the specific direction of any core receptor can also be determined from Table F.3-3a.

The dominant impact would be from the release of arsine from Building 893, Compound Semiconductor Research Laboratory [CSRL] for all alternatives. If implemented, the MESA Complex configuration for the Expanded Operations Alternative dominant impact would be from the release of arsine. In the case of

Table F.3–3a. Probability of Wind Direction for Tower A21 During Daytime and Nighttime Conditions

WIND DIRECTION		PROBABILITY	
FROM	TO	DAY	NIGHT
N	S	6.09	7.52
NNE	SSW	2.17	5.06
NE	SW	1.98	9.04
ENE	WSW	4.07	18.50
E	W	4.76	13.99
ESE	WNW	3.24	6.52
SE	NW	2.65	6.63
SSE	NNW	3.28	7.90
S	N	7.48	4.56
SSW	NNE	10.89	2.83
SW	NE	8.65	2.47
WSW	ENE	8.76	2.39
W	E	8.90	2.37
WNW	ESE	7.94	2.21
NW	SE	9.27	2.68
NNW	SSE	9.87	5.34
All Directions		100.0	100.0

Source: SNL/NM 1999b
Note: Daytime from 7 am to 7 pm; nighttime from 7 pm to 7 am.

Building 893, arsine is run at the building inventory level of 65 lb, based on data obtained from a facility walk-through and meeting with facility representatives. The release of the building inventory of arsine from Building 893 would result in a potential affected zone, at or above the ERPG-2 level, to a distance of 6,891 ft.

Table F.3–6 presents an estimate of the number of people that could be located within the ERPG-2 plume for a release of the building inventory. As can be seen, the potential number of people within the ERPG-2 plume can range from 2 to 558.-The average onsite population density over the northern part of KAFB is 0.00019 person per square ft and for the offsite population the density is 0.000112 person per square ft. At any specific location onsite or offsite, the population density could be higher or lower than these averages.

If implemented, the MESA Complex configuration for the Expanded Operations Alternative would have a building inventory of 80 lb of arsine, which could be stored in one or two separate locations. The arsine values shown in Tables F.3–4 and F.3–6 assume all of the arsine is in one location and represents the dominant impacts. If two separate locations are used to store arsine at the MESA Complex, the impacts of a catastrophic accident would be less. For those rare instances when the amount of arsine in the building exceeds 80 lb, the combination of the probability of the instance and the probability of the accident would result in a total accident probability much less than 10^{-6} per year.

The dominant chemical accident is 80 lb of arsine released at the MESA Complex. The release of the building inventory of arsine from the MESA Complex would result in a potential affected zone to a distance of

Table F.3–4. Dispersion Modeling Results for Chemicals with Highest Risk Hazard Indexes

BUILDING		CHEMICAL NAME	AMOUNT RELEASED (pounds)	ERPG-2 LEVEL (ppm)	ALOHA DISTANCE REQUIRED TO REACH ERPG-2 LEVEL (ft)
NAME	NUMBER				
Systems Research and Development	823	Nitrous Oxide	32.17	125	351
Microelectronics Development Laboratory (MDL)	858	Chlorine	106.4	3	3,726
Microsystems qnd Engineering Sciences Applications (MESA) Complex		Arsine	80	0.5	7,920
Industrial Hygiene Instrumentation Laboratory	869	Nitric Acid	18.6	15	666
Advanced Manufacturing Processes Laboratory	878	Nitrous Oxide	50.0	125	426
Computing Building	880	Hydrofluoric Acid	2.0	20	NR
Photovoltaic Device Fabrication Laboratory	883	Phosphine	6.8	0.5	3,357
6-MeV Tandem Van Der Graaf Generator	884	Hydrofluoric Acid	10.0	20	504
Lightning Simulation Facility	888	Fluorine	0.07	1	NR
Compound Semiconductor Laboratory (CSRL)–Gas Storage Location	893 Gas Storage Location	Arsine	65.0	0.5	6,891
Integrated Materials Research Laboratory	897	Chlorine	4.4	3	699
Explosive Components Facility	905	Thionyl Chloride	101.1	5	2,067

Source: Original
ERPG-2: Emergency Response Planning Guideline Level 2
ppm: parts per million
ALOHA: Areal Location of Hazardous Atmospheres computer code
NR: Not Reported. The model did not provide a plume footprint because the effects of near-field patchiness made dispersion prediction unreliable for short distances.

Table F.3-5. Receptor Locations Potentially within Emergency Response Planning Guideline Level 2

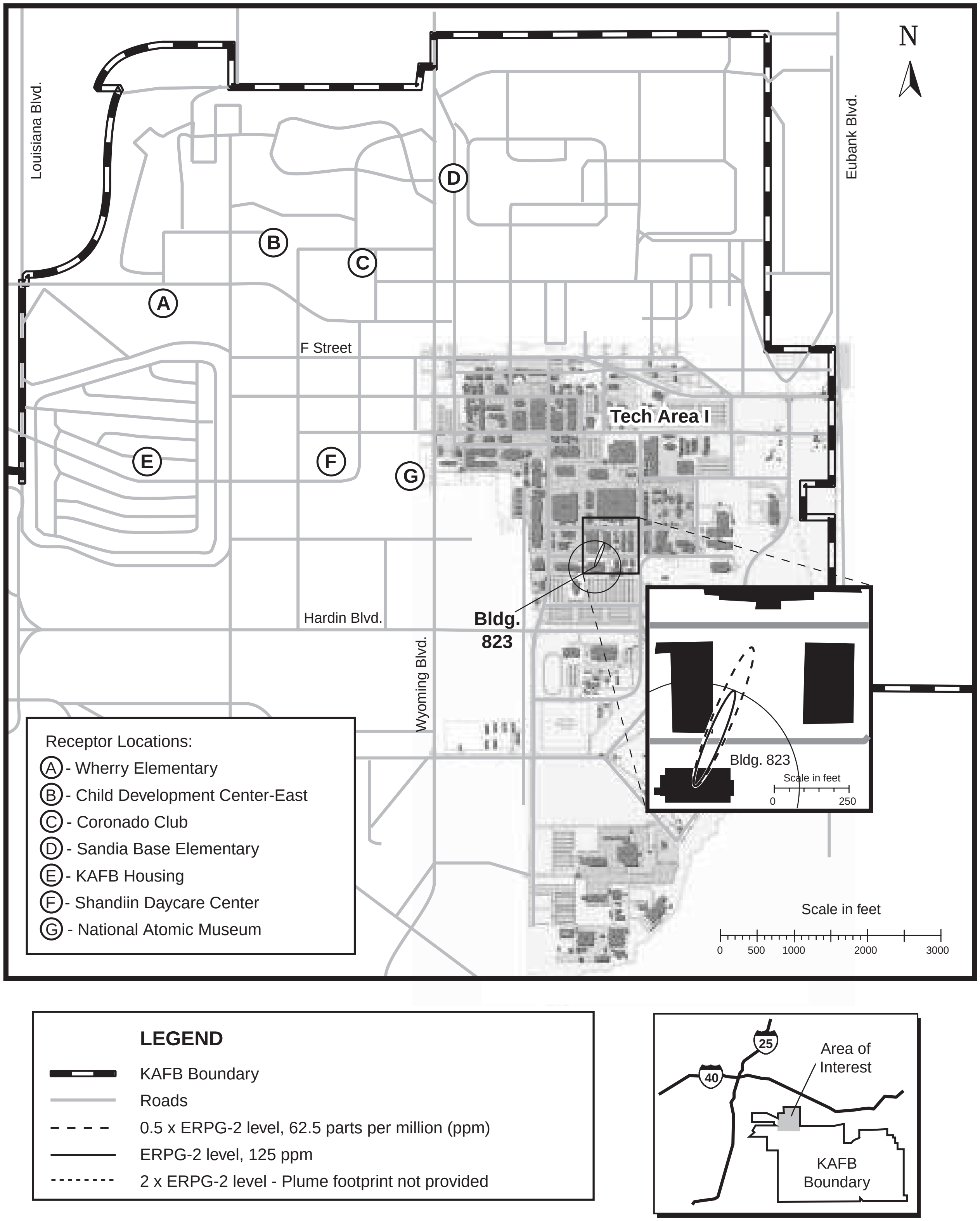
RECEPTOR LOCATION	DIRECTION FROM RELEASE POINT	RELEASE POINT	CHEMICAL RELEASED
A	WNW	Building 893 (CSRL)	Arsine
B	NW	Building 893 (CSRL)	Arsine
	WNW	MESA Complex	Arsine
C	NW	Building 893 (CSRL)	Arsine
	WNW	MESA Complex	Arsine
D	NNW	Building 893 (CSRL)	Arsine
	NW	MESA Complex	Arsine
E	W	Building 893 (CSRL)	Arsine
	W	MESA Complex	Arsine
F	W	MESA Complex	Arsine
	W	Building 893 (CSRL)	Arsine
G	WNW	Building 893 (CSRL)	Phosphine
	W	MESA Complex	Arsine
	W	Building 893 (CSRL)	Arsine

Source: Original
CSRL: Compound Semiconductor Research Laboratory
MESA: Microsystems and Engineering Sciences Applications
Note: See Figures F.3-6, F.3-9, and F.3-12

Table F.3–6. Potential Number of People at Risk of Exposure to Chemical Concentrations Above Emergency Response Planning Guideline Level 2

BUILDING NAME	BUILDING NUMBER	CHEMICAL NAME	BUILDING INVENTORYL ARGEST SINGLE SOURCE (pounds)	ALOHA DISTANCE * REQUIRED TO REACH ERPG-2 LEVEL (ft)	POTENTIAL NUMBER OF PEOPLE WITHIN ERPG-2 LEVEL PLUME *
Systems Research and Development	823	Nitrous oxide	32.17	351	2
Microelectronics Development Laboratory (MDL)	858	Chlorine	106.41	3,726	141
Microsystems and Engineering Sciences Applications (MESA) Complex		Arsine	80	7,920	558
Industrial Hygiene Instrumentation Laboratory	869	Nitric acid	18.6	666	6
Advanced Manufacturing Processes Laboratory	878	Nitrous oxide	50	426	3
Computing Building	880	Hydrofluoric acid	2	NR	NR
Photovoltaic Device Fabrication Laboratory	883	Phosphine	6.8	3,357	100
6-MeV Tandem Van Der Graaf Generator	884	Hydrofluoric acid	10	504	2
Lightning Simulation Facility	888	Fluorine	0.07	NR	NR
Compound Semiconductor Laboratory (CSRL)	893	Arsine	65	6,891	409
Integrated Materials Research Laboratory	897	Chlorine	4.4	699	5
Explosive Components Facility	905	Thionyl chloride	101.1	2,067	55

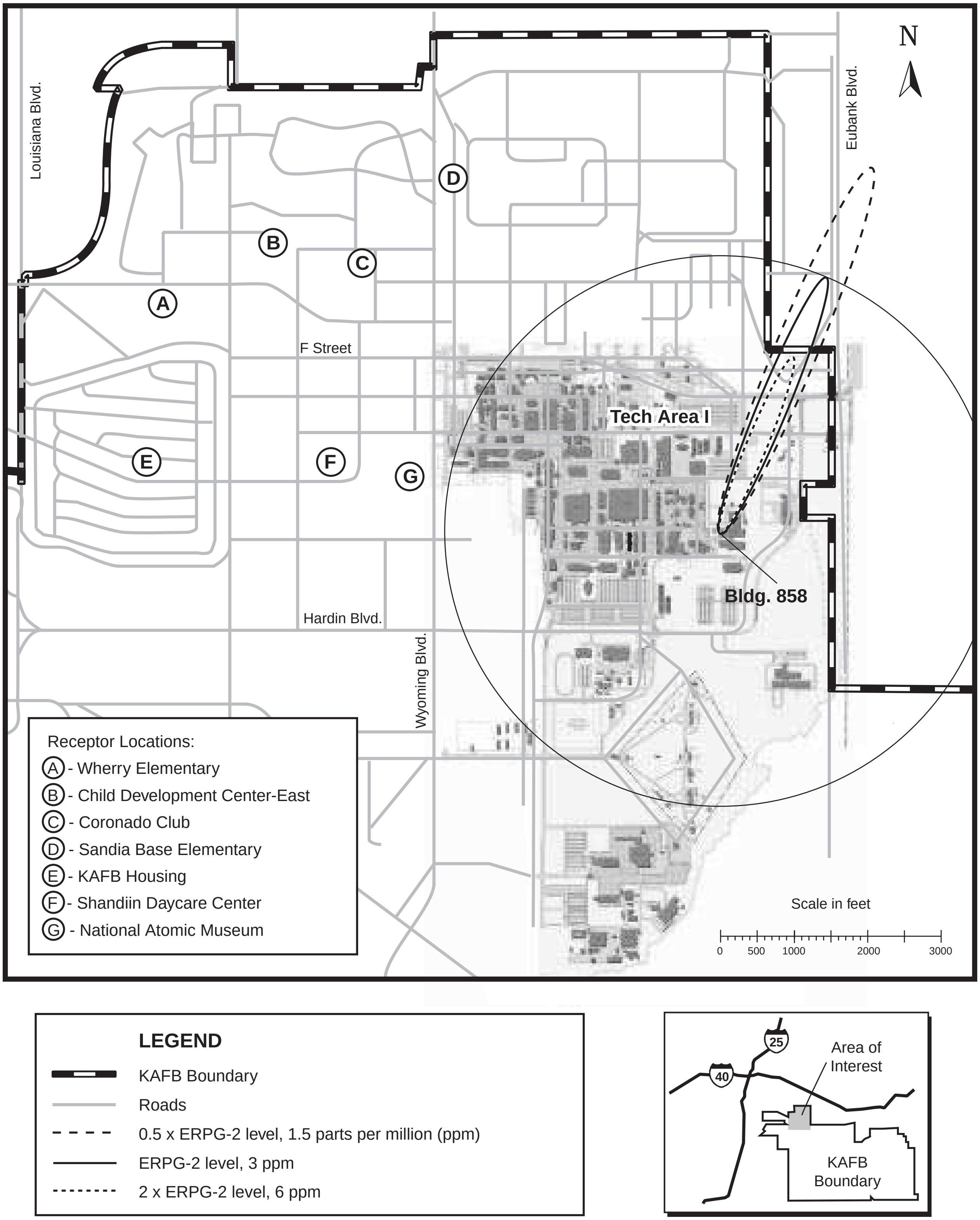
Source: Original
ALOHA: Areal Location of Hazardous Atmospheres computer code
ERPG-2: Emergency Response Planning Guideline Level 2
ft: feet
NR: Not reported. The *ALOHA* model did not provide a plume footprint because the effects of near-field patchiness made dispersion prediction unreliable for short distances. Therefore, no population estimates are available.
[a] Assume all arsine is stored in one location.
Note: 1) See Table F.3–4
2) Dispersion analysis assumes the building inventory is released into the atmosphere within 10 minutes.
3) Number of people is based on the area of plume and a uniform density both onsite (0.00019 person per square foot) and offsite (0.000112 person per square foot).



Source: Original
Note: See Table F.3–4.

Figure F.3–1. Accidental Release of Nitrous Oxide from Building 823

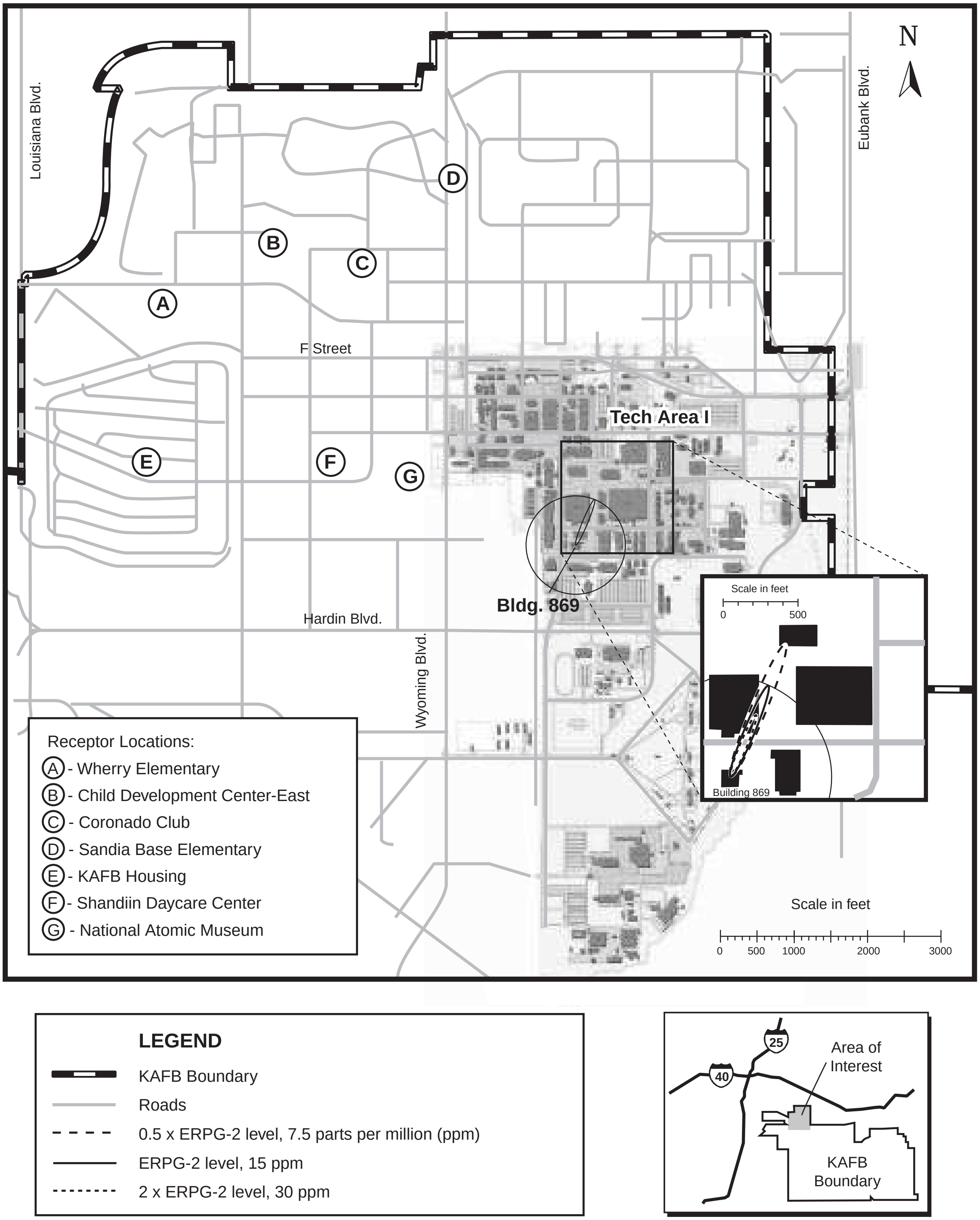
An accidental release of nitrous oxide from Building 823 could affect an area with ERPG-2 levels of exposure extending as far as 351 ft from the source.



Source: Original
See Table F.3–4.

Figure F.3–2. Accidental Release of Chlorine from Building 858

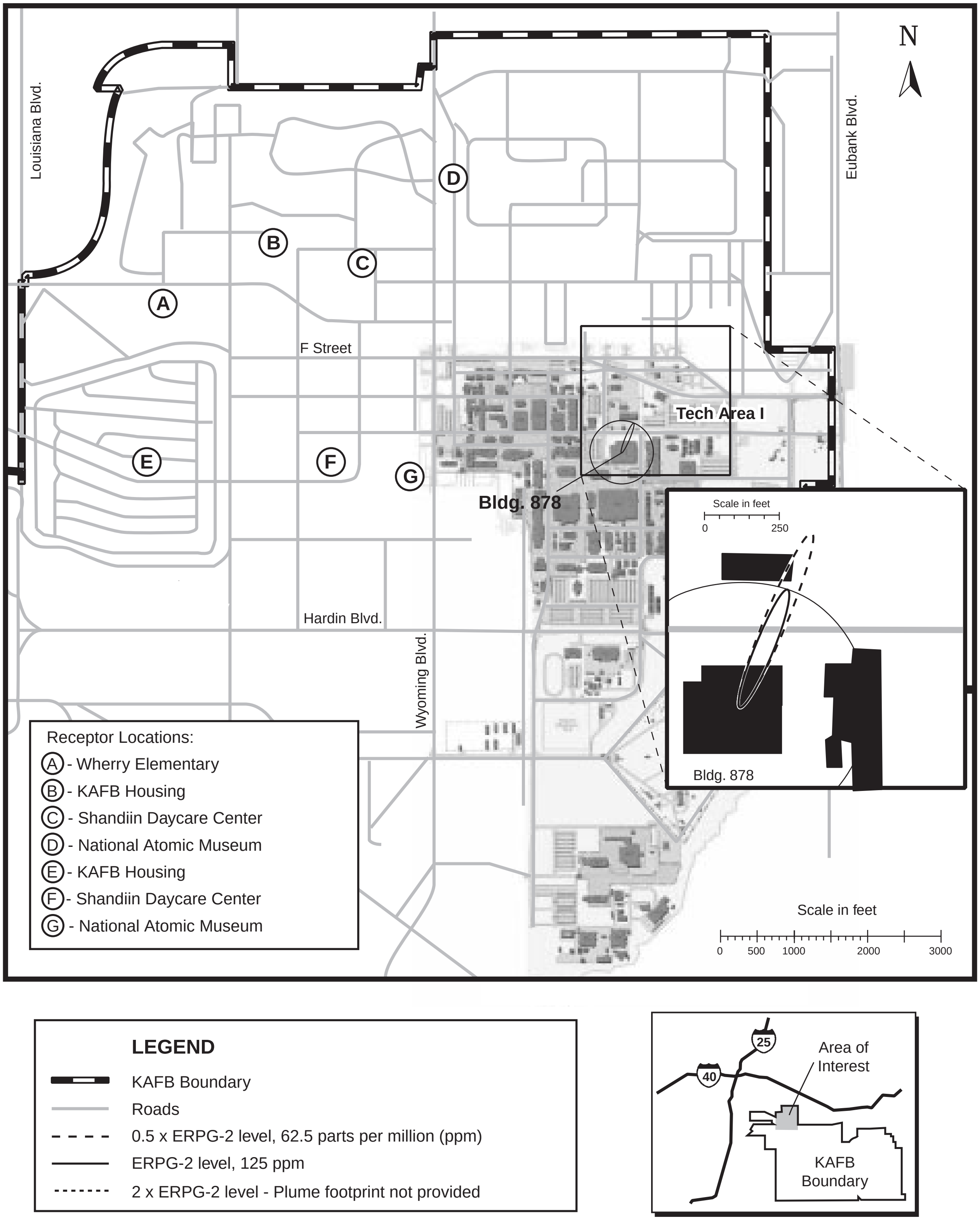
An accidental release of chlorine from Building 858 could affect an area with ERPG-2 levels of exposure extending as far as 3,726 ft from the source.



Source: Original
Note: See Table F.3–4.

Figure F.3–3. Accidental Release of Nitric Acid from Building 869

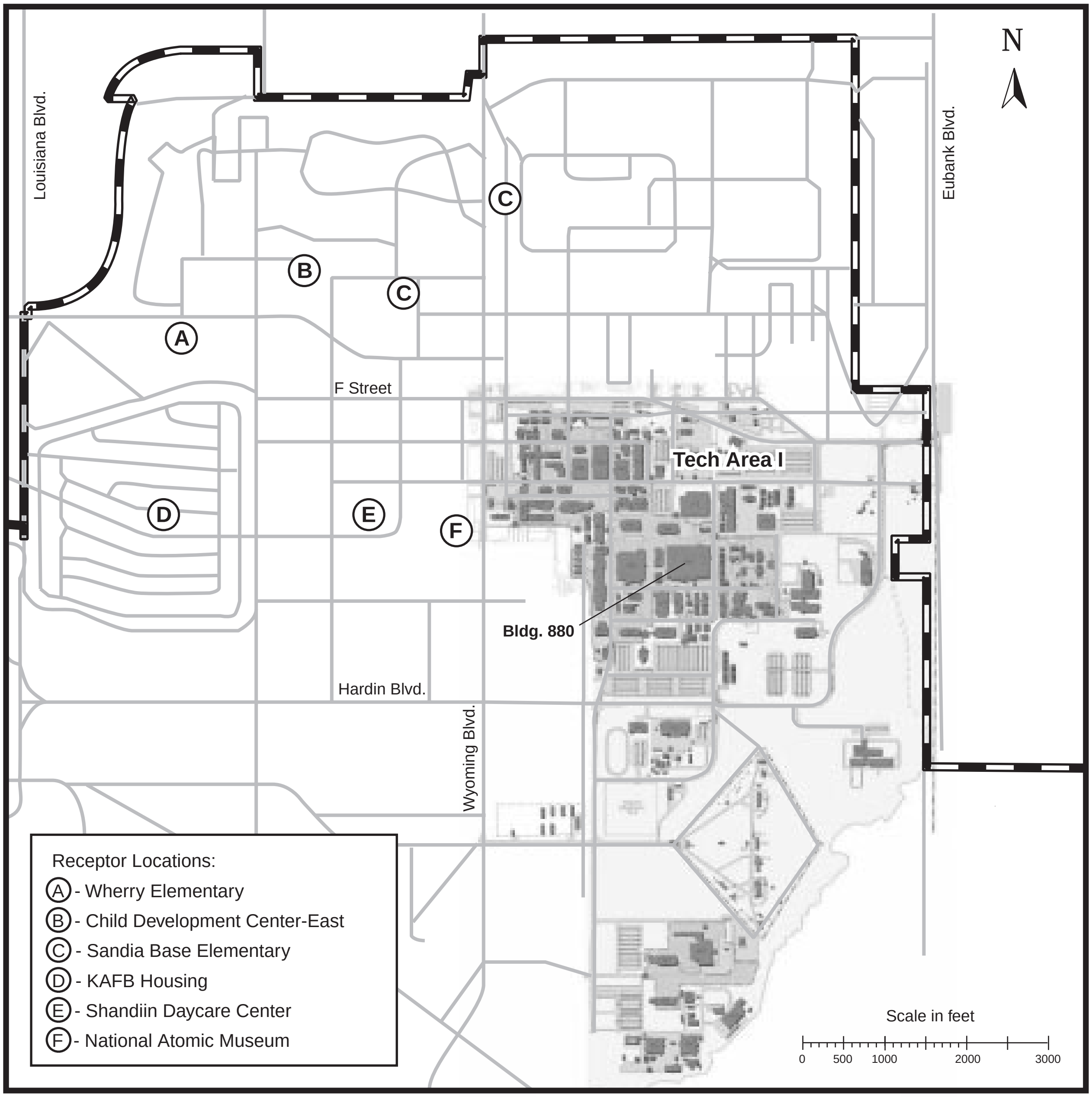
An accidental release of nitric acid from Building 869 could affect an area with ERPG-2 levels of exposure extending as far as 666 ft from the source.

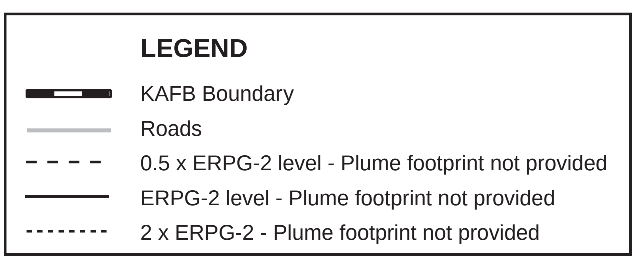


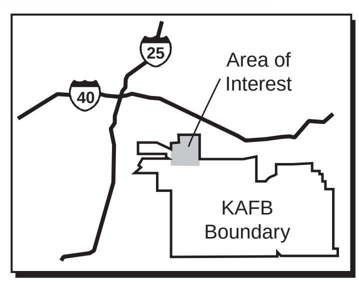
Source: Original
Note: See Table F.3–4.

Figure F.3–4. Accidental Release of Nitrous Oxide from Building 878

An accidental release of nitrous oxide from Building 878 could affect an area with ERPG-2 levels of exposure extending as far as 426 ft from the source.

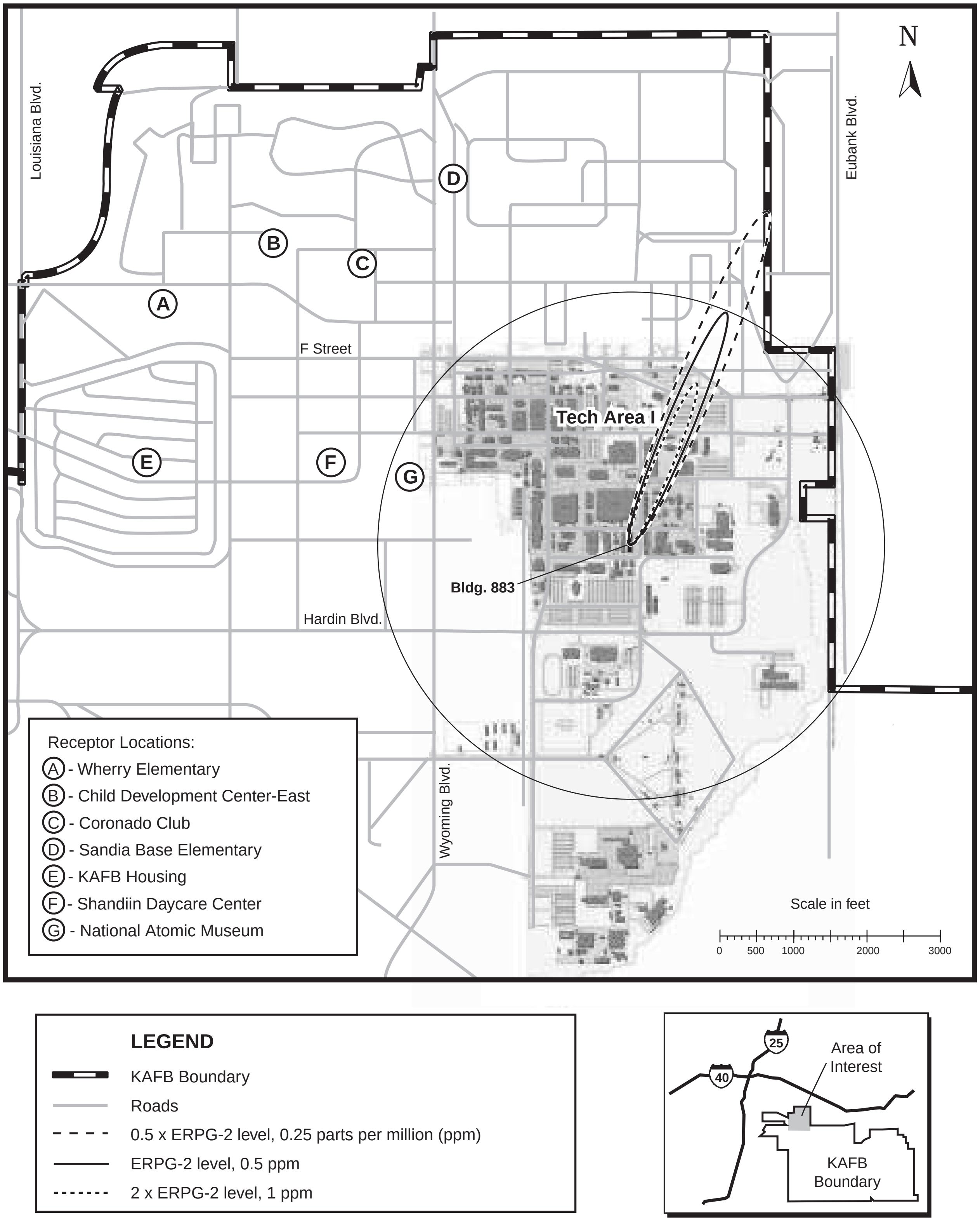






Source: Original
Note: See Table F.3–4.

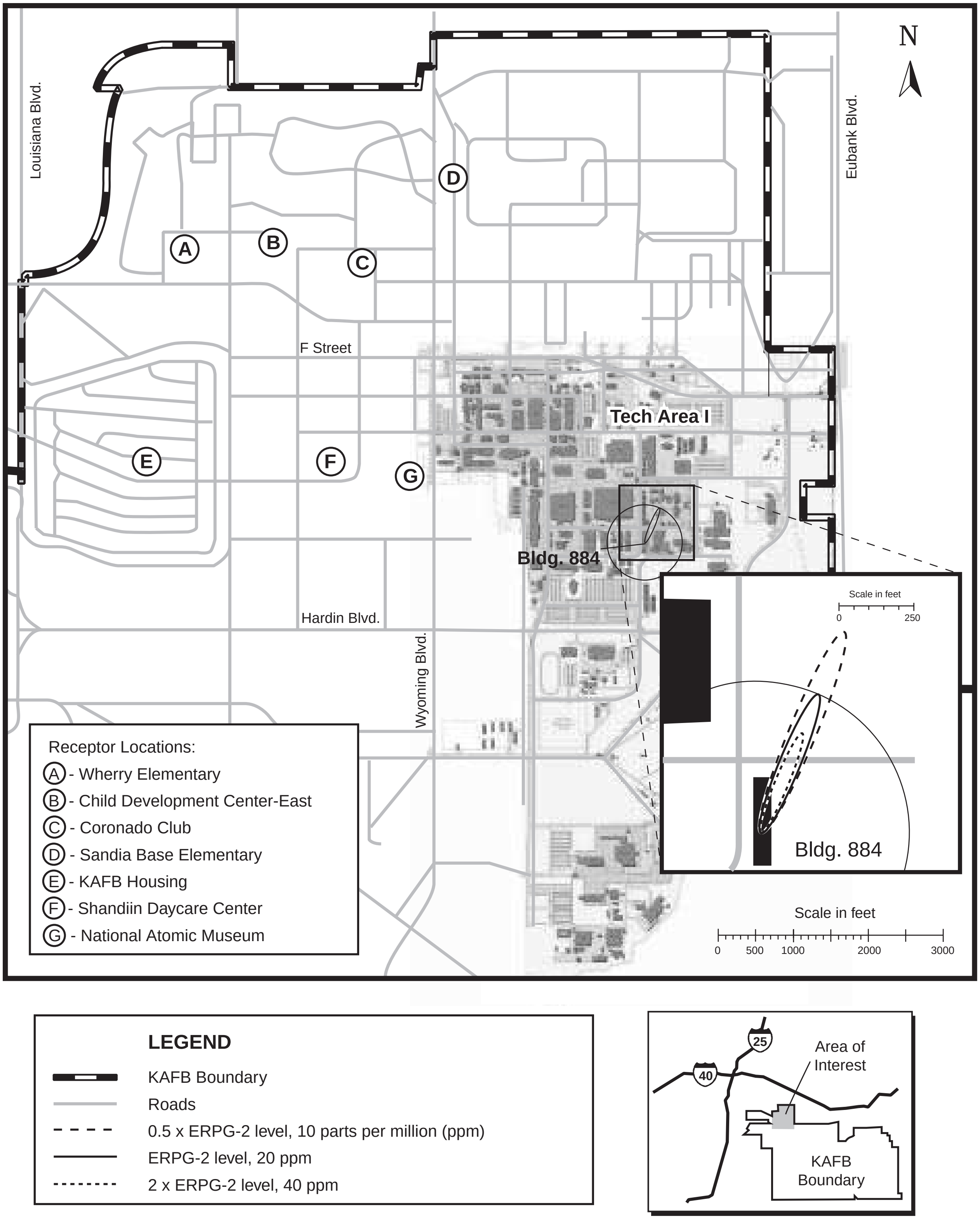
Figure F.3–5. Accidental Release of Hydrofluoric Acid from Building 880
The three plumes are too small to be shown and do not extend outside of Building 880.



Source: Original
Note: See Table F.3–4.

Figure F.3–6. Accidental Release of Phosphine from Building 883

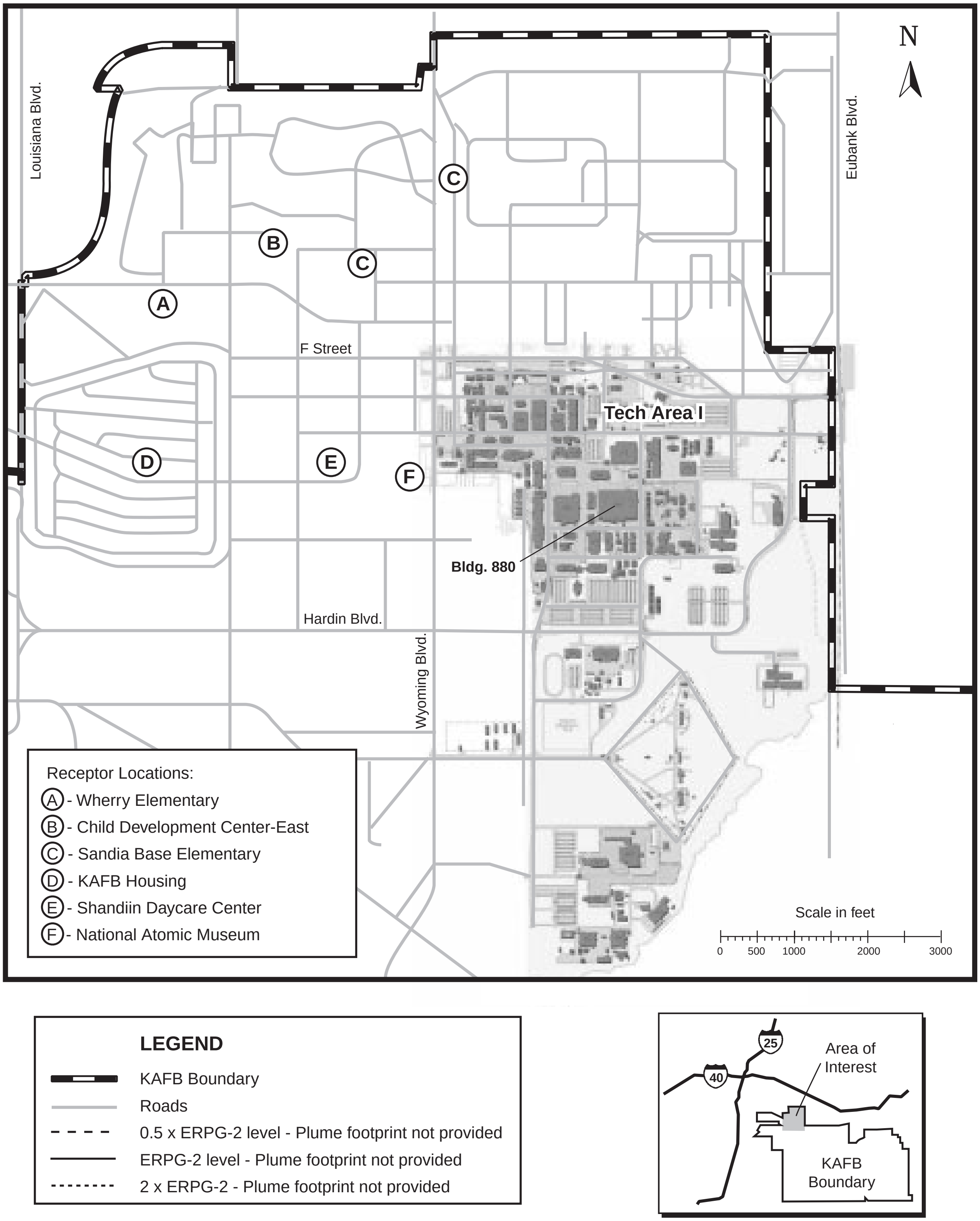
An accidental release of phosphine from Building 883 could affect an area with ERPG-2 levels of exposure extending as far as 3,357 ft from the source.



Source: Original
Note: See Table F.3–4.

Figure F.3–7. Accidental Release of Hydrofluoric Acid from Building 884

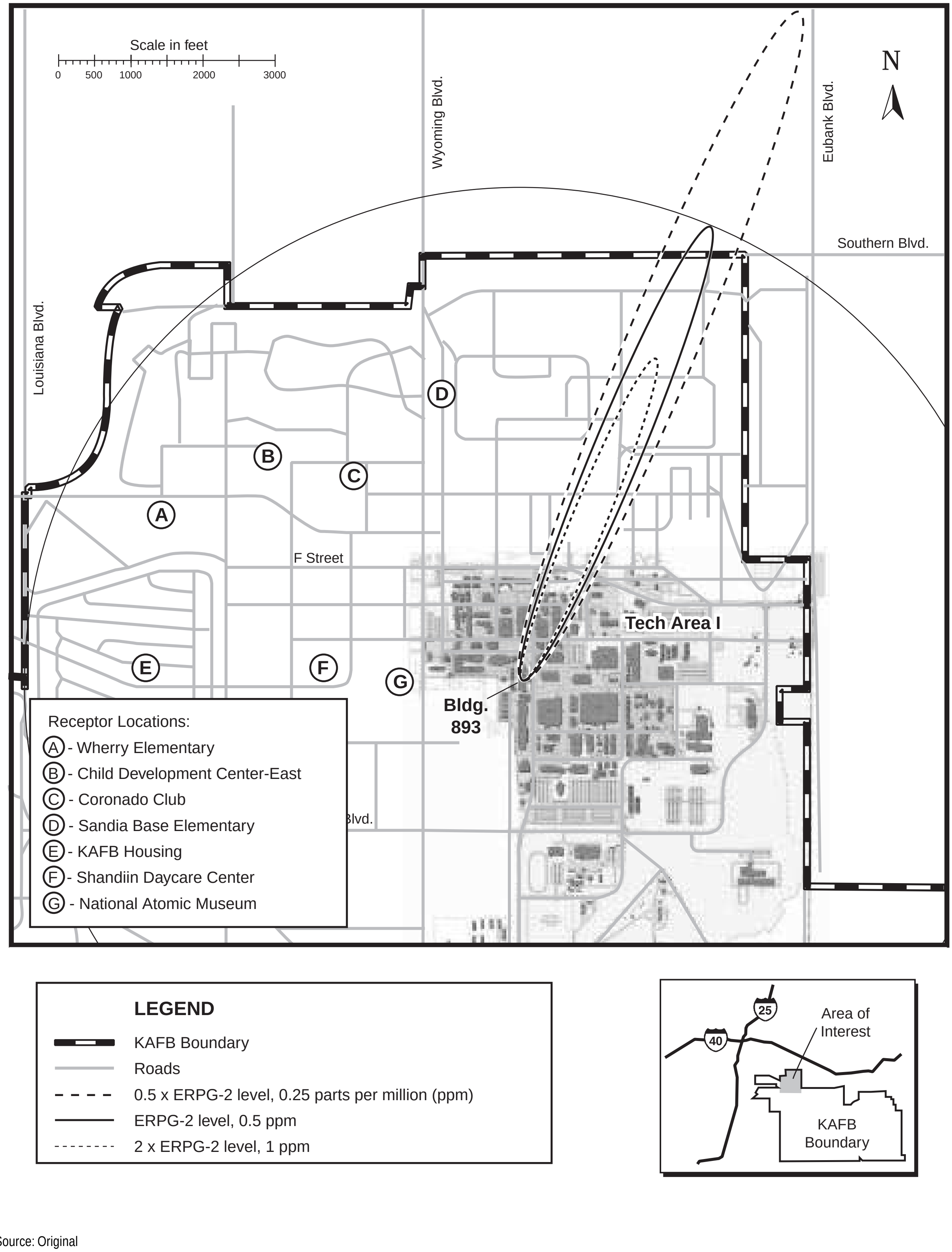
An accidental release of hydrofluoric acid from Building 884 could affct an area with ERPG-2 levels of exposure extrending as far as 504 ft from the source.



Source: Original
Note: See Table F.3–4.

Figure F.3–8. Accidental Release of Fluorine from Building 888

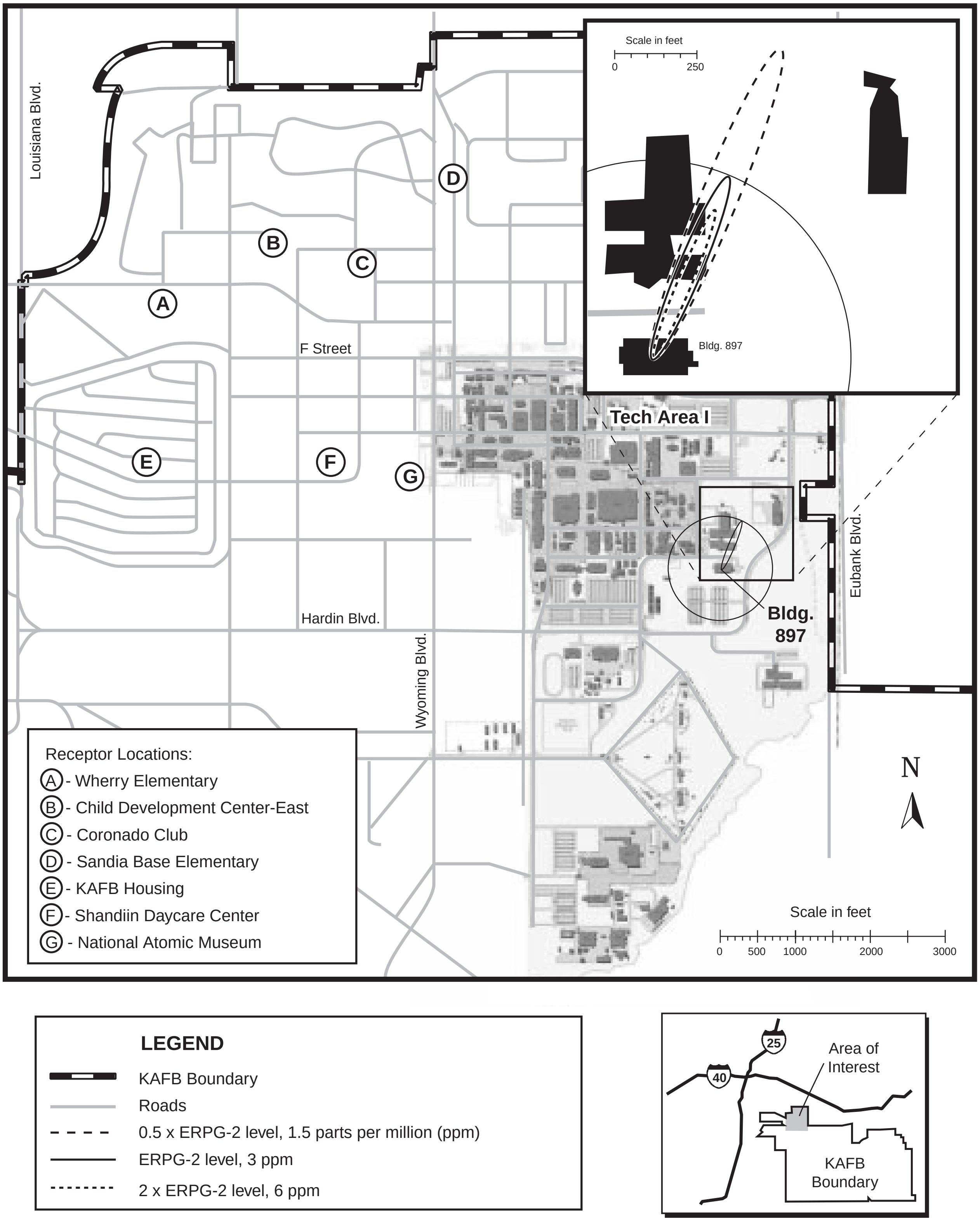
The three plumes are too small to be shown and do not extend outside of Building 888.



Source: Original
Note: See Table F.3–4.

Figure F.3–9. Accidental Release of Arsine from Building 893

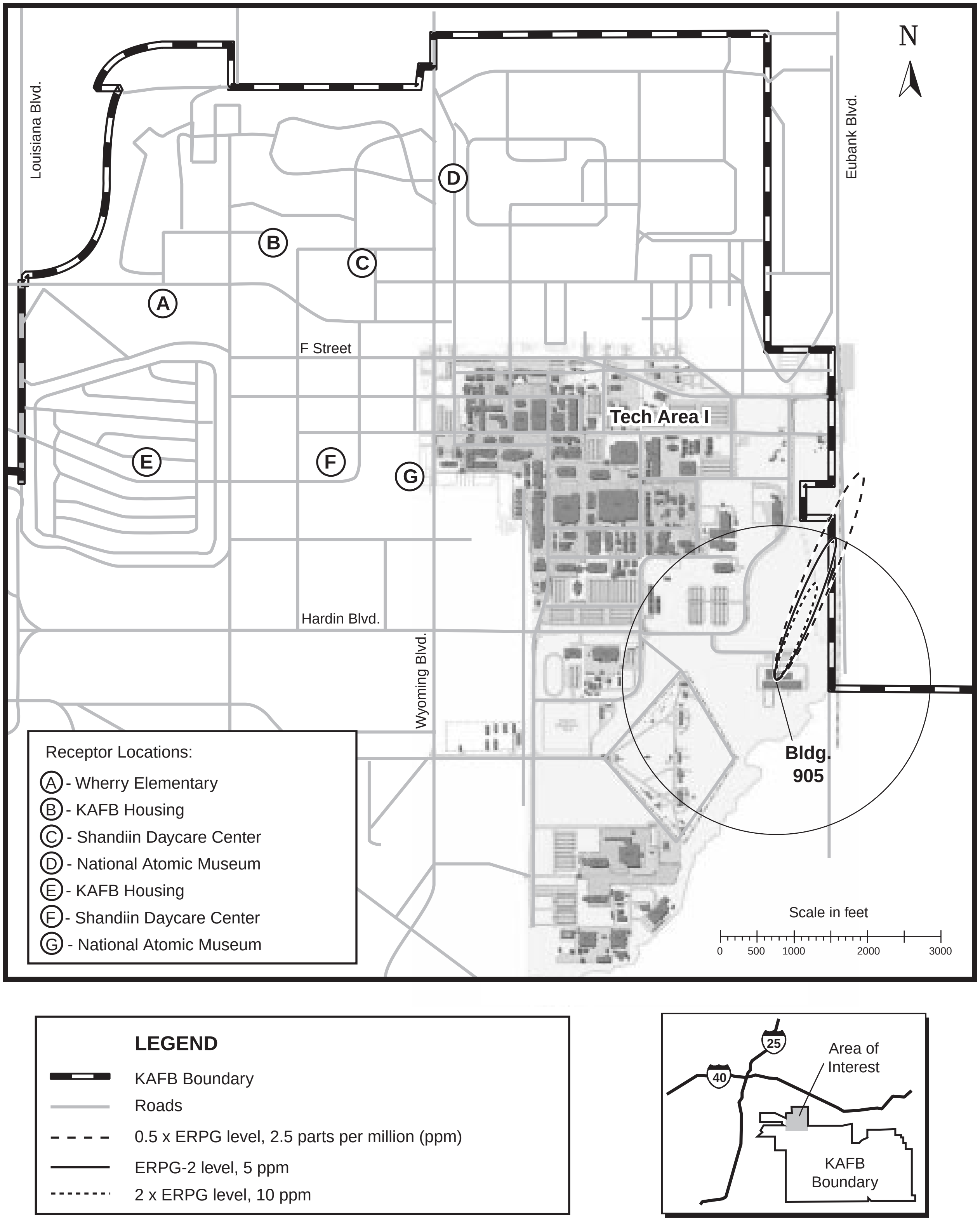
An accidental release of arsine from Building 893 could affect an area with ERPG-2 levels of exposure extending as far as 6,891 ft from the source.



Source: Original
Note: See Table F.3–4.

Figure F.3–10. Accidental Release of Chlorine from Building 897

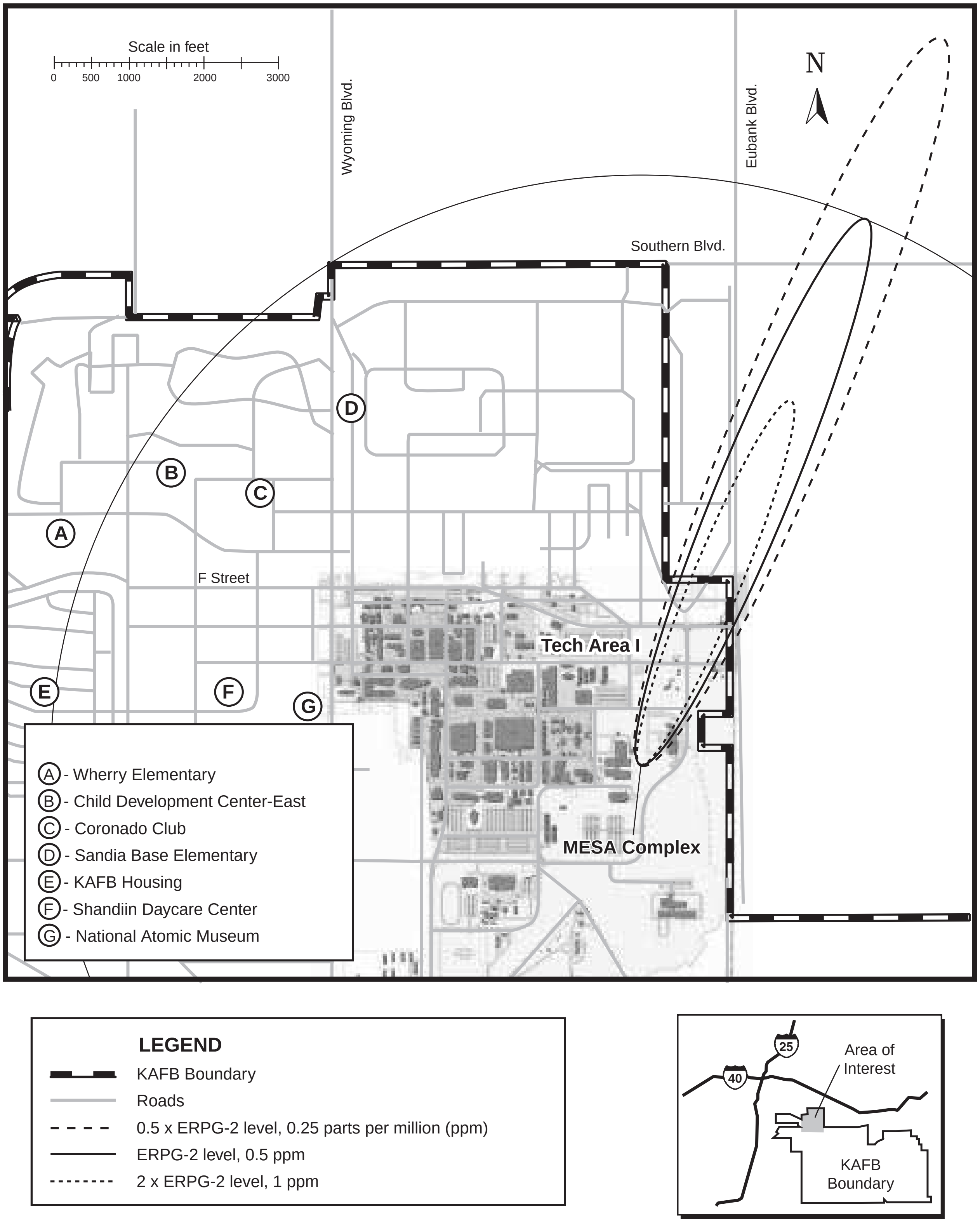
An accidental release of chlorine from Building 897 could affect an area with ERPG-2 levels of exposure extending as far as 699 ft from the source.



Source: Original
Note: See Table F.3–4.

Figure F.3–11. Accidental Release of Thionyl Chloride from Building 905

An accidental release of thionyl chloride from Building 905 could affect an area with ERPG-2 levels of exposure extending as far as 2,067 ft from the source.



Source: Original
Note: See Table F.3.–4

Figure F.3–12. Accidental Release of Arsine from MESA Complex

If implemented, an accidental release of arsine from the MESA Complex could affect an area with ERPG-2 levels of exposure extending as far as 7,920 ft from the source.

7,920 ft. The *ALOHA* model analysis shows that the area enclosed by the ERPG-2 plume is 4,871,008 ft^2, some extending offsite. This accident could expose 558 individuals to concentrations exceeding ERPG-2 levels. The plume would have a limited area; because, as it diffuses to a larger area, the concentration decreases below ERPG-2 levels. The ERPG-2 concentration area is shown in Figure F.3-12, along with two other concentrations to illustrate the shape and limited width of the plume. All other chemical accidents were estimated to have smaller areas exposed to ERPG-2 levels than the arsine plume.

Uncertainties due to various causes can affect the estimated chemical impacts. For instance, different chemicals released in an accident can interact to produce other chemicals. Such interactions are very complex, particularly in a fire, and are therefore difficult to model. Some chemicals, like phosphine and thionyl chloride, will react with oxygen when exposed to air, possibly limiting their dispersion. The *ALOHA* model is not capable of representing these effects, and, as a result, the impacts shown for phosphine and thionyl chloride are conservative. The actual forces and effects of a catastrophic accident like an airplane crash are similarly very complex. It is uncertain how much of a building's chemical inventory would be affected in an accident. The assumption was made that all of the building's expected chemical inventory would be released, which results in conservative impacts. Similarly, in the event of an earthquake, damage to buildings and effects on the building's chemical inventory are complex and difficult to predict. If a building was not expected to be intact following an earthquake (see Table F.7–3), it was conservatively assumed that the entire building's chemical inventory was released.

The actual population exposed to a chemical plume is also a source of uncertainty. The number of people at any one place and time is a variable. Particularly in the event of an earthquake or airplane crash, considerable chaos and unpredictable individual behavior will be present. Changing wind conditions will affect the direction of the plume. Buildings and other obstacles will affect the shape and direction of a plume. People located within buildings would be afforded some protection by the structure. It was assumed that the plume would travel in the highest frequency wind direction; that is, buildings and other obstacles would not affect the plume, and that no credit would be taken for the protection afforded by the building's structure. These assumptions all produce conservative impacts.

There is uncertainty in the level or seriousness of exposures to a chemical plume at various distances from the point of release. Although the exceedance distance for ERPG-2 was selected to distinguish between serious and reversible effects (ERPG-2) and minor or no effects (ERPG-1), chemical concentrations and the effects on exposed individuals vary over the entire range covered by a plume, from irreversible illness closest to the release (ERPG-3) to no effect at large distances from the point of release. As a result, the number of persons estimated to receive exposures in excess of ERPG-2 is a reasonable metric for comparing alternatives, but the actual health effects for exposed persons at any distance cannot be predicted.

F.4 IMPACTS FROM POSTULATED EXPLOSIONS

F.4.1 Introduction

This section documents the consequences of potential accidental explosions at SNL/NM. There are many potential sources of accidental explosions; however, this analysis evaluates the impacts from storage or transportation of flammable chemicals (Section F.4.2) and transportation of high explosives (Section F.4.3).

F.4.2 Explosions of Flammable Chemicals

In the Draft SWEIS, as a result of the review of available documentation, such as SARs, SAs, and HAs, and facility walk-throughs and meetings, the accident assessment team concluded that two separate cases of hydrogen tank explosion would bound the explosions of flammable chemicals. The first case involves a tanker truck containing about 40,000 ft^3 of hydrogen. This tanker truck could be stored at any of three locations: behind the Advanced Manufacturing Processes Laboratory (AMPL), in a remote location in TA-III, or next to Building 891; or it could be moving between locations within SNL/NM. Impacts from an explosion of this tanker truck, while located at the AMPL, are presented in the hydrogen tanker SAR. The second case involves approximately 90,000 ft^3 of hydrogen located adjacent to Building 893, the CSRL.

Since the Draft SWEIS was published, additional information revealed that a third case of hydrogen tank explosion would bound the explosions of flammable chemicals. The third case involves approximately 493,000 ft^3 of hydrogen located adjacent to Building

858, the Microelectronics Development Laboratory (MDL).

The first case examined is an explosion of the tanker truck while it is being moved within SNL/NM (either from TA-III to the AMPL or from offsite to the storage location within TA-III). According to the U.S. Department of Transportation (DOT) *Hazardous Materials Information System* database, there were six highway accidents resulting in explosions from compressed hydrogen and one resulting in a propane explosion during the 25-year period of 1971 through 1995. It could not be ascertained if these incidents were of a similar kind to that postulated for SNL/NM (LANL 1998). Such a low frequency of incidents, generically described as "explosions," involving these materials suggests that such incidents are extremely unlikely to occur. The data collected are for interstate shipments only; data for intrastate shipments resulting in accidents involving hazardous materials are not available because there are no DOT reporting requirements.

Assuming approximately 4 M mi of highways in the U.S., these data could be represented as $1x10^{-8}$ propane explosions per year per mile of highway, and $6x10^{-8}$ hydrogen explosions per year per mile of highway. Assuming this as the approximate rate for an accident and conservatively assuming 50 mi of network roads within SNL/NM (includes all TAs), the occurrence of this type of accident scenario is conservatively estimated to be on the order of $1x10^{-6}$ per year (or in the low end of the extremely unlikely frequency category).

The second case examined is an explosion postulated to occur from the inadvertent release of hydrogen stored outside the CSRL, Building 893. A set of horizontally mounted cylinders, having a combined volume capacity of approximately 90,000 ft^3 at standard temperature and pressure, is stored immediately east of the CSRL building (Kaczor 1998).

The third case examined is an explosion postulated to occur from the inadvertent release of hydrogen stored in a cryogenic tank located outside Building 858. The cryogenic tank, which holds about 493,000 ft^3 at standard temperature and pressure, is stored immediately north of Building 858 .

An explosion postulated in either the second or third case would occur from an accidental uncontrolled release of hydrogen caused by human error (such as mishandling activities) or equipment failure (such as a pipe joint failure) and the presence of an ignition source (such as a spark) near the location of release. Due to the number of failures that would have to occur for an uncontrolled release of hydrogen and explosion to occur, this accident scenario is considered to e extremely unlikely (between $1x10^{-6}$ and $1x10^{-4}$ per year).

The potential effects of hydrogen explosions are estimated using the trinitrotoluene (TNT)-equivalence model. The TNT-equivalence model relates the amount of flammable material to an equivalent amount of TNT, based on the relative heats of combustion, as shown in the following equation:

$$W = \frac{\eta M H_c}{H_{c-TNT}}$$

(Eq. F.4–1)

Where:

	W	=	equivalent mass of TNT (lb),
	h	=	empirical explosion yield (or efficiency) (dimensionless) (0.03 for hydrogen [FEMA 1989]),
	M	=	mass of flammable material released (516 lb of hydrogen for 90,000 ft^3 or 2,400 lb for 493,000 ft^3)
	H_c	=	net heat of combustion of flammable material ($6.1x10^4$ British Thermal Units [BTU]/lb) (LANL 1998),
	H_{c-TNT}	=	heat of combustion of TNT, approximately 2,000 BTU/lb,

For example, the TNT equivalence of 90,000 ft^3 of hydrogen is

$$W = \frac{0.03*516 lbm*6.1x10^4}{2,000} = 472 lb (TNT equivalence)$$

(Eq. F.4–2)

Table F.4–1 shows the TNT equivalence for 40,000 ft^3, 90,000 ft^3, and 493,000 ft^3 of hydrogen.

Once the TNT equivalence is calculated, the peak positive normal reflected pressure (P_r) can be determined from empirically derived curves such as Figure 4.13 from *A Manual for the Prediction of Blast and Fragment Loadings on Structures* (DOE 1992b). P_r is the pressure that the exterior walls of buildings or structures in the proximity of the explosion will experience from a blast wave traveling normally (perpendicular) to the walls.

To use Figure 4.13 from the DOE manual to determine P_r for SNL/NM, the TNT equivalence is used to calculate the "scaled ground distance" (Z_G in ft/lb$^{1/3}$).

$$Z_G = R_G/W^{1/3}$$

(Eq. F.4–3)

Where: R_G is the distance in ft, and W is the weight in pounds TNT equivalence for the explosion.

Values for Z_G and P_r are given in Table F.4–1 for the postulated flammable gas explosions.

The ears and lungs are the most vulnerable organs in the human body that are affected by shock explosions because these organs contain air or other gases. The damage is done at the gas-tissue interface, where flaking and tearing can occur. It has been found, however, that both the ear and the lung responses are dependent not only on the pressure but also on impulse and body orientation. The shorter the pulse width, the higher the pressure the body can tolerate. Depending on the body orientation, for a square-pressure wave and a pulse duration greater than 10 milliseconds, resulting in 50 percent survival, the pressure is about 50 pounds per square inch (psi). For eardrum rupture, the pressure is about 10 psi.

Structural damage produced by air blasts depends on the type of structural material. For partial demolition of houses (making them uninhabitable), overpressures of about 1 psi are needed. An overpressure of 2 to 3 psi will shatter unreinforced concrete or cinder block walls. At 10 psi, total destruction of buildings would be expected to occur (Glasstone & Doland n.d.).

For the CSRL hydrogen explosion, structural damage to buildings (that is, damage to cinder block walls) could occur out to distances of about 370 ft. Fatalities would be expected to occur within 61 ft, while eardrum ruptures could occur at distances up to about 126 ft. Figure F.4–1 shows the area affected at various pressure levels for the postulated CSRL hydrogen explosion. Figure F.4–2 shows similar information for the postulated explosion at MDL.

The actual number of persons in the vicinity of the accident depends upon many factors and the actual number of potential fatalities is uncertain. Factors include the time of day (start of work day, lunchtime, after hours), the actual location of the people (amount of shielding between the hydrogen tank and the person), and the actual spread of the pressure waves in a very complex arrangement of buildings, alleys, and walkways.

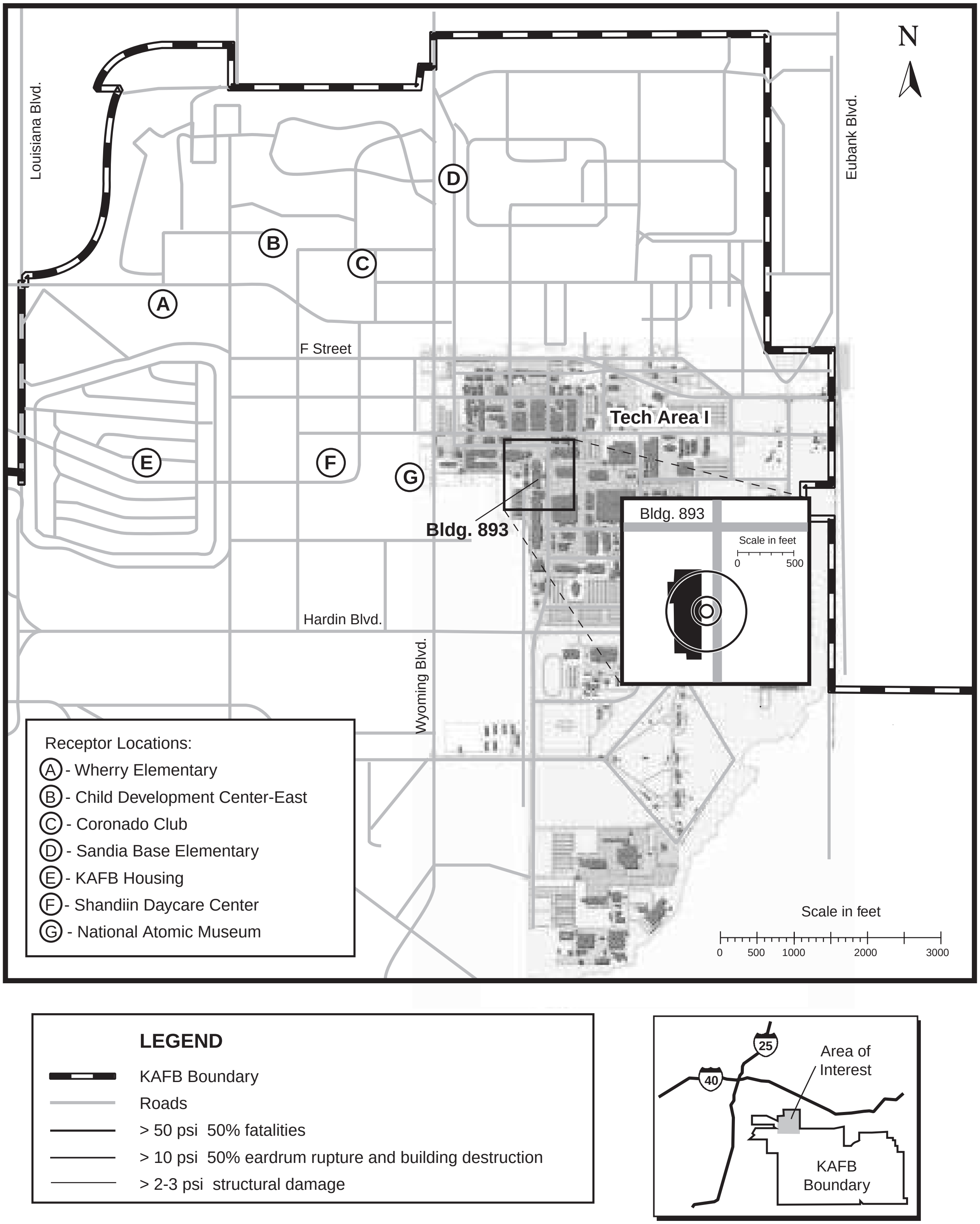
F.4.3 Explosions Involving High Explosives

Several scenarios are postulated involving the shipment of high explosives. The maximum allowable amount of high explosives that can be transported onsite,

Table F.4–1. Peak Reflective Pressures and Physical Effects as a Function of Distance for the Postulated Flammable Gas Explosions

Z_G (ft/lbs$^{1/3}$)	P_r (psi)	PHYSICAL EFFECTS	DISTANCE (ft)		
			472-lb TNT	209-lb TNT	2,203-lb TNT[a]
7.8	50	50% survival rate for pressures in excess of 50 psi	61	46	101
16.2	10	50% rate of eardrum rupture and total destruction of buildings for pressures in excess of 10 psi	126	96	210
47.5	2.0	Pressures in excess of 2-3 psi will cause concrete or cinder block walls to shatter.	370	282	617
84.4	1.0	Pressures in excess of 1 psi will cause a house to be demolished.	657	501	1,096

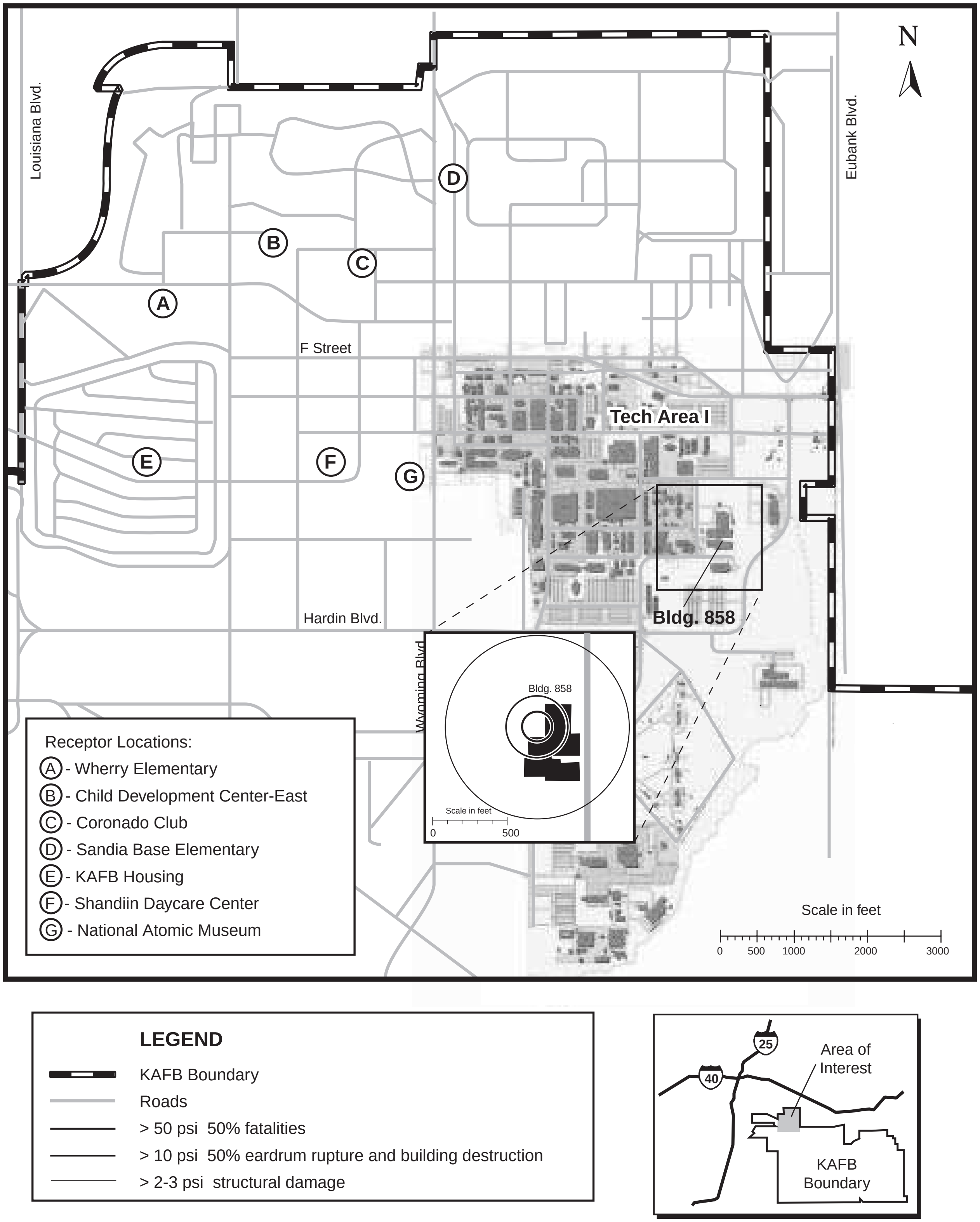
Source: Original
ft: feet
lb TNT: weight expressed as equivalent pounds of trinitrotoluene.
P_r: reflected pressure
psi: pounds per square inch
Z_G: scaled ground distance
[a] Dominant impact



Source: Original
Note: See Table F.4-1

Figure F.4-1. Hydrogen Explosion at Building 893.

The postulated hydrogen explosion at Building 893 would result in 50 percent fatalities at 61 ft, eardrum rupture and building destruction at 126 ft, and structural damage at up to 370 ft.



Source: Original
Note: See Table F.4-1

Figure F.4–2. Hydrogen Explosion at Building 858

The postulated hydrogen explosion at Building 858 would result in 50 percent fatalities at 101 feet, eardrum rupture and building destruction at approximately 210 feet, and structural damage at up to 617 feet.

unescorted, is 25 lb. The typical amount of escorted high explosives transported onsite is 25 kg (55 lb). The maximum amount of high explosives transported onsite (atypical) is 4,600 kg (10,120 lb). **Table** F.4–2 presents the Z_G values and P_r values as a function of distance for the three magnitudes of explosive accidents.

For the maximum explosive transportation accident (10,120-lb TNT), structural damage to buildings (damage to cinder block walls [2-3 psi]) could occur at distances of up to 1,000 ft. Fatalities would be expected to occur within 175 ft, while eardrum ruptures could occur at distances up to approximately 350 ft.

As a check of the impact, the direct static overpressures (ignoring reflective pressure) should be well below the reflective peak pressures. The correlation to calculate the direct static overpressure is found in the literature; a typical correlation is given below. This equation is used to correlate the distance to a given direct static overpressure (AICE 1989).

$$X = 0.3967 M^{1/3}_{TNT}\, Exp\left(3.5031 - 0.724(\ln O_p) + 0.0398(\ln O_p)^2\right) \quad \text{(Eq. F.4–4)}$$

Where: X = the distance to a given overpressure (m),

O_p = the peak static overpressure (psi),

M_{TNT} = the TNT-equivalent weight (kg),

Exp = exponent, and

ln = natural log.

Using the TNT-equivalent weight for the CSRL explosion and an overpressure of 10 psi, the distance to such overpressure would be about 60 ft. This compares to the results for the peak reflective pressure of 10 psi at 126 ft.

F.5 AIRPLANE CRASH FREQUENCY ANALYSIS

F.5.1 Introduction

This section documents the evaluation of potential airplane crashes into SNL/NM facilities. It discusses the selection of representative facilities for the airplane crash analysis, the sources of information on flight activities or frequencies, distances to the facilities from various airports around the Albuquerque metropolitan area, and the results of the analyses. A DOE standard (DOE-STD-3014) for airplane crash frequency analysis was issued in 1996 to help standardize the evaluation of aircraft crashes into facilities (DOE 1996f). Prior to the availability of the DOE standard, the frequencies of aircraft crashes into hazardous facilities at SNL/NM were calculated in various safety documents (for example, SARs and SAs) by other methodologies. In order to update the aircraft crash frequencies for SNL/NM facilities, the standard was used to produce aircraft crash frequencies for use in the SWEIS.

Table F.4–2. Scaled Ground Distance Peak Reflective Pressures as a Function of Distance for the Postulated Explosive Shipment Scenarios

TARGET (ft)	10,120-lb TNT		55-lb TNT		25-lb TNT	
	Z_G (lb/ft$^{1/3}$)	P_r(psi)	Z_G (lb/ft$^{1/3}$)	P_r(psi)	Z_G (lb/ft$^{1/3}$)	P_r(psi)
25	1.2	>1,000	6.6	60	8.6	38
50	2.3	>1,000	13.1	18	17.1	8
100	4.6	200	26.3	4	34.2	3
200	9.3	28	52.6	1.5	68.5	1.4
300	13.9	17	78.9	1.3	102.7	<1
400	18.5	6.5	105	<1	136.9	<1
500	23.2	5	131	<1	171.2	<1
750	34.8	3	197	<1	256.8	<1
1,000	46.4	2	262	<1	342.4	<1

Source: Original
ft: feet
lb TNT: weight expressed as equivalent pounds of trinitrotoluene
P_r: peak reflective pressure
psi: pounds per square inch
Z_G: scaled ground distance

Representative facilities within SNL/NM were selected for analysis based on their potential for public consequences. **Table** F.5–1 lists the facilities that were selected for analysis.

As indicated in **Table** F.5–1, several facilities were identified to represent TA-I due to the wide variation in building sizes and locations. The SPR was selected for analysis because it is representative of the other buildings in TA-V. The Radioactive and Mixed Waste Management Facility (RMWMF) was selected because it handles radioactive waste.

F.5.2 Methodology

Aircraft crash impact frequencies for facilities are determined using the "four-factor formula" from the DOE standard (DOE-STD-3014). This formula considers the number of aircraft operations; the probability that an aircraft will crash; the probability that, given a crash, the aircraft will crash into a 1-mi^2 area where the facility of interest is located; and the size of the facility. The formula from DOE-STD-3014 is

Table F.5–1. Selected Facilities for Aircraft Crash Frequency Calculations

REPRESENTATIVE FACILITY	TECHNICAL AREA
Integrated Materials Research Laboratory	I
Microelectronics Development Laboratory	I
Neutron Generator Facility	I
Advanced Manufacturing Processes Laboratory	I
Compound Semiconductor Research Laboratory	I
Microsystems and Engineering Sciences Applications Complex	I
Explosive Components Facility	II
Z-Machine	IV
Radioactive and Mixed Waste Management Facility	III
Sandia Pulsed Reactor	V

Source: Original

$$F = \Sigma N_{ijk} \bullet P_{ijk} \bullet f_{ijk}(x,y) \bullet A_{ij}$$

(Eq. F.5–1)

Where: F = estimated annual aircraft crash impact frequency for the facility of interest (number per year);

N_{ijk} = estimated annual number of site-specific airport operations takeoffs, landings, and in-flights for each applicable summation parameter;

P_{ijk} = aircraft crash rate for each applicable summation parameter;

$f_{ijk}(x,y)$ = aircraft crash location conditional probability (per square mile), given a crash valuated at the facility location for each applicable summation parameter;

A_{ij} = site-specific effective area for the facility of interest that includes the skid and fly-in effective areas (mi^2) for each applicable summation parameter;

i = index for flight phases (takeoff, in-flight, and landing);

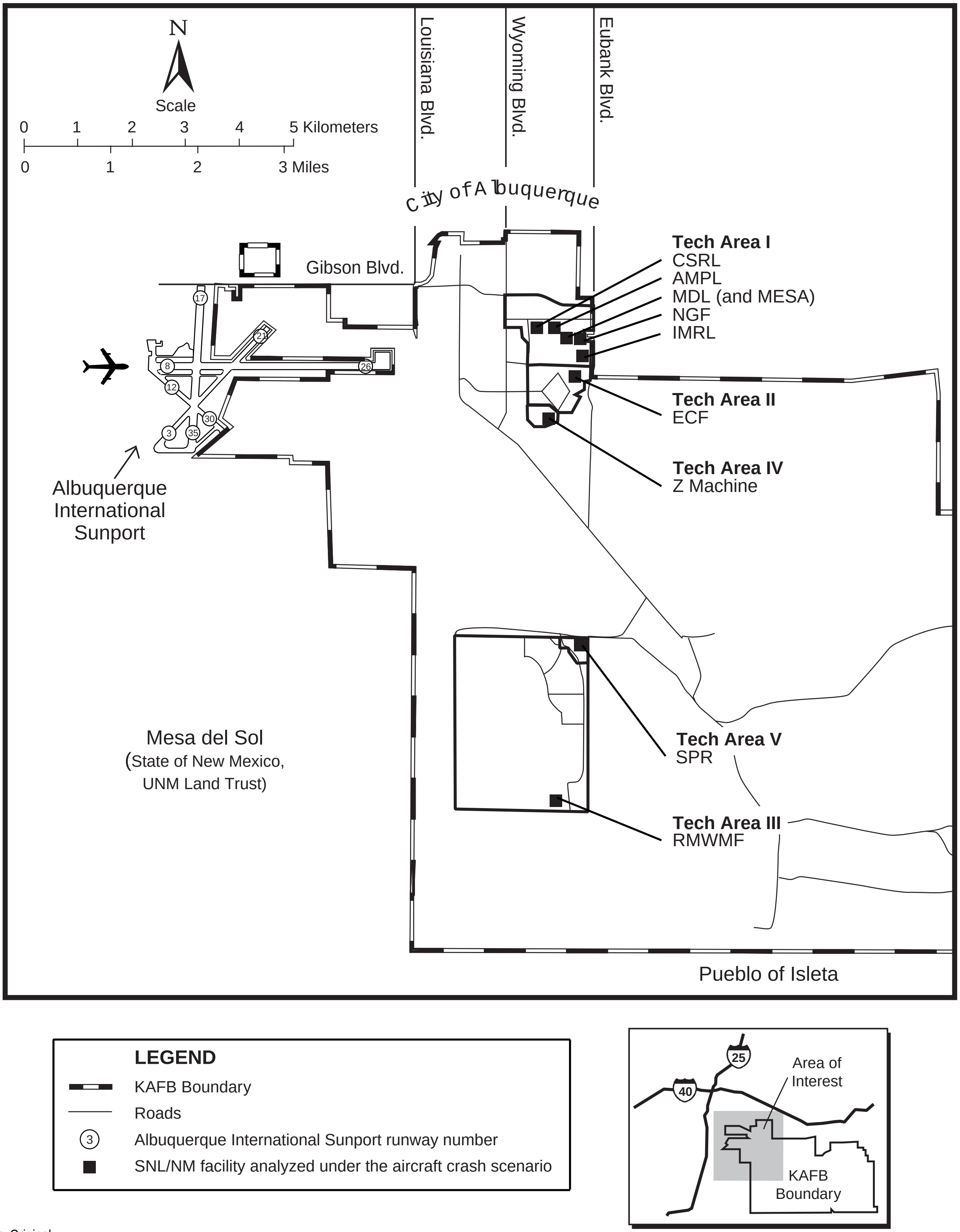
j = index for aircraft category or subcategory; and

k = index for flight source (specific runways).

The results of this analysis and a discussion of how the four-factor formula was applied to SNL/NM facilities follow.

F.5.3 Site-Specific Input Data

The Albuquerque International Sunport is the airport with the largest potential to affect SNL/NM facilities. There are other airports in the general area of SNL/NM. These airports include the Coronado Airport, Sandia Airpark, Alexander Airport, Mid-Valley Airport, and Double Eagle Airport. All of the aircraft operations at these airports are general aviation or helicopter, and the distances from the SNL/NM facilities to these airports are all greater than 10 mi. Although DOE-STD-3014 does not provide screening criteria for airports, the probability of general aviation aircraft crashes for airport operations presented in DOE-STD-3014 is considered insignificant at distances



Source: Original

Figure F.5–1. Releationship between Albuquerque International Sunport Runways and Selected Sandia National Laboratories/New Mexico Facilities

The Albuquerque International Sunport runways are shown relative to selected Sandia National Laboratories/New Mexico facilities.

greater than 8 mi. Aircraft operations at airports other than the Sunport are not evaluated in this analysis because the distances from the other area airports to the SNL/NM facilities are greater than 8 mi and because of the high number of aircraft operations at the Albuquerque International Sunport. Flights from these distant airports that could go over SNL/NM are covered in the section on nonairport impact frequencies (Section F.5.5). Figure F.5–1 shows the relationship of the Albuquerque International Sunport to the selected facilities on SNL/NM.

Table F.5–2 shows the number of takeoffs and landings by runway and aircraft type. In addition to the number of takeoffs and landings at nearby airports, the distances and directions from each runway to each facility (Table F.5–3) are also required as input. Table F.5–3 presents the ortho-normal distances relative to the center of each runway. These distances are required as part of the look-up of the aircraft crash location conditional probability ($f_{ijk}[x,y]$) given in Tables B–2 through B–13 in DOE-STD-3014. Table F.5–4 presents each facility's length, width, and height, which are needed in the calculation of the effective building area (A_{ij}).

F.5.4 Potential Aircraft Crash Frequencies

Table F.5–5 presents the total annual aircraft impact frequencies for facilities at SNL/NM. These frequencies, using the data in Tables F.5–2 through F.5–4 and the data in Appendix B of DOE-STD-3014, were calculated using the four-factor formula discussed above. Tables F.5–6 through F.5–15 provide a summary of the aircraft crash frequencies for each facility for each type of aircraft operation. The tables are further defined by airport-type crashes (due to takeoffs or landings) and nonairport type crashes (in-flights). The last row of each summary table sums the aircraft crash frequencies for each type of aircraft to give an overall aircraft impact frequency for each selected facility at SNL/NM.

F.5.4.1 Impact Frequencies from Airport Operations

The potential impact frequencies for aircraft crashes into SNL/NM facilities due to airport operations at the Albuquerque International Sunport were calculated according to the methodology in DOE-STD-3009 (DOE 1994c).

According to DOE-STD-3014, helicopters must fly over a facility for the flight to pose a hazard to the facility. Most helicopter operations will not fly near the SNL/NM facilities.

Tables B–4 through B–14 of Appendix B of DOE-STD-3014 list the probability that, given a crash upon takeoff or landing of a specific type of aircraft, the crash will occur in the 1-mi^2 area where the facility of interest is located. For military aircraft operations, for conservatism, the landing pattern side of the approach was assumed to be the side of the airport that resulted in the highest impact probability.

The takeoff and landing crash rates (P_{ijk}) for each type of aircraft are taken from Table B-1 of DOE-STD-3014. This table lists the probability that a given type of aircraft will crash upon takeoff or landing.

The calculation of the effective area is based on two components: the aircraft can crash directly into the facility or the aircraft can skid into the facility. The effective area of the facility is, therefore, dependent on the type of aircraft and the actual dimensions of the facility. Multiple factors affect the facility's effective area depending on the type of aircraft. The wingspan dictates how close the aircraft can come to the facility and still impact it. The type of aircraft also dictates the angle of impact into the facility, and the cotangent of this angle is used in the calculation. The skid distance of the aircraft is also defined by the type of aircraft and is a function of the aircraft airspeed. These variables are given in DOE-STD-3014 (Tables B-17 and B-18) for each type of aircraft.

The aircraft impact frequency per year for airport operations is determined by multiplying the number of operations, the conditional crash probability, the crash probability, and the effective area of the facility as described in the four-factor formula. The sums of the impact frequencies by aircraft type are presented in Tables F.5–6 through F.5–15.

F.5.4.2 Impact Frequency for Nonairport Operations

Although typically small, the impact frequency contribution for nonairport operations cannot be overlooked when following the DOE-STD-3014 methodology. The impact frequency for nonairport operations is calculated from the same four-factor formula used for airport operations, except that the first three terms are combined and given in DOE-STD-3014 (Tables B-14 and B-15). The standard provides site-specific values for the probability of an impact occurring in a 1-mi^2 area at the center of the site for each type of aircraft.

These frequencies are listed in Tables F.5–6 through F.5–15 and used along with the airport impact frequencies to determine the overall aircraft impact frequency per year for the facility of interest.

Table F.5–2. Number of Takeoffs and Landings at Albuquerque International Sunport

AIRCRAFT TYPE	LANDINGS BY RUNWAY								
	8	26	17	35	3	21	12	30	TOTALS
Fixed-Wing Single	5,349	1,070	856	1070	11,554	0	214	1,284	21,396
Fixed-Wing Twin	1,783	357	285	357	3,851	0	71	428	7,132
Fixed-Wing Turbojet	297	59	48	59	642	0	12	71	1,189
Air Carrier	13,224	5,731	1,322	1,322	22,481	0	0	0	44,081
Air Taxi	4,080	1,632	490	490	9,140	0	0	490	16,322
Large Military	974	204	47	31	267	0	0	0	1,525
Small High-Performance	5,225	1,096	253	169	1,433	0	0	0	8,175
Helicopter	0	0	0	0	0	0	0	2,305	2,305
AIRCRAFT TYPE	**TAKEOFFS BY RUNWAY**								
	8	**26**	**17**	**35**	**3**	**21**	**12**	**30**	**TOTALS**
Fixed-Wing Single	7,489	214	642	856	0	2,354	9,628	214	21,396
Fixed-Wing Twin	2,496	71	214	285	0	785	3,209	71	7,132
Fixed-Wing Turbojet	416	12	36	48	0	131	535	12	1,189
Air Carrier	34,383	882	2,645	1,322	0	4,849	0	0	44,081
Air Taxi	12,241	326	979	490	0	1,795	490	0	16,322
Large Military	1,182	187	47	47	0	62	0	0	1,525
Small High-Performance	6,340	1,001	250	250	0	334	0	0	8,175
Helicopter	0	0	0	0	0	0	2,305	0	2,305

Sources: Jacox 1998, Kauffman 1994

Table F.5–3. Orthonormal Distances from Albuquerque International Sunport Runways to Selected Facilities

DISTANCE (miles)					DISTANCE (miles)				
	RUNWAY 17		RUNWAY 35			RUNWAY 3		RUNWAY 21	
Facility	**X**	**Y**	**X**	**Y**	***Facility***	**X**	**Y**	**X**	**Y**
IMRL	0.52	4.16	-0.52	-4.16	***IMRL***	3.10	-3.46	-3.10	3.46
MDL	0.39	4.17	-0.39	-4.17	***MDL***	3.21	-3.39	-3.21	3.39
NGF	0.44	4.02	-0.44	-4.02	***NGF***	3.06	-3.31	-3.06	3.31
AMPL	0.19	3.97	-0.19	-3.97	***AMPL***	3.22	-3.11	-3.22	3.11
MESA Complex	0.43	4.50	-0.43	-4.50	***MESA Complex***	3.38	-3.67	-3.38	3.67
CSRL	0.21	3.77	-0.21	-3.77	***CSRL***	3.09	-2.97	-3.09	2.97
ECF	0.80	4.25	-0.80	-4.25	***ECF***	2.94	-3.71	-2.94	3.71
Z-Machine	1.39	3.73	-1.39	-3.73	***Z-Machine***	2.16	-3.69	-2.16	3.69
RMWMF	5.67	3.10	-5.67	-3.10	***RMWMF***	-1.53	-5.96	1.53	5.96
SPR	3.85	3.68	-3.85	-3.68	***SPR***	0.24	-5.24	-0.24	5.24

DISTANCE (miles)					DISTANCE (miles)				
	RUNWAY 8		RUNWAY 26			RUNWAY 12		RUNWAY 30	
Facility	**X**	**Y**	**X**	**Y**	***Facility***	**X**	**Y**	**X**	**Y**
IMRL	3.41	-0.41	-3.41	0.41	***IMRL***	3.50	2.60	-3.50	-2.60
MDL	3.42	-0.28	-3.42	0.28	***MDL***	3.43	2.71	-3.43	-2.71
NGF	3.26	-0.34	-3.26	0.34	***NGF***	3.35	2.57	-3.35	-2.57
AMPL	3.21	-0.09	-3.21	0.09	***AMPL***	3.15	2.73	-3.15	-2.73
MESA Complex	3.75	-0.32	-3.75	0.32	***MESA Complex***	3.71	2.89	-3.71	-2.89
CSRL	3.02	-0.10	-3.02	0.10	***CSRL***	3.01	2.59	-3.01	-2.59
ECF	3.49	-0.69	-3.49	0.69	***ECF***	3.75	2.44	-3.75	-2.44
Z-Machine	2.98	-1.28	-2.98	1.28	***Z-Machine***	3.73	1.66	-3.73	-1.66
RMWMF	2.34	-5.56	-2.34	5.56	***RMWMF***	6.00	-2.03	-6.00	2.03
SPR	2.93	-3.74	-2.93	3.74	***SPR***	5.28	-0.26	-5.28	0.26

Sources: USGS 1990, 1991
AMPL: Advanced Manufacturing Processes Laboratory
CSRL: Compound Semiconductor Research Laboratory
ECF: Explosive Components Facility
IMRL: Integrated Materials Research Laboratory
MDL: Microelectronics Development Laboratory
MESA: Microsystems and Engineering Sciences Applications
NGF: Neutron Generator Facility
RMWMF: Radioactive and Mixed Waste Management Facility
SPR: Sandia Pulsed Reactor

Table F.5–4. Length, Width, and Height of Selected Buildings

BUILDING		DIMENSION (feet)		
NAME	NUMBER	LENGTH	WIDTH	HEIGHT
Integrated Materials Research Lab	897	296	151	64.0
Microelectronics Development Lab	858	536	352	46.0
Neutron Generator Facility	870	295	233.5	47.5
Advanced Manufacturing Processes Laboratory	878	362	295.5	46.9
Microsystems and Engineering Sciences Applications (MESA) Complex	MESA	250	85	60.0
Compound Semiconductor Research Laboratory	893	351	101	19.0
Explosive Components Facility	905	523	275	30.8
Z-Machine	983	227	176.5	39.2
Radioactive and Mixed Waste Management Facility	6920	128	80	27.3
Sandia Pulsed Reactor	6593	144	103	22.0

Source: SNL/NM 1998h, 1999b

Table F.5–5. Annual Aircraft Impact Frequencies for SNL/NM Facilities

FACILITY	ANNUAL IMPACT FREQUENCY
Integrated Materials Research Laboratory	6.6×10^{-5}
Microelectronics Development Laboratory	9.7×10^{-5}
Neutron Generator Facility	6.0×10^{-5}
Advanced Manufacturing Processes Laboratory	3.2×10^{-5}
Microsystems and Engineering Sciences Applications Complex [a]	4.9×10^{-5}
Compound Semiconductor Research Laboratory [b]	4.3×10^{-5}
Explosive Components Facility	9.0×10^{-5}
Z-Machine	1.8×10^{-5}
Radioactive and Mixed Waste Management Facility	2.8×10^{-6}
Sandia Pulsed Reactor	6.3×10^{-6}

Source: Original
[a] Expanded Operations Only.
[b] No Action and Reduced Operations Alternatives

Table F.5–6. Summary of Aircraft Crash Frequencies for the Integrated Materials Research Laboratory

TYPE OF CRASH	AIRCRAFT OPERATION	AIRCRAFT CRASH FREQUENCY (per year)
Airport	Fixed-Wing – Single Engine (Takeoff)	5.6×10^{-6}
	Fixed-Wing – Single Engine (Landing)	6.9×10^{-6}
	Fixed-Wing – Twin Engine (Takeoff)	1.6×10^{-6}
	Fixed-Wing – Twin Engine (Landing)	2.7×10^{-6}
	Fixed-Wing – Turbojet (Takeoff)	4.0×10^{-8}
	Fixed-Wing – Turbojet (Landing)	9.0×10^{-8}
	Commercial Aviation Air Carrier (Takeoff)	6.4×10^{-6}
	Commercial Aviation Air Carrier (Landing)	3.5×10^{-6}
	Commercial Aviation Air Taxi (Takeoff)	1.1×10^{-5}
	Commercial Aviation Air Taxi (Landing)	7.5×10^{-6}
	Military Aviation Large Aircraft (Takeoff)	1.4×10^{-7}
	Military Aviation Large Aircraft (Landing)	3.6×10^{-7}
	Military Aviation Small Aircraft (Takeoff)	5.4×10^{-6}
	Military Aviation Small Aircraft (Landing)	3.3×10^{-6}
Total of Airport Operations Aircraft Crash Frequency		**5.6×10^{-5}**
Nonairport	General Aviation	1.0×10^{-5}
	Commercial Aviation Air Carrier	7.0×10^{-9}
	Commercial Aviation Air Taxi	9.5×10^{-9}
	Military Aviation Large Aircraft	2.9×10^{-9}
	Military Aviation Small Aircraft	9.4×10^{-8}
Total of Nonairport Operations Aircraft Crash Frequency		**1.0×10^{-5}**
TOTAL AIRCRAFT CRASH FREQUENCY		**6.6×10^{-5}**

Source: Original

Table F.5–7. Summary of Aircraft Crash Frequencies for the Microelectronics Development Laboratory

TYPE OF CRASH	AIRCRAFT OPERATION	AIRCRAFT CRASH FREQUENCY (per year)
Airport	Fixed-Wing – Single Engine (Takeoff)	$1.0x10^{-5}$
	Fixed-Wing – Single Engine (Landing)	$1.2x10^{-5}$
	Fixed-Wing – Twin Engine (Takeoff)	$2.9x10^{-6}$
	Fixed-Wing – Twin Engine (Landing)	$1.5x10^{-6}$
	Fixed-Wing – Turbojet (Takeoff)	$7.3x10^{-8}$
	Fixed-Wing – Turbojet (Landing)	$1.6x10^{-7}$
	Commercial Aviation Air Carrier (Takeoff)	$1.1x10^{-5}$
	Commercial Aviation Air Carrier (Landing)	$2.3x10^{-6}$
	Commercial Aviation Air Taxi (Takeoff)	$1.9x10^{-5}$
	Commercial Aviation Air Taxi (Landing)	$4.7x10^{-6}$
	Military Aviation Large Aircraft (Takeoff)	$2.2x10^{-7}$
	Military Aviation Large Aircraft (Landing)	$4.6x10^{-7}$
	Military Aviation Small Aircraft (Takeoff)	$9.6x10^{-6}$
	Military Aviation Small Aircraft (Landing)	$4.1x10^{-6}$
Total of Airport Operations Aircraft Crash Frequency		**$7.9x10^{-5}$**
Nonairport	General Aviation	$1.9x10^{-5}$
	Commercial Aviation Air Carrier	$1.2x10^{-8}$
	Commercial Aviation Air Taxi	$1.7x10^{-8}$
	Military Aviation Large Aircraft	$4.6x10^{-9}$
	Military Aviation Small Aircraft	$1.6x10^{-7}$
Total of Nonairport Operations Aircraft Crash Frequency		**$1.9x10^{-5}$**
TOTAL AIRCRAFT CRASH FREQUENCY		**$9.7x10^{-5}$**

Source: Original

Table F.5–8. Summary of Aircraft Crash Frequencies for the Neutron Generator Facility

TYPE OF CRASH	AIRCRAFT OPERATION	AIRCRAFT CRASH FREQUENCY (per year)
Airport	Fixed-Wing – Single Engine (Takeoff)	$5.5x10^{-6}$
	Fixed-Wing – Single Engine (Landing)	$6.8x10^{-6}$
	Fixed-Wing – Twin Engine (Takeoff)	$1.6x10^{-6}$
	Fixed-Wing – Twin Engine (Landing)	$2.6x10^{-6}$
	Fixed-Wing – Turbojet (Takeoff)	$3.9x10^{-8}$
	Fixed-Wing – Turbojet (Landing)	$8.9x10^{-8}$
	Commercial Aviation Air Carrier (Takeoff)	$6.7x10^{-6}$
	Commercial Aviation Air Carrier (Landing)	$3.7x10^{-6}$
	Commercial Aviation Air Taxi (Takeoff)	$1.0x10^{-5}$
	Commercial Aviation Air Taxi (Landing)	$7.0x10^{-6}$
	Military Aviation Large Aircraft (Takeoff)	$1.4x10^{-6}$
	Military Aviation Large Aircraft (Landing)	$3.5x10^{-7}$
	Military Aviation Small Aircraft (Takeoff)	$5.5x10^{-7}$
	Military Aviation Small Aircraft (Landing)	$3.3x10^{-6}$
Total of Airport Operations Aircraft Crash Frequency		**$5.0x10^{-5}$**
Nonairport	General Aviation	$1.0x10^{-5}$
	Commercial Aviation Air Carrier	$7.3x10^{-9}$
	Commercial Aviation Air Taxi	$1.0x10^{-8}$
	Military Aviation Large Aircraft	$3.0x10^{-9}$
	Military Aviation Small Aircraft	$9.4x10^{-8}$
Total of Nonairport Operations Aircraft Crash Frequency		**$1.0x10^{-5}$**
TOTAL AIRCRAFT CRASH FREQUENCY		**$6.0x10^{-5}$**

Source: Original

Table F.5–9. Summary of Aircraft Crash Frequencies for the Advanced Manufacturing Processes Laboratory

TYPE OF CRASH	AIRCRAFT OPERATION	AIRCRAFT CRASH FREQUENCY (per year)
Airport	Fixed-Wing – Single Engine (Takeoff)	4.4×10^{-6}
	Fixed-Wing – Single Engine (Landing)	5.3×10^{-6}
	Fixed-Wing – Twin Engine (Takeoff)	1.2×10^{-6}
	Fixed-Wing – Twin Engine (Landing)	2.0×10^{-6}
	Fixed-Wing – Turbojet (Takeoff)	3.1×10^{-8}
	Fixed-Wing – Turbojet (Landing)	6.9×10^{-8}
	Commercial Aviation Air Carrier (Takeoff)	2.8×10^{-6}
	Commercial Aviation Air Carrier (Landing)	1.5×10^{-7}
	Commercial Aviation Air Taxi (Takeoff)	4.3×10^{-6}
	Commercial Aviation Air Taxi (Landing)	2.9×10^{-7}
	Military Aviation Large Aircraft (Takeoff)	8.3×10^{-7}
	Military Aviation Large Aircraft (Landing)	2.4×10^{-7}
	Military Aviation Small Aircraft (Takeoff)	3.6×10^{-7}
	Military Aviation Small Aircraft (Landing)	1.9×10^{-6}
Total of Airport Operations Aircraft Crash Frequency		**2.4×10^{-5}**
Nonairport	General Aviation	7.8×10^{-6}
	Commercial Aviation Air Carrier	3.0×10^{-9}
	Commercial Aviation Air Taxi	3.7×10^{-9}
	Military Aviation Large Aircraft	1.8×10^{-9}
	Military Aviation Small Aircraft	4.6×10^{-8}
Total of Nonairport Operations Aircraft Crash Frequency		**7.9×10^{-6}**
TOTAL AIRCRAFT CRASH FREQUENCY		**3.2×10^{-5}**

Source: Original

Table F.5–10. Summary of Aircraft Crash Frequencies for the Explosive Components Facility

TYPE OF CRASH	AIRCRAFT OPERATION	AIRCRAFT CRASH FREQUENCY (per year)
Airport	Fixed-Wing – Single Engine (Takeoff)	7.3×10^{-6}
	Fixed-Wing – Single Engine (Landing)	8.6×10^{-6}
	Fixed-Wing – Twin Engine (Takeoff)	2.1×10^{-6}
	Fixed-Wing – Twin Engine (Landing)	3.3×10^{-6}
	Fixed-Wing – Turbojet (Takeoff)	5.2×10^{-8}
	Fixed-Wing – Turbojet (Landing)	1.1×10^{-7}
	Commercial Aviation Air Carrier (Takeoff)	9.2×10^{-6}
	Commercial Aviation Air Carrier (Landing)	5.1×10^{-6}
	Commercial Aviation Air Taxi (Takeoff)	1.6×10^{-5}
	Commercial Aviation Air Taxi (Landing)	1.1×10^{-5}
	Military Aviation Large Aircraft (Takeoff)	1.8×10^{-6}
	Military Aviation Large Aircraft (Landing)	4.2×10^{-7}
	Military Aviation Small Aircraft (Takeoff)	7.2×10^{-6}
	Military Aviation Small Aircraft (Landing)	4.4×10^{-6}
Total of Airport Operations Aircraft Crash Frequency		**7.7×10^{-5}**
Nonairport	General Aviation	1.3×10^{-5}
	Commercial Aviation Air Carrier	1.0×10^{-8}
	Commercial Aviation Air Taxi	1.4×10^{-8}
	Military Aviation Large Aircraft	3.9×10^{-9}
	Military Aviation Small Aircraft	1.2×10^{-7}
Total of Nonairport Operations Aircraft Crash Frequency		**1.3×10^{-5}**
TOTAL AIRCRAFT CRASH FREQUENCY		**9.0×10^{-5}**

Source: Original

Table F.5–11. Summary of Aircraft Crash Frequencies for the Z-Machine

TYPE OF CRASH	AIRCRAFT OPERATION	AIRCRAFT CRASH FREQUENCY (per year)
Airport	Fixed-Wing – Single Engine (Takeoff)	2.5×10^{-6}
	Fixed-Wing – Single Engine (Landing)	2.0×10^{-6}
	Fixed-Wing – Twin Engine (Takeoff)	7.2×10^{-7}
	Fixed-Wing – Twin Engine (Landing)	7.8×10^{-7}
	Fixed-Wing – Turbojet (Takeoff)	1.8×10^{-8}
	Fixed-Wing – Turbojet (Landing)	2.7×10^{-8}
	Commercial Aviation Air Carrier (Takeoff)	7.0×10^{-7}
	Commercial Aviation Air Carrier (Landing)	8.5×10^{-9}
	Commercial Aviation Air Taxi (Takeoff)	1.2×10^{-6}
	Commercial Aviation Air Taxi (Landing)	3.0×10^{-8}
	Military Aviation Large Aircraft (Takeoff)	3.0×10^{-7}
	Military Aviation Large Aircraft (Landing)	3.2×10^{-7}
	Military Aviation Small Aircraft (Takeoff)	2.5×10^{-6}
	Military Aviation Small Aircraft (Landing)	1.8×10^{-6}
Total of Airport Operations Aircraft Crash Frequency		**1.3×10^{-5}**
Nonairport	General Aviation	5.1×10^{-6}
	Commercial Aviation Air Carrier	2.6×10^{-9}
	Commercial Aviation Air Taxi	3.0×10^{-9}
	Military Aviation Large Aircraft	1.4×10^{-9}
	Military Aviation Small Aircraft	3.2×10^{-8}
Total of Nonairport Operations Aircraft Crash Frequency		**5.1×10^{-6}**
TOTAL AIRCRAFT CRASH FREQUENCY		**1.8×10^{-5}**

Source: Original

Table F.5–12. Summary of Aircraft Crash Frequencies for the Radioactive and Mixed Waste Management Facility

TYPE OF CRASH	AIRCRAFT OPERATION	AIRCRAFT CRASH FREQUENCY (per year)
Airport	Fixed-Wing – Single Engine (Takeoff)	0.0×10^{1}
	Fixed-Wing – Single Engine (Landing)	9.9×10^{-9}
	Fixed-Wing – Twin Engine (Takeoff)	0.0×10^{1}
	Fixed-Wing – Twin Engine (Landing)	3.8×10^{-9}
	Fixed-Wing – Turbojet (Takeoff)	0.0
	Fixed-Wing – Turbojet (Landing)	1.3×10^{-10}
	Commercial Aviation Air Carrier (Takeoff)	7.7×10^{-9}
	Commercial Aviation Air Carrier (Landing)	0.0
	Commercial Aviation Air Taxi (Takeoff)	1.2×10^{-8}
	Commercial Aviation Air Taxi (Landing)	0.0
	Military Aviation Large Aircraft (Takeoff)	0.0
	Military Aviation Large Aircraft (Landing)	7.6×10^{-9}
	Military Aviation Small Aircraft (Takeoff)	2.9×10^{-7}
	Military Aviation Small Aircraft (Landing)	0.0
Total of Airport Operations Aircraft Crash Frequency		**3.3×10^{-7}**
Nonairport	General Aviation	2.4×10^{-6}
	Commercial Aviation Air Carrier	2.0×10^{-9}
	Commercial Aviation Air Taxi	2.2×10^{-9}
	Military Aviation Large Aircraft	8.3×10^{-10}
	Military Aviation Small Aircraft	2.4×10^{-8}
Total of Nonairport Operations Aircraft Crash Frequency		**2.4×10^{-6}**
TOTAL AIRCRAFT CRASH FREQUENCY		**2.8×10^{-6}**

Source: Original

Table F.5–13. Summary of Aircraft Crash Frequencies for the Sandia Pulsed Reactor

TYPE OF CRASH	AIRCRAFT OPERATION	AIRCRAFT CRASH FREQUENCY (per year)
Airport	Fixed-Wing – Single Engine (Takeoff)	1.7×10^{-6}
	Fixed-Wing – Single Engine (Landing)	8.4×10^{-7}
	Fixed-Wing – Twin Engine (Takeoff)	4.9×10^{-7}
	Fixed-Wing – Twin Engine (Landing)	3.2×10^{-7}
	Fixed-Wing – Turbojet (Takeoff)	1.2×10^{-8}
	Fixed-Wing – Turbojet (Landing)	1.1×10^{-8}
	Commercial Aviation Air Carrier (Takeoff)	2.7×10^{-8}
	Commercial Aviation Air Carrier (Landing)	0.0
	Commercial Aviation Air Taxi (Takeoff)	5.3×10^{-8}
	Commercial Aviation Air Taxi (Landing)	1.5×10^{-7}
	Military Aviation Large Aircraft (Takeoff)	0.0
	Military Aviation Large Aircraft (Landing)	4.8×10^{-8}
	Military Aviation Small Aircraft (Takeoff)	1.0×10^{-7}
	Military Aviation Small Aircraft (Landing)	3.4×10^{-8}
Total of Airport Operations Aircraft Crash Frequency		**3.8×10^{-6}**
Nonairport	General Aviation	2.5×10^{-6}
	Commercial Aviation Air Carrier	3.2×10^{-9}
	Commercial Aviation Air Taxi	4.0×10^{-9}
	Military Aviation Large Aircraft	1.4×10^{-9}
	Military Aviation Small Aircraft	3.2×10^{-8}
Total of Nonairport Operations Aircraft Crash Frequency		**2.5×10^{-6}**
TOTAL AIRCRAFT CRASH FREQUENCY		**6.3×10^{-6}**

Source: Original

Table F.5–14. Summary of Aircraft Crash Frequencies for the Microsystems and Engineering Sciences Applications Complex

TYPE OF CRASH	AIRCRAFT OPERATION	AIRCRAFT CRASH FREQUENCY (per year)
Airport	Fixed-Wing – Single Engine (Takeoff)	4.2×10^{-6}
	Fixed-Wing – Single Engine (Landing)	4.5×10^{-6}
	Fixed-Wing – Twin Engine (Takeoff)	1.2×10^{-6}
	Fixed-Wing – Twin Engine (Landing)	1.7×10^{-6}
	Fixed-Wing – Turbojet (Takeoff)	2.9×10^{-8}
	Fixed-Wing – Turbojet (Landing)	5.9×10^{-8}
	Commercial Aviation Air Carrier (Takeoff)	5.1×10^{-6}
	Commercial Aviation Air Carrier (Landing)	2.8×10^{-6}
	Commercial Aviation Air Taxi (Takeoff)	8.5×10^{-6}
	Commercial Aviation Air Taxi (Landing)	5.9×10^{-6}
	Military Aviation Large Aircraft (Takeoff)	1.1×10^{-6}
	Military Aviation Large Aircraft (Landing)	2.7×10^{-7}
	Military Aviation Small Aircraft (Takeoff)	4.1×10^{-6}
	Military Aviation Small Aircraft (Landing)	2.6×10^{-6}
Total of Airport Operations Aircraft Crash Frequency		**4.2×10^{-5}**
Nonairport	General Aviation	7.3×10^{-6}
	Commercial Aviation Air Carrier	5.6×10^{-9}
	Commercial Aviation Air Taxi	7.5×10^{-9}
	Military Aviation Large Aircraft	7.3×10^{-9}
	Military Aviation Small Aircraft	7.3×10^{-8}
Total of Nonairport Operations Aircraft Crash Frequency		**7.4×10^{-6}**
TOTAL AIRCRAFT CRASH FREQUENCY		**4.9×10^{-5}**

Source: Original

Table F.5–15. Summary of Aircraft Crash Frequencies for the Compound Semiconductor Research Laboratory

TYPE OF CRASH	AIRCRAFT OPERATION	AIRCRAFT CRASH FREQUENCY (per year)
Airport	Fixed-Wing – Single Engine (Takeoff)	$2.7x10^{-6}$
	Fixed-Wing – Single Engine (Landing)	$3.0x10^{-6}$
	Fixed-Wing – Twin Engine (Takeoff)	$7.6x10^{-7}$
	Fixed-Wing – Twin Engine (Landing)	$1.2x10^{-6}$
	Fixed-Wing – Turbojet (Takeoff)	$1.9x10^{-8}$
	Fixed-Wing – Turbojet (Landing)	$4.0x10^{-8}$
	Commercial Aviation Air Carrier (Takeoff)	$5.3x10^{-6}$
	Commercial Aviation Air Carrier (Landing)	$2.9x10^{-6}$
	Commercial Aviation Air Taxi (Takeoff)	$9.1x10^{-6}$
	Commercial Aviation Air Taxi (Landing)	$6.3x10^{-6}$
	Military Aviation Large Aircraft (Takeoff)	$1.0x10^{-6}$
	Military Aviation Large Aircraft (Landing)	$2.1x10^{-7}$
	Military Aviation Small Aircraft (Takeoff)	$3.2x10^{-6}$
	Military Aviation Small Aircraft (Landing)	$2.2x10^{-6}$
Total of Airport Operations Aircraft Crash Frequency		**$3.9x10^{-5}$**
Nonairport	General Aviation	$4.8x10^{-6}$
	Commercial Aviation Air Carrier	$5.8x10^{-9}$
	Commercial Aviation Air Taxi	$8.0x10^{-9}$
	Military Aviation Large Aircraft	$2.2x10^{-9}$
	Military Aviation Small Aircraft	$6.0x10^{-8}$
Total of Nonairport Operations Aircraft Crash Frequency		**$4.9X10^{-6}$**
TOTAL AIRCRAFT CRASH FREQUENCY		**$4.3X10^{-5}$**

Source: Original

F.6 OTHER FACILITY HAZARDS

Potential accidents and their impacts associated with facility hazards are described in various SNL/NM reports (SNL/NM 1998a). SNL/NM facilities vary in their documentation of hazards and potential accidents. This section summarizes the hazards at SNL/NM facilities in TAs-I, -III, and -IV and the Coyote Test Field (for which accident information is provided in these reports), which are not otherwise addressed in Sections F.2, F.3, and F.4. The results shown for these facilities are considered representative of the potential accidents associated with facility hazards at other facilities in these TAs. The results given are applicable to the No Action, Expanded Operations, and Reduced Operations Alternatives.

Table F.6–1. Frequency Descriptors

LIKELIHOOD	FREQUENCY DESCRIPTOR	FREQUENCY (per year)
A	Likely	$F > 10^{-2}$
B	Unlikely	$10^{-3} < F < 10^{-2}$
C	Occasional	$10^{-4} < F < 10^{-3}$
D	Extremely Unlikely	$10^{-6} < F < 10^{-4}$
E	Incredible	$F < 10^{-6}$

Source: DOE 1994c

Accident frequencies have been categorized as shown in Table F.6–1. The risk matrix in Table F.6–2 shows the severity of hazards qualitatively, reflecting both the accident frequency and consequence (for example, an accident with a risk of III/D is an accident with "significant" consequences and a frequency of "extremely unlikely"). This method of categorization of frequencies and hazard severity follows the format of input information provided in source documents, but differs from other methods of categorizing that follow DOE-STD-3009, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Report* (DOE 1994c).

Table F.6–3 lists the hazards at many SNL/NM facilities. Many of these hazards represent routine workplace risks of injury and fatality for involved workers.

F.6.1 Technical Area-II

F.6.1.1 Explosive Components Facility

Hazards associated with the ECF are shown in Table F.6–4. The table identifies the accident risk index for nine hazardous events or activities at the facility. Risk matrixes for the worker, onsite individual, and offsite public are shown in Tables F.6–5, F.6–6, and F.6–7, respectively.

F.6.2 Technical Area-III

F.6.2.1 Radioactive and Mixed Waste Management Facility

Hazards associated with the RMWMF are shown in Table F.6–8. The table identifies the accident risk index for 10 hazardous events or activities at the facility. Risk matrixes for the worker, onsite individual, and offsite public are shown in Tables F.6–9, F.6–10, and F.6–11, respectively.

F.6.2.2 Sled Track Complex

Hazards associated with the Sled Track Complex are shown in Table F.6–12. The table identifies the accident risk index for 11 hazardous events or activities at the facility. Risk matrixes for the worker, onsite individual, and offsite public are shown in Tables F.6–13, F.6–14, and F.6–15, respectively.

Table F.6–2. Risk Matrix

LIKELIHOOD	CONSEQUENCE SEVERITY				
	CATASTROPHIC I	CRITICAL II	SIGNIFICANT III	MARGINAL IV	NEGLIGIBLE V
A - Likely	I/A	II/A	III/A	IV/A	V/A
B - Unlikely	I/B	II/B	III/B	IV/B	V/B
C - Occasional	I/C	II/C	III/C	IV/C	V/C
D - Extremely Unlikely	I/D	II/D	III/D	IV/D	V/D
E - Incredible	I/E	II/E	III/E	IV/E	V/E

Source: DOE 1994c

Table F.6–3. Facility Hazards

FACILITY	HAZARDS
TECHNICAL AREA-I	
Microelectronics Development Laboratory	Compressed gas cylinders, chemical storage bays, bulk chemical storage, flammable gas bunkers, hydrogen supply tank, and gas cabinets
6-MeV Tandem Van Der Graaf Generator	Ionizing radiation, high voltage, insulating gases, and ammonia
Photovoltaic Device Fabrication Laboratory	Various toxic and hazardous materials
Lightning Simulation Facility	Lasers, fluorine
Integrated Materials Research Laboratory	Various hazardous chemicals
Systems Research and Development Facility	Laser operations, hazardous chemicals, flammable gases, compressed gas, chemical storage containers
Compound Semiconductor Research Laboratory	Hazardous chemicals, chemical storage containers
Advanced Manufacturing Processes Laboratory	Hazardous chemicals, chemical storage containers, tritium
Power Development Laboratory	Hazardous chemicals, chemical storage containers
Ion Beam Materials Research Laboratory	Hazardous chemicals, chemical storage containers, sealed radioactive sources
Neutron Generator Facility	Tritium, hydrogen
TECHNICAL AREA-II	
Explosive Components Facility	Fire, explosion, radiation, toxic or hazardous materials, laser beams
TECHNICAL AREA-III	
Sled Track Complex	Explosive materials, laboratory chemicals, compressed gases, radioactive materials
Radiant Heat Facility	Chemicals, compressed gases, combustible materials
Terminal Ballistics Complex	Flak and shrapnel, large projectiles, rocket motors, X-ray, explosives, flammable materials
Drop/Impact Complex	Noise, metal fragments
Centrifuge Complex	Noise, fragment projectiles

Table F.6–3. Facility Hazards (continued)

FACILITY	HAZARDS
Liquid Metal Processing Laboratory	Carbon monoxide cylinder storage
Hammermill	Normal industrial hazards
TECHNICAL AREA-IV	
High Energy Radiation Megavolt Electron Source (HERMES III)	Electric shock, X-rays, hazardous chemicals and materials, flammables, laser beams
Z-Machine	Electric shock, X-rays, hazardous chemicals and materials, flammables, laser beams
Repetitive High Energy Pulsed Power Unit I (RHEPP I)	Electric shock, X-rays, hazardous chemicals and materials, flammables
Repetitive High Energy Pulsed Power Unit II (RHEPP II)	Electric shock, X-rays, hazardous chemicals and materials, flammables
Sandia Accelerator & Beam Research Experiment (SABRE)	Electric shock, X-rays, hazardous chemicals and materials, flammables, laser beams
SATURN	Electric shock, X-rays, hazardous chemicals and materials, flammables
Short-Pulse High Intensity Nanosecond X-Radiator (SPHINX)	Electric shock, X-rays, hazardous chemicals and materials, flammables
Tera-Electron Volt Semiconducting Linear Accelator (TESLA)	Electric shock, X-rays, hazardous chemicals and materials, flammables
High Power Microwave Laboratory	Electric shock, X-rays, hazardous chemicals and materials, flammables
Advanced Pulsed Power Research Module	Electric shock, X-rays, hazardous chemicals and materials, flammables, laser beams
Pelletron	Electric shock, X-rays, hazardous chemicals and materials, flammables
Excimer Laser Processing Laboratory	Hazardous chemicals, laser operations
TECHNICAL AREA-V	
Annular Core Research Reactor	Radioactive fission products, high energy sources, high pressures, explosives
Sandia Pulsed Reactor	Radioactive fission products, liquid nitrogen
Hot Cell Facility	Radioactive fission products, hazardous chemicals, compressed gases
Gamma Irradiation Facility	High-intensity radioactive sources, ozone

Table F.6–3. Facility Hazards (concluded)

FACILITY	HAZARDS
COYOTE TEST FIELD	
Manzano Waste Storage Facilities	Radioactive wastes, toxic wastes
Aerial Cable Facility	Rocket motors and explosives, missiles, artillery, hot test debris, radioactive materials
Containment Technology Test Facility-West	Airborne fragments, noise
National Solar Thermal Test Facility	Concentrated solar energy
Explosives Application Laboratory	Explosives, acetylene welding, X-rays
Lurance Canyon Burn Site	Radioactive materials, rocket propellant, aviation fuel, toxic plumes
Exterior Sensor Field	Hazardous wastes
Photovoltaic Systems Evaluation Laboratory	Lead acid-battery chemicals, electricity
INFRASTRUCTURE	
Steam Plant	Natural gas, diesel fuel, steam
Hazardous Waste Management Facility	Hazardous chemical wastes
Radioactive and Mixed Waste Management Facility	Flammable and combustible waste, reactive waste, radioactive waste

Source: SNL/NM 1998a
MeV: million electron volts

Table F.6–4. Explosive Components Facility Accident Risk

EVENT	RISK INDEX		
	INVOLVED WORKER	ONSITE INDIVIDUAL	OFFSITE PUBLIC
Unintentional detonation of 1,000 g of high explosives in shipping and receiving	I/D	V/D	V/D
Unintentional detonation of 500 g of high explosives during transportation inside of Explosive Components Facility	I/D	V/D	V/D
Unintentional detonation of 5 lb of high explosives in magazine area	I/D	V/D	V/D
Unintentional detonation of 500 g of high explosives during physical testing	I/D	V/D	V/D
Unintentional detonation of 1,000 g of high explosives during explosive test firing	I/D	V/D	V/D
Premature detonation of 50 g of high explosives during gas gun testing	I/D	V/D	V/D
Unintentional deflagration of 1,500 g of high propellant during abuse testing	I/D	V/D	V/D
Violent rupture of lithium cell or expulsion of thionyl chloride during battery testing	II/B	V/B	V/B
Aircraft crash	II/B	V/B	V/B

Source: SNL/NM 1998a
g: gram
lb: pound

Table F.6–5. Explosive Components Facility Involved Worker Risk Matrix

LIKELIHOOD	HAZARD SEVERITY				
	CATASTROPHIC I	CRITICAL II	SIGNIFICANT III	MARGINAL IV	NEGLIGIBLE V
A-Likely					
B-Unlikely		II/B			
C-Occasional					
D-Extremely Unlikely	I/D				
E-Incredible					

Source: SNL/NM 1998a

Table F.6–6. Explosive Components Facility Onsite Individual Risk Matrix

LIKELIHOOD	HAZARD SEVERITY				
	CATASTROPHIC I	CRITICAL II	SIGNIFICANT III	MARGINAL IV	NEGLIGIBLE V
A-Likely					
B-Unlikely					V/B
C-Occasional					
D-Extremely Unlikely					V/D
E-Incredible					

Source: SNL/NM 1998a

Table F.6–7. Explosive Components Facility Offsite Public Risk Matrix

LIKELIHOOD	HAZARD SEVERITY				
	CATASTROPHIC I	CRITICAL II	SIGNIFICANT III	MARGINAL IV	NEGLIGIBLE V
A-Likely					
B-Unlikely					V/B
C-Occasional					
D-Extremely Unlikely					V/D
E-Incredible					

Source: SNL/NM 1998a

Table F.6–8. Radioactive and Mixed Waste Management Facility Accident Risk

EVENT	RISK INDEX		
	INVOLVED WORKER	ONSITE INDIVIDUAL	OFFSITE PUBLIC
Severe earthquake	I/D	V/D	V/D
Severe wind	II/B	V/B	V/B
Aircraft crash	I/D	V/D	V/D
Waste container fire (outside building)	IV/B	V/B	V/B
Waste container ruptured by forklift	IV/A	V/A	V/A
Waste container rupture from internal pressure	IV/B	V/B	V/B
Local fire in building	IV/B	V/B	V/B
Liquified petroleum gas tank explosion	II/D	V/D	V/D
Fire in reactive waste storage building	IV/B	V/B	V/B
Fire in flammable waste storage building	IV/B	V/B	V/B

Source: SNL/NM 1998a

Table F.6–9. Radioactive and Mixed Waste Management Facility Involved Worker Risk Matrix

LIKELIHOOD	HAZARD SEVERITY				
	CATASTROPHIC I	CRITICAL II	SIGNIFICANT III	MARGINAL IV	NEGLIGIBLE V
A-Likely				IV/A	
B-Unlikely		II/B		IV/B	
C-Occasional					
D-Extremely Unlikely	I/D	II/D			
E-Incredible					

Source: SNL/NM 1998a

Table F.6–10. Radioactive and Mixed Waste Management Facility Onsite Individual Risk Matrix

LIKELIHOOD	HAZARD SEVERITY				
	CATASTROPHIC I	CRITICAL II	SIGNIFICANT III	MARGINAL IV	NEGLIGIBLE V
A-Likely					V/A
B-Unlikely					V/B
C-Occasional					
D-Extremely Unlikely					V/D
E-Incredible					

Source: SNL/NM 1998a

Table F.6–11. Radioactive and Mixed Waste Management Facility Offsite Public Risk Matrix

LIKELIHOOD	HAZARD SEVERITY				
	CATASTROPHIC I	CRITICAL II	SIGNIFICANT III	MARGINAL IV	NEGLIGIBLE V
A-Likely					V/A
B-Unlikely					V/B
C-Occasional					
D-Extremely Unlikely					V/D
E-Incredible					

Source: SNL/NM 1998a

Table F.6–12. Sled Track Complex Accident Risk

EVENT	RISK INDEX		
	INVOLVED WORKER	ONSITE INDIVIDUAL	OFFSITE PUBLIC
Explosives transportation	I/E	III/E	V/E
Explosives storage	I/D	II/D	V/D
Explosives assembly	I/D	III/D	N/A
Explosives arming	I/D	III/E	N/A
Explosives firing	I/D	III/D	N/A
Rocket motor transportation	I/E	III/E	V/E
Rocket motor storage	I/D	IV/D	V/D
Rocket motor assembly	I/D	III/D	N/A
Rocket motor arming	I/D	III/D	N/A
Fire set electrocution	I/E	N/A	N/A
Missiles and projectiles	I/E	V/E	II/E

Source: SNL/NM 1998a N/A: none applicable

Table F.6–13. Sled Track Complex Involved Worker Risk Matrix

LIKELIHOOD	HAZARD SEVERITY				
	CATASTROPHIC I	CRITICAL II	SIGNIFICANT III	MARGINAL IV	NEGLIGIBLE V
A-Likely					
B-Unlikely					
C-Occasional					
D-Extremely Unlikely	I/D				
E-Incredible	I/E				

Source: SNL/NM 1998a

Table F.6–14. Sled Track Complex Onsite Individual Risk Matrix

LIKELIHOOD	HAZARD SEVERITY				
	CATASTROPHIC I	CRITICAL II	SIGNIFICANT III	MARGINAL IV	NEGLIGIBLE V
A-Likely					
B-Unlikely					
C-Occasional					
D-Extremely Unlikely		II/D	III/D	IV/D	
E-Incredible			III/E		V/E

Source: SNL/NM 1998a

Table F.6–15. Sled Track Complex Offsite Public Risk Matrix

LIKELIHOOD	HAZARD SEVERITY				
	CATASTROPHIC I	CRITICAL II	SIGNIFICANT III	MARGINAL IV	NEGLIGIBLE V
A-Likely					
B-Unlikely					
C-Occasional					
D-Extremely Unlikely					V/D
E-Incredible		II/E			V/E

Source: SNL/NM 1998a

F.6.3 Technical Area-IV

F.6.3.1 Z-Machine

Hazards associated with the Z-Machine are shown in Table F.6–16. There are a number of other accelerators in TA-IV with potential accident hazards that are equivalent to the Z-Machine. The table identifies the accident risk index for 10 hazardous events or activities at the facility. Risk matrixes for the worker, onsite individual, and offsite public are shown in Tables F.6–17, F.6–18, and F.6–19, respectively.

Table F.6–16. Z-Machine Accident Risk

EVENT	RISK INDEX		
	INVOLVED WORKER	ONSITE INDIVIDUAL	OFFSITE PUBLIC
Electric shock	II/D	V/D	V/D
Radiation exposure	V/B	V/B	V/B
Fire	IV/E	V/E	V/E
Asphyxiation	I/D	V/D	V/D
Earthquake	V/B	V/B	V/B
Tornado	I/B	V/B	V/B
High winds	V/A	V/A	V/A
Flood	V/B	V/B	V/B
Aircraft crash	II/D	V/D	V/D
External oil spill	II/D	V/D	V/D

Source: SNL/NM 1998a

F.6.4 Aerial Cable Facility

F.6.4.1 Existing Hazards

Hazards associated with the Aerial Cable Facility and presented in the Aerial Cable Facility SAR are shown in Table F.6–20. The table identifies the accident risk index for 11 hazardous events or activities at the facility. Risk matrixes for the worker, onsite individual, and offsite public are shown in Tables F.6–21, F.6–22, and F.6–23, respectively.

F.6.4.2 New Proposed Activity

The accidental detonation of high explosives at the Aerial Cable Facility, not involving nuclear materials, has been estimated to have no impact on the public and potentially catastrophic consequences for involved workers (fatalities). The frequency of such an event has been estimated to beyond extremely unlikely (that is, less than 10^{-4} per year). An accident involving the release of nuclear materials at the Aerial Cable Facility, not involving explosives, has been estimated to have no impact on the public and no permanent effect on workers. These types of events include mechanical failures, such as a breach of the casing or component containing the nuclear material, that can cause localized contamination. Cleaning up the area would reduce any effects of ground contamination. There would be minimal worker exposure to radioactivity and no public exposure. The frequency of such an event has been estimated to be in the range of 10^{-6} to 10^{-4} per year. (SNL/NM 1995q).

Test activities proposed at the Aerial Cable Facility could include test specimens containing both explosives and nuclear material, which introduces the possibility of dispersal of the nuclear material by an accidental

Table F.6–17. Z-Machine Involved Worker Risk Matrix

LIKELIHOOD	HAZARD SEVERITY				
	CATASTROPHIC I	CRITICAL II	SIGNIFICANT III	MARGINAL IV	NEGLIGIBLE V
A-Likely					V/A
B-Unlikely	I/B				V/B
C-Occasional					
D-Extremely Unlikely	I/D	II/D			
E-Incredible				IV/E	

Source: SNL/NM 1998a

Table F.6–18. Z-Machine Onsite Individual Risk Matrix

LIKELIHOOD	HAZARD SEVERITY				
	CATASTROPHIC I	CRITICAL II	SIGNIFICANT III	MARGINAL IV	NEGLIGIBLE V
A-Likely					V/A
B-Unlikely					V/B
C-Occasional					
D-Extremely Unlikely					V/D
E-Incredible					V/E

Source: SNL/NM 1998a

Table F.6–19. Z-Machine Offsite Public Risk Matrix

LIKELIHOOD	HAZARD SEVERITY				
	CATASTROPHIC I	CRITICAL II	SIGNIFICANT III	MARGINAL IV	NEGLIGIBLE V
A-Likely					
B-Unlikely					V/B
C-Occasional					
D-Extremely Unlikely					V/D
E-Incredible					V/E

Source: SNL/NM 1998a

Table F.6–20. Aerial Cable Facility Accident Risk for Historical Activities

EVENT	RISK INDEX		
	INVOLVED WORKER	ONSITE INDIVIDUAL	OFFSITE PUBLIC
Explosives transportation	I/D	IV/D	IV/D
Explosives storage	I/D	IV/D	IV/D
Explosives assembly	II/C	IV/D	N/A
Explosives arming	I/D	IV/D	N/A
Explosives firing	I/D	IV/D	N/A
Rocket motor transportation	I/D	IV/D	IV/D
Rocket motor storage	I/D	IV/D	IV/D
Rocket motor assembly	I/C	IV/D	N/A
Rocket motor arming	I/D	IV/D	N/A
Fire set electrocution	I/C	N/A	N/A

Source: SNL/NM 1998a
N/A: not applicable

Table F.6–21. Aerial Cable Facility Involved Worker Risk Matrix

LIKELIHOOD	HAZARD SEVERITY				
	CATASTROPHIC I	CRITICAL II	SIGNIFICANT III	MARGINAL IV	NEGLIGIBLE V
A-Likely					
B-Unlikely					
C-Occasional	I/C	II/C			
D-Extremely Unlikely	I/D				
E-Incredible					

Source: SNL/NM 1998a

Table F.6–22. Aerial Cable Facility Onsite Individual Risk Matrix

LIKELIHOOD	HAZARD SEVERITY				
	CATASTROPHIC I	CRITICAL II	SIGNIFICANT III	MARGINAL IV	NEGLIGIBLE V
A-Likely					
B-Unlikely					
C-Occasional					
D-Extremely Unlikely				IV/D	
E-Incredible					

Source: SNL/NM 1998a

Table F.6–23. Aerial Cable Facility Offsite Public Risk Matrix

LIKELIHOOD	HAZARD SEVERITY				
	CATASTROPHIC I	CRITICAL II	SIGNIFICANT III	MARGINAL IV	NEGLIGIBLE V
A-Likely					
B-Unlikely					
C-Occasional					
D-Extremely Unlikely	I/D			IV/D	
E-Incredible					

Source: SNL/NM 1998a

detonation of the explosives or a fire involving the explosives. Typical test specimens contain up to 734 lb of depleted uranium, 44 lb of enriched uranium, and 83 lb of insensitive high explosive (IHE) of the type PBX-9502 or LX-17 (Johns 1998). The specific activities of depleted uranium and enriched uranium are $3.3x10^{-7}$ Ci/g and $2.13x10^{-6}$ Ci/g, respectively. These specimens are nuclear weapon mockups, but they do not contain the materials and component configurations necessary to produce a nuclear yield even in the event of an accidental detonation of the explosives. Dispersal of nuclear material would be the worst possible consequence of an accident involving these specimens. Tests of assemblies with any possibility of producing nuclear yield are prohibited at SNL/NM. Tables F.6–24 through F.6–26 present the population distribution, the distance by direction for the core receptors, and the distance by direction to the KAFB boundary.

Scenario 1: Fire Causing IHE Deflagration

During testing, staging, or local transport, a fire starts external to the specimen and progresses to and ignites the IHE. Such a fire at the Aerial Cable Facility is unlikely. The test area is clear of vegetation and most other combustible materials. The fuel from vehicles is one possible source of a fire, however.

Only deflagration of the IHE is postulated for this scenario, even though the IHE is in a confined configuration. It is assumed that the heat of the fire does not detonate the explosives. To bound the radiological consequences of this scenario, the IHE deflagration is postulated to completely consume and oxidize the enriched uranium present in the specimen. The uranium will not be in an exposed metal configuration and any oxidation, no less complete oxidation, is unlikely. In addition, the uranium is assumed to be pure uranium-235 even though the enriched uranium in the test specimen will be less than 100 percent uranium-235. The depleted uranium is not considered as a source for

Table F.6–24. Population Distribution Surrounding the Aerial Cable Facility

DIRECTION	DISTANCE (miles)									
	0.12	0.5	1	1.5	2	2.5	3	3.5	4	4.5
N	0	0	0	0	0	0	0	0	73	82
NNE	0	0	0	0	0	0	0	0	68	81
NE	0	0	0	0	0	0	0	0	75	84
ENE	0	0	0	0	0	0	0	0	71	88
E	0	0	0	0	0	0	0	0	71	80
ESE	0	0	0	0	0	0	0	0	71	80
SE	0	0	0	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0	0	74	77
S	0	0	0	0	0	0	0	66	66	80
SSW	0	0	0	0	0	0	0	0	72	77
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	61	71	88
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**127**	**712**	**817**

DIRECTION	DISTANCE (miles)								
	5	7.5	10	15	20	30	40	50	0-50
N	92	603	844	2,412	650	819	1,147	1,474	8,196
NNE	92	824	935	2,431	1,362	1,516	2,760	8,835	18,904
NE	90	604	844	2,004	1,079	2,331	3,260	4,131	14,502
ENE	87	604	849	820	805	2,325	3,256	1,751	10,656
E	100	602	844	157	137	2,229	1,142	526	5,888
ESE	99	591	847	2,341	894	277	388	498	6,086
SE	95	602	837	980	96	654	387	498	4,149
SSE	99	592	546	69	97	276	1,381	498	3,709
S	99	479	177	77	229	1,009	1,780	337	4,399
SSW	89	473	277	856	1,250	3,572	3,189	174	10,029
SW	0	601	549	911	1,269	7,334	10,534	1,371	22,569
WSW	0	0	5,035	9,065	6,762	10,080	5,545	5,324	41,811
W	0	0	17,291	40,769	7,877	9,644	10,710	2,603	88,894
WNW	0	0	3,840	58,181	63,847	37,314	10,020	4,160	177,362
NW	48	13,267	24,150	76,281	91,327	66,918	1,159	1,491	274,641
NNW	89	3,186	14,832	39,764	8,768	24,124	1,132	1,455	93,570
Total	**1,079**	**23,028**	**72,697**	**237,118**	**186,449**	**170,422**	**57,790**	**35,126**	**785,365**

Source: SNL/NM 1998dd

Table F.6–25. Distance and Direction to Core Receptor Locations from the Aerial Cable Facility

CORE RECEPTOR LOCATION	DIRECTION	DISTANCE (meters)
Base Housing	WNW	14,100
Child Development Center-East	WNW	14,300
Child Development Center-West	WNW	17,900
Coronado Club	WNW	14,100
Golf Course	WNW	9,600
Kirtland Elementary School	WNW	18,200
Kirtland Underground Munitions and Maintenance Storage Complex (KUMMSC)	W	11,700
Lovelace Hospital	WNW	16,200
National Atomic Energy Museum	WNW	13,600
Riding Stables	WNW	9,100
Sandia Base Elementary School	NW-WNW	13,900-14,000
Shandiin Day Care Center	WNW	14,100
Veterans Affairs Medical Center	WNW	15,800
Wherry Elementary School	WNW	14,700

Source: SNL/NM 1998dd
Notes:
1) If more than one direction is indicated, the core receptor location spans more than one section. The range in distance is also provided.
2) Distances are rounded to the nearest 100 m

Table F.6–26. Distance and Direction from Aerial Cable Facility to KAFB Boundary

DIRECTION	DISTANCE (meters)
N	5,000
NNE	5,100
NE	5,000
ENE	4,800
E	5,000
ESE	5,100
SE	6,000
SSE	5,100
S	4,900
SSW	4,900
SW	5,900
WSW	8,700
W	13,500
WNW	10,700
NW	4,100
NNW	4,200

Source: SNL/NM 1998dd
Note: Distances rounded to the nearest 100 m

radioactive release because its contribution to the dose consequences will be insignificant relative to the enriched uranium due to its low specific activity relative to enriched uranium. The likelihood of this scenario has been estimated to be in the frequency range of 10^{-6} to 10^{-4} per year.

Scenario 2: IHE Detonation

Similar to Scenario 1, a fire external to the test specimen starts during testing, staging, or local transport of the specimen. In this scenario, however, the fire progresses to the IHE, burns without intervention, and produces sufficient heat in the necessary spatial locations relative to the explosives to detonate the confined IHE. As in Scenario 1, bounding assumptions are postulated. The enriched uranium is assumed to be in an exposed metal form and to be pure uranium-235, and the depleted uranium is not included in the analysis because it will not contribute to the consequences. The likelihood of this scenario has been estimated to be in the frequency range of 10^{-6} to 10^{-4} per year.

Detonation of the IHE from the drop test impact has been identified as another possible initiator for this scenario. Detonation from impact is estimated to be in the frequency range of 10^{-5} to 10^{-4} per year for PBX-9502 IHE, and 10^{-7} to 10^{-5} per year for LX-17 IHE.

The radiological consequences of Scenarios 1 and 2 were determined based on the above descriptions and assumptions. For Scenario 1, the ARF and RF for thermal release of metallic uranium were used. These ARF/RF values are $1x10^{-3}$ and 1.0, respectively (DOE 1994b) (see Section 4.1, page 4–3). The buoyant plume model was used, assuming a 1-MW fire (see Section F.2.2) for an explanation of the basis for the fire size). For Scenario 2, the explosion was assumed to disperse the entire inventory of enriched uranium (such as, ARF/RF = 1.0/1.0). This is consistent with the recommendations in DOE-HDBK-3010-94 for the quantity of explosives present (DOE 1994b; see Section 4.1, page 4–3). The nonbuoyant plume model was used because the radioactive material is dispersed by the explosive pressure and not a thermal plume.

The calculated radiological consequences from Scenarios 1 and 2 are provided in Tables F.6–27 through F.6–29. If Scenario 1 were to occur, a noninvolved worker located as a distance of 100 m from the fire would receive an estimated dose of $3.8x10^{-4}$ rem and an increased probability of a latent cancer fatality of $1.5x10^{-7}$. Involved workers in closer proximity to the accident could receive injuries resulting from the fire and exposure to airborne radioactive material that is released. The MEI would receive an estimated dose of $4.4x10^{-7}$ rem and an increased probability of a latent cancer fatality of $2.2x10^{-10}$. The public, out to a distance of 50 miles, would receive an estimated dose of $4.3x10^{-3}$ person-rem and an increased number of latent cancer fatalities of $2.1x10^{-6}$.

If Scenario 2 were to occur, a noninvolved worker located at a distance of 100 m from the detonation would receive an estimated dose of 2.6 rem and an increased probability of a latent cancer fatality of $1.0x10^{-3}$. Involved workers in close proximity to the accident could receive injuries resulting from the detonation and exposure to airborne radioactive material and radioactive debris that are released. The MEI would receive an estimated dose of $4.0x10^{-4}$ rem and an increased probability of a latent cancer fatality of $2.0x10^{-7}$. The public, out to a distance of 50 mi, would receive an estimated dose of 3.5 person-rem and an increased number of latent cancer fatalities of $1.8x10^{-3}$.

For all scenarios discussed in this section, cleaning up the area would reduce the effects of ground contamination.

Dispersal of Hazardous Chemicals

In addition to the radiological hazards evaluated in the previous section, hazardous chemicals may also be present in some test specimens. A fire involving certain chemicals present in the specimens might generate toxic fumes. These chemical hazards would not affect the public because of the quantities involved and the dispersion that will occur over the distances involved (Table F.6–24). Involved workers could suffer minor consequences. It is assumed that involved workers will evacuate the area if a fire is initiated around a test specimen containing explosives, thereby limiting the impact. An accident scenario involving an explosion would have less impact than a scenario involving a fire because the explosion would disperse the chemicals locally without generating toxic fumes.

Table F.6–27. Aerial Cable Facility Radiological Consequences to Maximally Exposed Individual and Noninvolved Worker

Accident ID[a]	Accident Scenario Description	Accident Frequency (per year)	Applicable Alternative[b]	Maximally Exposed Individual[c]		Noninvolved Worker	
				Dose (rem)	Increased Probability of Latent Cancer Fatality	Dose (rem)	Increased Probability of Latent Cancer Fatality
ACF-1	IHE Deflagration	$1.0x10^{-4}$ to $1.0x10^{-6}$	All	$4.4x10^{-7}$	$2.2x10^{-10}$	$3.8x10^{-4}$	$1.5x10^{-7}$
ACF-2	IHE Explosion	$1.0x10^{-4}$ to $1.0x10^{-6}$	All	$4.0x10^{-4}$	$2.0x10^{-7}$	2.6	$1.0x10^{-3}$

Source: Original
IHE: insensitive high explosive
[a] Facility Accident Descriptors:
Aerial Cable Facility: ACF-1, ACF-2
[b] Applicable Alternative:
All–Scenario applicable to all three alternatives
[c] Maximally exposed individual located at site boundary

Table F.6–28. Aerial Cable Facility Radiological Consequences to the 50-Mile Population

ACCIDENT ID[a]	ACCIDENT SCENARIO DESCRIPTION	ACCIDENT FREQUENCY (per year)	DOSE (person-rem)	ADDITIONAL LATENT CANCER FATALITY
ALL ALTERNATIVES				
ACF-1	IHE Deflagration	$1.0x10^{-4}$ to $1.0x10^{-6}$	$4.3x10^{-3}$	$2.1x10^{-6}$
ACF-2	IHE Explosion	$1.0x10^{-4}$ to $1.0x10^{-6}$	3.5	$1.8x10^{-3}$

Source: Original
IHE: insensitive high explosive
[a] Facility Accident Descriptors:
Aerial Cable Facility: ACF-1, ACF-2

Table F.6–29. Aerial Cable Facility Radiological Consequences to Core Receptor Locations

ACCIDENT ID[a]	ACCIDENT SCENARIO DESCRIPTION	ACCIDENT FREQUENCY (per year)	APPLICABLE ALTERNATIVE[b]	DOSE (person-rem)	INCREASED PROBABILITY OF LATENT CANCER FATALITY	DOSE (person-rem)	INCREASED PROBABILITY OF LATENT CANCER FATALITY
				Kirtland Underground Munitions and Maintenance Storage Complex (KUMMSC) (8.1-12.1 km to W)		***Golf Course, Riding Stables (8.1 - 12.1 km to WNW)***	
ACF-1	IHE Deflagration	$1.0x10^{-4}$ to $1.0x10^{-6}$	All	$4.6x10^{-8}$	$2.3x10^{-11}$	$3.6x10^{-8}$	$1.8x10^{-11}$
ACF-2	IHE Explosion	$1.0x10^{-4}$ to $1.0x10^{-6}$	All	$3.9x10^{-5}$	$1.9x10^{-8}$	$3.1x10^{-5}$	$1.5x10^{-8}$
				Sandia Base Elementary (12.1 - 16.1 km to NW)		***Kirtland Elementary, Child Development Center - West, Lovelace Hospital (16.1 - 24.1 to NW)***	
ACF-1	IHE Deflagration	$1.0x10^{-4}$ to $1.0x10^{-6}$	All	$2.3x10^{-8}$	$1.2x10^{-11}$	$9.9x10^{-9}$	$4.9x10^{-12}$
ACF-2	IHE Explosion	$1.0x10^{-4}$ to $1.0x10^{-6}$	All	$1.8x10^{-5}$	$9.0x10^{-9}$	$8.3x10^{-6}$	$4.2x10^{-9}$
				Sandia Base Elementary, Wherry Elementary, Coronado Club, National Atomic Museum, Base Housing, Child Development Center - East, Shandiin Day Care Center, Veterans Affairs Medical Center (12.1 - 16.1 km to WNW)			
ACF-1	IHE Deflagration	$1.0x10^{-4}$ to $1.0x10^{-6}$	All	$1.9x10^{-10}$	$9.4x10^{-14}$		
ACF-2	IHE Explosion	$1.0x10^{-4}$ to $1.0x10^{-6}$	All	$1.6x10^{-5}$	$7.9x10^{-9}$		

Source: Original
IHE: insensitive high explosive

[a] Facility Accident Descriptors:
Aerial Cable Facility: ACF-1, ACF-2

[b] Applicable Alternative:
All–Scenario is applicable to all three alternatives

F.7 SITE-WIDE EARTHQUAKE

This section presents the impacts from a site-wide earthquake. The section is divided into three subsections. The first describes the methodology used to determine which buildings would remain intact after an earthquake of sufficient energy to destroy buildings throughout SNL/NM. The second describes the resulting radiological impacts, while the third describes the resulting chemical impacts.

F.7.1 Building Status Methodology

This subsection discusses the methodology for determining the structural status of selected buildings following an earthquake. The earthquake considered in this section is of an intensity specified in the UBC applicable for the SNL/NM area (SNL/NM 1995a). This earthquake is approximately 0.17 *g* acceleration.

All SNL/NM buildings were screened from 1997-1998 for life safety in response to Executive Order (EO) 12941 (59 FR 62545). This EO requested an inventory of all Federally owned or leased buildings and an estimate of the cost of mitigating unacceptable risks for the Federally owned buildings.

Paragon Structural Engineering, LLP, prepared a study for SNL/NM (Paragon 1997 & 1998) that complies with EO 12941. Paragon used the "LANL Seismic Screening Method" (LANL 1997) to determine the status of each building at SNL/NM. The Los Alamos National Laboratory (LANL) method uses two phases to determine the status of each facility. Phase I consists of a review of construction drawings and a visual inspection of the building. Phase II, through the use of capacity/demand ratios, identifies the buildings having inadequate strength to resist a lateral load. Phase II is a very conservative assessment; a more rigorous structural analysis may reveal additional structural capacity or lower seismic demand. For the SWEIS, if a building was designed after the benchmark year but failed Phase II, it was felt that a detailed analysis would show that the building would remain intact, because a detailed seismic study would have been performed to document that the building would meet the UBC. The benchmark year is the edition of the UBC where ductile detailing requirements were first incorporated.

Table F.7–1 shows the results of the study in two phases. For the SWEIS, it was assumed that all buildings or portions of buildings that were designed in years after the benchmark year and had passed Phase I would remain intact. If the buildings were designed prior to the benchmark year and had passed both Phase I and Phase II studies, the buildings were assumed to remain intact. Regardless of the year that the buildings were designed, if they did not pass Phase I, they were considered to fail. If the buildings were designed prior to the benchmark year, passed Phase I, and failed Phase II, they were also considered to fail. This logic is presented in Table F.7–2. Table F.7–3 presents the building responses for the purposes of the SWEIS. If a building was considered to remain intact for the purposes of the study, it means that the building did not receive enough damage to cause a catastrophic release from the building. If a building was considered not to remain intact for the purposes of the study, it means that the building would receive enough damage to cause a catastrophic release. This study did not evaluate in detail the amount of a building's collapse. The study's intent was to evaluate where the building would remain intact enough to allow occupants to evacuate the building safely.

The Paragon Study did not include the MESA Complex, because this facility has not yet even been designed. If implemented, the new MESA Complex would be designed to withstand the UBC earthquake.

F.7.2 Frequency of Earthquakes

The UBC, which is used in the design of buildings and facilities at SNL/NM, specifies different levels of earthquake severity depending on the proposed use of the building. For office and other nonhazardous use buildings, such as many of those in TA-I, the 0.17 *g* level is used as the design criteria. For facilities in TA-V, the design criteria are established at a higher level of loading (0.22 *g*).

Based on recently completed probabilistic ground motion estimates, the U.S. Geological Survey revised the mean annual frequency versus peak acceleration (USGS 1996). For SNL/NM stiff soil, an acceleration of 0.17 *g* has a frequency of 1.0×10^{-3}, while an acceleration of 0.22 *g* has a frequency of 7.0×10^{-4}. For a site-wide earthquake-induced release of chemicals, an acceleration of 0.17 *g* with a frequency of 1.0×10^{-3} is used. For an earthquake-induced release of radiological material, a ground acceleration of 0.22 *g* with a frequency of 7.0×10^{-4} is used. The Manzano Waste Storage Facilities, which may contain notable inventories of radioactive material, do not contribute to the site-wide earthquake accident. Accidents at these facilities are evaluated in Section F.2.8. The Manzano Waste Storage Facilities include four storage bunkers: two are drilled out of rock and two are reinforced concrete covered with several feet of soil. The Paragon study did not evaluate the underground bunkers, noting that these buildings will not require seismic upgrades (Paragon 1997 & 1998). The SAR for these facilities (SNL/NM 1997q) includes a detailed structural analysis that concludes that these

Table F.7–1. Summary of Results of Life Safety Study

BUILDING		AFTER BENCHMARK YEAR	RESULT	
NUMBER	NAME		PHASE I	PHASE II
823	*Systems Research and Development Facility*	yes	Passed	Failed
858	*Microelectronics Development Laboratory*	yes	North and south wings failed	Not calculated
			Clean room passed	Clean room failed
869	*Environmental Health Laboratory*	no	Failed	Not calculated
870	*Neutron Generator Facility*	yes	Passed	Passed
878	*Advanced Manufacturing Processes Laboratory*	yes	Passed	Failed
880	*Computing*	no	Failed	Not calculated
884	*Ion Beam Materials Research Laboratory*	no	Passed	Failed
888	*Lightning Simulation Facility*	yes	Passed	Passed
893	*Compound Semiconductor Research Laboratory*	yes	Equipment room addition (gas bunker) passed	Passed
			Clean room passed	Passed
			Rest of building failed	Not calculated
897	*Integrated Materials Research Laboratory*	yes	Passed	Failed
905	*Explosive Components Facility*	yes	Passed	Southwest wing passed
				Southeast wing (south half), passed
				Rest failed
6580	*Hot Cell Facility*	no	Failed	not calculated
6588	*Annular Core Research Reactor*	no	Failed	not calculated
6593	*Sandia Pulsed Reactor*	no	Kiva passed	not calculated
			Vault addition failed	not calculated

Source: Paragon 1997 &1998

Table F.7–2. Logic Used in Applying Life Safety Study

AFTER BENCHMARK YEAR	PHASE I	PHASE II	BUILDING STATUS
Yes	Passed	—	Intact
Yes	Failed	—	Not intact
No	Passed	Passed	Intact
No	Passed	Failed	Not intact
No	Failed	—	Not intact

Source: Original

Table F.7–3. Building Status as Applied for SWEIS Site-Wide Earthquake

NUMBER	BUILDING NAME	SNL/NM SWEIS BUILDING RESPONSE
823	*Systems Research and Development Facility*	Intact
858	*Microelectronics Development Laboratory*	Only clean room intact
869	*Environmental Health Laboratory*	Non intact
	Microsystems and Engineering Sciences Applications Complex	Only clean room intact
878	*Advanced Manufacturing Processes Laboratory*	Intact
880	*Computing*	Not intact
883 [a]	*Photovoltaic Device Fabrication Facility*	Assumed failed
884	*Ion Beam Materials Research Laboratory*	Not intact
888	*Lightning Simulation Facility*	Intact
893	*Compound Semiconductor Research Laboratory*	Gas bunker and clean room intact
897	*Integrated Materials Research Laboratory*	Intact
905	*Explosive Components Facility*	Not intact (areas with thionyl chloride assumed failed and explosive bunkers failed)
6580	*Hot Cell Facility*	Not intact
6588	*Annular Core Research Reactor*	Not intact
6593	*Sandia Pulsed Reactor*	Kiva intact; North Vault not intact

Source: Original

[a] Not included in Paragon study; therefore, the SWEIS analysis assumed failure of the building.

bunkers have sufficient structural capacity to withstand a UBC earthquake of 0.17 *g*. The SAR noted that even if one of these bunkers were to collapse in the event of a larger earthquake, any material stored inside would be buried in the soil and rubble and would not be released in any significant quantity.

F.7.3 Radiological Impact

The radiological impacts of a site-wide earthquake are shown in Tables F.7–4 through F.7–6. It is assumed that, in the event of an earthquake, all the TA-V facilities would fail except for the SPR Kiva. The highest impact accident on the site would be SP-1 for all alternatives. Under all alternatives except No Action, the ACRR would be configured for medical isotopes production. Under the No Action Alternative and in an emergency,

Table F.7–4. Site-Wide Earthquake Radiological Consequences to the Maximally Exposed Individual and Noninvolved Worker

ACCIDENT ID	ACCIDENT SCENARIO DESCRIPTION	ACCIDENT FREQUENCY (per year)	MAXIMALLY EXPOSED INDIVIDUAL		NONINVOLVED WORKER	
			DOSE (rem)	INCREASED PROBABILITY OF LATENT CANCER FATALITY	DOSE (rem)	INCREASED PROBABILITY OF LATENT CANCER FATALITY
NO ACTION ALTERNATIVE						
Technical Area-I						
NG-1	Catastrophic release of building's tritium	7.0×10^{-4}	2.9×10^{-6}	1.4×10^{-9}	7.9×10^{-3}	3.2×10^{-6}
Technical Area-II						
ECF-1	Catastrophic release of building's tritium	7.0×10^{-4}	3.1×10^{-7}	1.5×10^{-10}	4.6×10^{-4}	1.9×10^{-7}
Technical Area-V						
AM-2	Earthquake - collapse of bridge crane	7.0×10^{-4}	4.8×10^{-4}	2.4×10^{-7}	1.9×10^{-1}	7.4×10^{-5}
HC-1	Earthquake - building collapse	7.0×10^{-4}	1.4×10^{-2}	6.9×10^{-6}	3.7×10^{1}	3.0×10^{-2}
SP-1	Earthquake - building collapse	7.0×10^{-4}	1.2×10^{-3}	5.8×10^{-7}	6.9×10^{-1}	2.7×10^{-4}
AR-5	Earthquake - collapse of bridge crane	7.0×10^{-4}	1.7×10^{-3}	8.4×10^{-7}	5.6×10^{-1}	2.2×10^{-4}
NO ACTION ALTERNATIVE TOTALS			**1.7×10^{-2}**	**8.6×10^{-6}**	[c]	[c]
EXPANDED OPERATIONS ALTERNATIVE						
Technical Area-I						
NG-1	Catastrophic release of building's tritium	7.0×10^{-4}	2.9×10^{-6}	1.4×10^{-9}	7.9×10^{-3}	3.2×10^{-6}
Technical Area-II						
ECF-1	Catastrophic release of building's tritium	7.0×10^{-4}	3.1×10^{-7}	1.5×10^{-10}	4.6×10^{-4}	1.9×10^{-7}

Table F.7–4. Site-Wide Earthquake Radiological Consequences to the Maximally Exposed Individual and Noninvolved Worker (concluded)

ACCIDENT ID	ACCIDENT SCENARIO DESCRIPTION	ACCIDENT FREQUENCY (per year)	MAXIMALLY EXPOSED INDIVIDUAL		NONINVOLVED WORKER	
			DOSE (rem)	INCREASED PROBABILITY OF LATENT CANCER FATALITY	DOSE (rem)	INCREASED PROBABILITY OF LATENT CANCER FATALITY
Technical Area-V						
AM-2	Earthquake - collapse of bridge crane	7.0×10^{-4}	4.8×10^{-4}	2.4×10^{-7}	1.9×10^{-1}	7.4×10^{-5}
HC-1	Earthquake - building collapse	7.0×10^{-4}	1.4×10^{-2}	6.9×10^{-6}	3.7×10^{1}	3.0×10^{-2}
SP-1	Earthquake - building collapse	7.0×10^{-4}	1.2×10^{-3}	5.8×10^{-7}	6.9×10^{-1}	2.7×10^{-4}
EXPANDED OPERATIONS ALTERNATIVE TOTALS			**1.6×10^{-2}**	**7.8×10^{-6}**	[c]	[c]
REDUCED OPERATIONS ALTERNATIVE						
Technical Area-I						
NG-1	Catastrophic release of building's tritium	7.0×10^{-4}	2.9×10^{-6}	1.4×10^{-9}	7.9×10^{-3}	3.2×10^{-6}
Technical Area-II						
ECF-1	Catastrophic release of building's tritium	7.0×10^{-4}	3.1×10^{-7}	1.5×10^{-10}	4.6×10^{-4}	1.9×10^{-7}
Technical Area-V						
AM-2	Earthquake - collapse of bridge crane	7.0×10^{-4}	4.8×10^{-4}	2.4×10^{-7}	1.9×10^{-1}	7.4×10^{-5}
HC-1	Earthquake - building collapse	7.0×10^{-4}	1.4×10^{-2}	6.9×10^{-6}	3.7×10^{1}	3.0×10^{-2}
SP-1	Earthquake - building collapse	7.0×10^{-4}	1.2×10^{-3}	5.8×10^{-7}	6.9×10^{-1}	2.7×10^{-4}
REDUCED OPERATIONS ALTERNATIVE TOTALS			**1.6×10^{-2}**	**7.8×10^{-6}**	[c]	[c]

Source: Original

[a] Facility Accident Descriptors:
Annular Core Research Reactor-Defense Programs: AR-5
Annular Core Research Reactor-Medical Isotopes Production: AM-2
Explosive Component Facility: ECF-1
Hot Cell Facility: HC-1
Neutron Generator Facility: NG-1
Sandia Pulsed Reactor: SP-1

[b] The maximally exposed individual would be located at the Golf Course and the consequences can be added.

[c] Because the noninvolved worker would be 100 meters from the release, he would be located at different places for each technical area, therefore, the consequences cannot be added across technical areas.

Notes: 1) Under the No Action Alternative, the Annular Core Research Reactor can be operated in either the medical isotopes production or Defense Programs configuration. The highest consequence (AR-5) was used.
2) Under the Expanded Operations Alternative, the earthquake for the Annular Core Research Reactor-Defense Programs configuration is not applicable because the location or facility was not selected. It was assumed that the new facility would be designed to withstand the Uniform Building Code earthquake.

Table F.7–5. Site-Wide Earthquake Radiological Consequence to the 50-Mile Population

ACCIDENT ID[a]	ACCIDENT SCENARIO DESCRIPTION	ACCIDENT FREQUENCY (per year)	DOSE (person-rem)	ADDITIONAL LATENT CANCER FATALITY
NO ACTION ALTERNATIVE				
Technical Area-I				
NG-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$1.0x10^{-1}$	$5.1x10^{-5}$
Technical Area-II				
ECF-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$5.9x10^{-3}$	$3.0x10^{-6}$
Technical Area-V				
AM-2	Earthquake - collapse of bridge crane	$7.0x10^{-4}$	3.9	$2.0x10^{-3}$
HC-1	Earthquake - building collapse	$7.0x10^{-4}$	$1.3x10^{2}$	$6.4x10^{-2}$
SP-1	Earthquake - building collapse	$7.0x10^{-4}$	$1.8x10^{1}$	$9.2x10^{-3}$
AR-5	Earthquake - collapse of bridge crane	$7.0x10^{-4}$	$1.2x10^{1}$	$5.9x10^{-3}$
TOTALS FOR NO ACTION ALTERNATIVE			**$1.6x10^{2}$**	**$8.2x10^{-2}$**
EXPANDED OPERATIONS ALTERNATIVE				
Technical Area-I				
NG-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$1.0x10^{-1}$	$5.1x10^{-5}$
Technical Area-II				
ECF-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$5.9x10^{-3}$	$3.0x10^{-6}$
Technical Area-V				
AM-2	Earthquake - collapse of bridge crane	$7.0x10^{-4}$	3.9	$2.0x10^{-3}$
HC-1	Earthquake - building collapse	$7.0x10^{-4}$	$1.3x10^{2}$	$6.4x10^{-2}$
SP-1	Earthquake - building collapse	$7.0x10^{-4}$	$1.8x10^{1}$	$9.2x10^{-3}$
TOTALS FOR EXPANDED OPERATIONS ALTERNATIVE			**$1.5x10^{2}$**	**$7.6x10^{-2}$**
REDUCED OPERATIONS ALTERNATIVE				
Technical Area-I				
NG-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$1.0x10^{-1}$	$5.1x10^{-5}$
Technical Area-II				
ECF-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$5.9x10^{-3}$	$3.0x10^{-6}$
Technical Area-V				
AM-2	Earthquake - collapse of bridge crane	$7.0x10^{-4}$	3.9	$2.0x10^{-3}$
HC-1	Earthquake - building collapse	$7.0x10^{-4}$	$1.3x10^{2}$	$6.4x10^{-2}$
SP-1	Earthquake - building collapse	$7.0x10^{-4}$	$1.8x10^{1}$	$9.2x10^{-3}$
TOTALS FOR REDUCED OPERATIONS ALTERNATIVE			**$1.5x10^{2}$**	**$7.6x10^{-2}$**

Source: Original

[a] Facility Accident Descriptors:
Neutron Generator Facility: NG-1
Explosive Component Facility: ECF-1
Annular Core Research Reactor-Medical Isotopes Production: AM-2
Annular Core Research Reactor-Defense Programs: AR-5
Hot Cell Facility: HC-1
Sandia Pulsed Reactor: SP-1

Notes: 1) Under the No Action Alternative, the Annular Core Research Reactor can be operated in either the medical isotopes production or Defense Programs configuration. The highest consequence (AR-5) was used.
2) Under the Expanded Operations Alternative, the earthquake for the Annular Core Research Reactor-Defense Programs configuration would not be applicable because the location or facility was not selected. It was assumed that the new facility would be designed to withstand the Uniform Building Code earthquake.

Table F.7–6. Site-Wide Increased Probability of Latent Cancer Fatalities for Core Receptor Locations

ACCIDENT ID[a]	ACCIDENT SCENARIO DESCRIPTION	ACCIDENT FREQUENCY (per year)	DOSE (rem)	INCREASED PROBABILITY OF LATENT CANCER FATALITY	DOSE (rem)	INCREASED PROBABILITY OF LATENT CANCER FATALITY
NO ACTION ALTERNATIVE						
			Golf Course		***Riding Stables***	
NG-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$2.9x10^{-6}$	$1.4x10^{-9}$	$1.4x10^{-6}$	$6.8x10^{-10}$
ECF-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$3.1x10^{-7}$	$1.5x10^{-10}$	$7.9x10^{-8}$	$4.0x10^{-11}$
AM-2	Earthquake - collapse of bridge crane	$7.0x10^{-4}$	$4.8x10^{-4}$	$2.4x10^{-7}$	$4.7x10^{-4}$	$2.4x10^{-7}$
HC-1	Earthquake - building collapse	$7.0x10^{-4}$	$1.4x10^{-2}$	$6.9x10^{-6}$	$1.3x10^{-2}$	$6.3x10^{-6}$
SP-1	Earthquake - building collapse	$7.0x10^{-4}$	$1.2x10^{-3}$	$5.8x10^{-7}$	$1.1x10^{-3}$	$5.3x10^{-7}$
AR-5	Earthquake - collapse of bridge crane	$7.0x10^{-4}$	$1.7x10^{-3}$	$8.4x10^{-7}$	$1.6x10^{-3}$	$8.1x10^{-7}$
NO ACTION ALTERNATIVE			**$1.7x10^{-2}$**	**$8.3x10^{-6}$**	**$1.5x10^{-2}$**	**$7.6x10^{-6}$**
			Kirtland Underground Munitions and Maintenance Storage Complex (KUMMSC)		***National Atomic Museum***	
NG-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$1.1x10^{-6}$	$5.6x10^{-10}$	$5.7x10^{-6}$	$2.8x10^{-9}$
ECF-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$7.1x10^{-8}$	$3.5x10^{-11}$	$1.4x10^{-7}$	$7.0x10^{-11}$
AM-2	Earthquake - collapse of bridge crane	$7.0x10^{-4}$	$3.7x10^{-4}$	$1.9x10^{-7}$	$7.7x10^{-5}$	$3.9x10^{-8}$
HC-1	Earthquake - building collapse	$7.0x10^{-4}$	$1.1x10^{-2}$	$5.5x10^{-6}$	$1.5x10^{-3}$	$7.7x10^{-7}$
SP-1	Earthquake - building collapse	$7.0x10^{-4}$	$9.7x10^{-4}$	$4.8x10^{-7}$	$2.1x10^{-4}$	$1.1x10^{-7}$
AR-5	Earthquake - collapse of bridge crane	$7.0x10^{-4}$	$1.3x10^{-3}$	$6.5x10^{-7}$	$2.4x10^{-4}$	$1.2x10^{-7}$
NO ACTION ALTERNATIVE TOTALS			**$1.3x10^{-2}$**	**$6.6x10^{-6}$**	**$2.0x10^{-3}$**	**$9.9x10^{-7}$**
			Base Housing		***Shandiin Day Care Center***	
NG-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$2.5x10^{-6}$	$1.2x10^{-9}$	$2.5x10^{-6}$	$1.2x10^{-9}$
ECF-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$1.4x10^{-7}$	$7.0x10^{-11}$	$1.4x10^{-7}$	$7.0x10^{-11}$
AM-2	Earthquake - collapse of bridge crane	$7.0x10^{-4}$	$7.7x10^{-5}$	$3.9x10^{-8}$	$7.7x10^{-5}$	$3.9x10^{-8}$

Table F.7–6. Site-Wide Increased Probability of Latent Cancer Fatalities for Core Receptor Locations (continued)

ACCIDENT ID[a]	ACCIDENT SCENARIO DESCRIPTION	ACCIDENT FREQUENCY (per year)	DOSE (rem)	INCREASED PROBABILITY OF LATENT CANCER FATALITY	DOSE (rem)	INCREASED PROBABILITY OF LATENT CANCER FATALITY
HC-1	Earthquake - building collapse	$7.0x10^{-4}$	$1.5x10^{-3}$	$7.7x10^{-7}$	$1.5x10^{-3}$	$7.7x10^{-7}$
SP-1	Earthquake - building collapse	$7.0x10^{-4}$	$2.1x10^{-4}$	$1.1x10^{-7}$	$2.1x10^{-4}$	$1.1x10^{-7}$
AR-5	Earthquake - collapse of bridge crane	$7.0x10^{-4}$	$2.4x10^{-4}$	$1.2x10^{-7}$	$2.4x10^{-4}$	$1.2x10^{-7}$
NO ACTION ALTERNATIVE TOTALS			**$2.0x10^{-3}$**	**$9.9x10^{-7}$**	**$2.0x10^{-3}$**	**$9.9x10^{-7}$**
			Sandia Base Elementary School		***Wherry Elementary School***	
NG-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$7.8x10^{-6}$	$3.9x10^{-9}$	$2.4x10^{-6}$	$1.2x10^{-9}$
ECF-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$2.0x10^{-7}$	$9.8x10^{-11}$	$8.3x10^{-8}$	$4.2x10^{-11}$
AM-2	Earthquake - collapse of bridge crane	$7.0x10^{-4}$	$7.5x10^{-5}$	$3.8x10^{-8}$	$6.4x10^{-5}$	$3.2x10^{-8}$
HC-1	Earthquake - building collapse	$7.0x10^{-4}$	$1.4x10^{-3}$	$6.9x10^{-7}$	$1.2x10^{-3}$	$6.2x10^{-7}$
SP-1	Earthquake - building collapse	$7.0x10^{-4}$	$2.1x10^{-4}$	$1.0x10^{-7}$	$1.8x10^{-4}$	$8.9x10^{-8}$
AR-5	Earthquake - collapse of bridge crane	$7.0x10^{-4}$	$2.2x10^{-4}$	$1.1x10^{-7}$	$1.9x10^{-4}$	$9.7x10^{-8}$
NO ACTION ALTERNATIVE TOTALS			**$1.8x10^{-3}$**	**$9.0x10^{-7}$**	**$1.6x10^{-3}$**	**$8.1x10^{-7}$**
			Coronado Club		***Child Development Center-East***	
NG-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$6.2x10^{-6}$	$3.1x10^{-9}$	$2.6x10^{-6}$	$1.3x10^{-9}$
ECF-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$2.0x10^{-7}$	$9.8x10^{-11}$	$8.3x10^{-8}$	$4.2x10^{-11}$
AM-2	Earthquake - collapse of bridge crane	$7.0x10^{-4}$	$6.4x10^{-5}$	$3.2x10^{-8}$	$6.4x10^{-5}$	$3.2x10^{-8}$
HC-1	Earthquake - building collapse	$7.0x10^{-4}$	$1.2x10^{-3}$	$6.2x10^{-7}$	$1.2x10^{-3}$	$6.2x10^{-7}$
SP-1	Earthquake - building collapse	$7.0x10^{-4}$	$1.8x10^{-4}$	$8.9x10^{-8}$	$1.8x10^{-4}$	$8.9x10^{-8}$
AR-5	Earthquake - collapse of bridge crane	$7.0x10^{-4}$	$1.9x10^{-4}$	$9.7x10^{-8}$	$1.9x10^{-4}$	$9.7x10^{-8}$
NO ACTION ALTERNATIVE TOTALS			**$1.6x10^{-3}$**	**$8.1x10^{-7}$**	**$1.6x10^{-3}$**	**$8.1x10^{-7}$**
			Veterans Affairs Medical Center		***Lovelace Hospital***	
NG-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$8.2x10^{-7}$	$4.1x10^{-10}$	$8.1x10^{-7}$	$4.0x10^{-10}$
ECF-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$3.3x10^{-8}$	$1.7x10^{-11}$	$3.3x10^{-8}$	$1.7x10^{-11}$

Table F.7–6. Site-Wide Increased Probability of Latent Cancer Fatalities for Core Receptor Locations (continued)

ACCIDENT ID[a]	ACCIDENT SCENARIO DESCRIPTION	ACCIDENT FREQUENCY (per year)	DOSE (rem)	INCREASED PROBABILITY OF LATENT CANCER FATALITY	DOSE (rem)	INCREASED PROBABILITY OF LATENT CANCER FATALITY
AM-2	Earthquake - collapse of bridge crane	$7.0x10^{-4}$	$6.4x10^{-5}$	$3.2x10^{-8}$	$5.4x10^{-5}$	$2.7x10^{-8}$
HC-1	Earthquake - building collapse	$7.0x10^{-4}$	$1.2x10^{-3}$	$6.2x10^{-7}$	$1.0x10^{-3}$	$5.1x10^{-7}$
SP-1	Earthquake - building collapse	$7.0x10^{-4}$	$1.8x10^{-4}$	$8.9x10^{-8}$	$1.5x10^{-4}$	$7.4x10^{-8}$
AR-5	Earthquake - collapse of bridge crane	$7.0x10^{-4}$	$1.9x10^{-4}$	$9.7x10^{-8}$	$1.6x10^{-4}$	$7.9x10^{-8}$
NO ACTION ALTERNATIVE TOTALS			**$1.6x10^{-3}$**	**$8.1x10^{-7}$**	**$1.3x10^{-3}$**	**$6.6x10^{-7}$**
			Kirtland Elementary School		***Child Development Center-West***	
NG-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$3.3x10^{-7}$	$1.7x10^{-10}$	$4.3x10^{-7}$	$2.1x10^{-10}$
ECF-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$1.5x10^{-8}$	$7.6x10^{-12}$	$1.9x10^{-8}$	$9.4x10^{-12}$
AM-2	Earthquake - collapse of bridge crane	$7.0x10^{-4}$	$3.0x10^{-5}$	$1.5x10^{-8}$	$3.0x10^{-5}$	$1.5x10^{-8}$
HC-1	Earthquake - building collapse	$7.0x10^{-4}$	$5.2x10^{-4}$	$2.6x10^{-7}$	$5.2x10^{-4}$	$2.6x10^{-7}$
SP-1	Earthquake - building collapse	$7.0x10^{-4}$	$8.0x10^{-5}$	$4.0x10^{-8}$	$8.0x10^{-5}$	$4.0x10^{-8}$
AR-5	Earthquake - collapse of bridge crane	$7.0x10^{-4}$	$8.2x10^{-5}$	$4.1x10^{-8}$	$8.2x10^{-5}$	$4.1x10^{-8}$
NO ACTION ALTERNATIVE TOTALS			**$6.8x10^{-4}$**	**$3.4x10^{-7}$**	**$6.8x10^{-4}$**	**$3.4x10^{-7}$**
EXPANDED OPERATIONS ALTERNATIVE						
			Golf Course		***Riding Stables***	
NG-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$2.9x10^{-6}$	$1.4x10^{-9}$	$1.4x10^{-6}$	$6.8x10^{-10}$
ECF-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$3.1x10^{-7}$	$1.5x10^{-10}$	$7.9x10^{-8}$	$4.0x10^{-11}$
AM-2	Earthquake - collapse of bridge crane	$7.0x10^{-4}$	$4.8x10^{-4}$	$2.4x10^{-7}$	$4.7x10^{-4}$	$2.4x10^{-7}$
HC-1	Earthquake - building collapse	$7.0x10^{-4}$	$1.4x10^{-2}$	$6.9x10^{-6}$	$1.3x10^{-2}$	$6.3x10^{-6}$
SP-1	Earthquake - building collapse	$7.0x10^{-4}$	$1.2x10^{-3}$	$5.8x10^{-7}$	$1.1x10^{-3}$	$5.3x10^{-7}$
EXPANDED OPERATIONS ALTERNATIVE TOTALS			**$1.5x10^{-2}$**	**$7.7x10^{-6}$**	**$1.4x10^{-2}$**	**$7.1x10^{-6}$**

Table F.7–6. Site-Wide Increased Probability of Latent Cancer Fatalities for Core Receptor Locations (continued)

ACCIDENT ID[a]	ACCIDENT SCENARIO DESCRIPTION	ACCIDENT FREQUENCY (per year)	DOSE (rem)	INCREASED PROBABILITY OF LATENT CANCER FATALITY	DOSE (rem)	INCREASED PROBABILITY OF LATENT CANCER FATALITY
			Kirtland Underground Munitions and Maintenance Storage Complex (KUMMSC)		***National Atomic Museum***	
NG-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$1.1x10^{-6}$	$5.6x10^{-10}$	$5.7x10^{-6}$	$2.8x10^{-9}$
ECF-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$7.1x10^{-8}$	$3.5x10^{-11}$	$1.4x10^{-7}$	$7.0x10^{-11}$
AM-2	Earthquake - collapse of bridge crane	$7.0x10^{-4}$	$3.7x10^{-4}$	$1.9x10^{-7}$	$7.7x10^{-5}$	$3.9x10^{-8}$
HC-1	Earthquake - building collapse	$7.0x10^{-4}$	$1.1x10^{-2}$	$5.5x10^{-6}$	$1.5x10^{-3}$	$7.7x10^{-7}$
SP-1	Earthquake - building collapse	$7.0x10^{-4}$	$9.7x10^{-4}$	$4.8x10^{-7}$	$2.1x10^{-4}$	$1.1x10^{-7}$
EXPANDED OPERATIONS ALTERNATIVE TOTALS			**$1.2x10^{-2}$**	**$6.1x10^{-6}$**	**$1.8x10^{-3}$**	**$9.1x10^{-7}$**
			Base Housing		***Shandiin Day Care Center***	
NG-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$2.5x10^{-6}$	$1.2x10^{-9}$	$2.5x10^{-6}$	$1.2x10^{-9}$
ECF-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$1.4x10^{-7}$	$7.0x10^{-11}$	$1.4x10^{-7}$	$7.0x10^{-11}$
AM-2	Earthquake - collapse of bridge crane	$7.0x10^{-4}$	$7.7x10^{-5}$	$3.9x10^{-8}$	$7.7x10^{-5}$	$3.9x10^{-8}$
HC-1	Earthquake - building collapse	$7.0x10^{-4}$	$1.5x10^{-3}$	$7.7x10^{-7}$	$1.5x10^{-3}$	$7.7x10^{-7}$
SP-1	Earthquake - building collapse	$7.0x10^{-4}$	$2.1x10^{-4}$	$1.1x10^{-7}$	$2.1x10^{-4}$	$1.1x10^{-7}$
EXPANDED OPERATIONS ALTERNATIVE TOTALS			**$1.8x10^{-3}$**	**$9.1x10^{-7}$**	**$1.8x10^{-3}$**	**$9.1x10^{-7}$**
			Sandia Base Elementary School		***Wherry Elementary School***	
NG-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$7.8x10^{-6}$	$3.9x10^{-9}$	$2.4x10^{-6}$	$1.2x10^{-9}$
ECF-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$2.0x10^{-7}$	$9.8x10^{-11}$	$8.3x10^{-8}$	$4.2x10^{-11}$
AM-2	Earthquake - collapse of bridge crane	$7.0x10^{-4}$	$7.5x10^{-5}$	$3.8x10^{-8}$	$6.4x10^{-5}$	$3.2x10^{-8}$
HC-1	Earthquake - building collapse	$7.0x10^{-4}$	$1.4x10^{-3}$	$6.9x10^{-7}$	$1.2x10^{-3}$	$6.2x10^{-7}$
SP-1	Earthquake - building collapse	$7.0x10^{-4}$	$2.1x10^{-4}$	$1.0x10^{-7}$	$1.8x10^{-4}$	$8.9x10^{-8}$
EXPANDED OPERATIONS ALTERNATIVE TOTALS			**$1.7x10^{-3}$**	**$8.3x10^{-7}$**	**$1.5x10^{-3}$**	**$7.4x10^{-7}$**

Table F.7–6. Site-Wide Increased Probability of Latent Cancer Fatalities for Core Receptor Locations (continued)

ACCIDENT ID[a]	ACCIDENT SCENARIO DESCRIPTION	ACCIDENT FREQUENCY (per year)	DOSE (rem)	INCREASED PROBABILITY OF LATENT CANCER FATALITY	DOSE (rem)	INCREASED PROBABILITY OF LATENT CANCER FATALITY
			Coronado Club		***Child Development Center-East***	
NG-1	Catastrophic release of building's tritium	7.0×10^{-4}	6.2×10^{-6}	3.1×10^{-9}	2.6×10^{-6}	1.3×10^{-9}
ECF-1	Catastrophic release of building's tritium	7.0×10^{-4}	2.0×10^{-7}	9.8×10^{-11}	8.3×10^{-8}	4.2×10^{-11}
AM-2	Earthquake - collapse of bridge crane	7.0×10^{-4}	6.4×10^{-5}	3.2×10^{-8}	6.4×10^{-5}	3.2×10^{-8}
HC-1	Earthquake - building collapse	7.0×10^{-4}	1.2×10^{-3}	6.2×10^{-7}	1.2×10^{-3}	6.2×10^{-7}
SP-1	Earthquake - building collapse	7.0×10^{-4}	1.8×10^{-4}	8.9×10^{-8}	1.8×10^{-4}	8.9×10^{-8}
EXPANDED OPERATIONS ALTERNATIVE TOTALS			**1.5×10^{-3}**	**7.4×10^{-7}**	**1.5×10^{-3}**	**7.4×10^{-7}**
			Veterans Affairs Medical Center		***Lovelace Hospital***	
NG-1	Catastrophic release of building's tritium	7.0×10^{-4}	8.2×10^{-7}	4.1×10^{-10}	8.1×10^{-7}	4.0×10^{-10}
ECF-1	Catastrophic release of building's tritium	7.0×10^{-4}	3.3×10^{-8}	1.7×10^{-11}	3.3×10^{-8}	1.7×10^{-11}
AM-2	Earthquake - collapse of bridge crane	7.0×10^{-4}	6.4×10^{-5}	3.2×10^{-8}	5.4×10^{-5}	2.7×10^{-8}
HC-1	Earthquake - building collapse	7.0×10^{-4}	1.2×10^{-3}	6.2×10^{-7}	1.0×10^{-3}	5.1×10^{-7}
SP-1	Earthquake - building collapse	7.0×10^{-4}	1.8×10^{-4}	8.9×10^{-8}	1.5×10^{-4}	7.4×10^{-8}
EXPANDED OPERATIONS ALTERNATIVE TOTALS			**1.5×10^{-3}**	**7.4×10^{-7}**	**1.2×10^{-3}**	**6.1×10^{-7}**
			Kirtland Elementary School		***Child Development Center-West***	
NG-1	Catastrophic release of building's tritium	7.0×10^{-4}	3.3×10^{-7}	1.7×10^{-10}	4.3×10^{-7}	2.1×10^{-10}
ECF-1	Catastrophic release of building's tritium	7.0×10^{-4}	1.5×10^{-8}	7.6×10^{-12}	1.9×10^{-8}	9.4×10^{-12}
AM-2	Earthquake - collapse of bridge crane	7.0×10^{-4}	3.0×10^{-5}	1.5×10^{-8}	3.0×10^{-5}	1.5×10^{-8}
HC-1	Earthquake - building collapse	7.0×10^{-4}	5.2×10^{-4}	2.6×10^{-7}	5.2×10^{-4}	2.6×10^{-7}
SP-1	Earthquake - building collapse	7.0×10^{-4}	8.0×10^{-5}	4.0×10^{-8}	8.0×10^{-5}	4.0×10^{-8}
EXPANDED OPERATIONS ALTERNATIVE TOTALS			**6.3×10^{-4}**	**3.2×10^{-7}**	**6.3×10^{-4}**	**3.2×10^{-7}**

Table F.7–6. Site-Wide Increased Probability of Latent Cancer Fatalities for Core Receptor Locations (continued)

ACCIDENT ID[a]	ACCIDENT SCENARIO DESCRIPTION	ACCIDENT FREQUENCY (per year)	DOSE (rem)	INCREASED PROBABILITY OF LATENT CANCER FATALITY	DOSE (rem)	INCREASED PROBABILITY OF LATENT CANCER FATALITY
REDUCED OPERATIONS ALTERNATIVE						
			Golf Course		***Riding Stables***	
NG-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$2.9x10^{-6}$	$1.4x10^{-9}$	$1.4x10^{-6}$	$6.8x10^{-10}$
ECF-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$3.1x10^{-7}$	$1.5x10^{-10}$	$7.9x10^{-8}$	$4.0x10^{-11}$
AM-2	Earthquake - collapse of bridge crane	$7.0x10^{-4}$	$4.8x10^{-4}$	$2.4x10^{-7}$	$4.7x10^{-4}$	$2.4x10^{-7}$
HC-1	Earthquake - building collapse	$7.0x10^{-4}$	$1.4x10^{-2}$	$6.9x10^{-6}$	$1.3x10^{-2}$	$6.3x10^{-6}$
SP-1	Earthquake - building collapse	$7.0x10^{-4}$	$1.2x10^{-3}$	$5.8x10^{-7}$	$1.1x10^{-3}$	$5.3x10^{-7}$
REDUCED OPERATIONS ALTERNATIVE TOTALS			**$1.5x10^{-2}$**	**$7.7x10^{-6}$**	**$1.4x10^{-2}$**	**$7.1x10^{-6}$**
			Kirtland Underground Munitions and Maintenance Storage Complex (KUMMSC)		***National Atomic Museum***	
NG-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$1.1x10^{-6}$	$5.6x10^{-10}$	$5.7x10^{-6}$	$2.8x10^{-9}$
ECF-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$7.1x10^{-8}$	$3.5x10^{-11}$	$1.4x10^{-7}$	$7.0x10^{-11}$
AM-2	Earthquake - collapse of bridge crane	$7.0x10^{-4}$	$3.7x10^{-4}$	$1.9x10^{-7}$	$7.7x10^{-5}$	$3.9x10^{-8}$
HC-1	Earthquake - building collapse	$7.0x10^{-4}$	$1.1x10^{-2}$	$5.5x10^{-6}$	$1.5x10^{-3}$	$7.7x10^{-7}$
SP-1	Earthquake - building collapse	$7.0x10^{-4}$	$9.7x10^{-4}$	$4.8x10^{-7}$	$2.1x10^{-4}$	$1.1x10^{-7}$
REDUCED OPERATIONS ALTERNATIVE TOTALS			**$1.2x10^{-2}$**	**$6.1x10^{-6}$**	**$1.8x10^{-3}$**	**$9.1x10^{-7}$**
			Base Housing		***Shandiin Day Care Center***	
NG-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$2.5x10^{-6}$	$1.2x10^{-9}$	$2.5x10^{-6}$	$1.2x10^{-9}$
ECF-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$1.4x10^{-7}$	$7.0x10^{-11}$	$1.4x10^{-7}$	$7.0x10^{-11}$
AM-2	Earthquake - collapse of bridge crane	$7.0x10^{-4}$	$7.7x10^{-5}$	$3.9x10^{-8}$	$7.7x10^{-5}$	$3.9x10^{-8}$
HC-1	Earthquake - building collapse	$7.0x10^{-4}$	$1.5x10^{-3}$	$7.7x10^{-7}$	$1.5x10^{-3}$	$7.7x10^{-7}$
SP-1	Earthquake - building collapse	$7.0x10^{-4}$	$2.1x10^{-4}$	$1.1x10^{-7}$	$2.1x10^{-4}$	$1.1x10^{-7}$
REDUCED OPERATIONS ALTERNATIVE TOTALS			**$1.8x10^{-3}$**	**$9.1x10^{-7}$**	**$1.8x10^{-3}$**	**$9.1x10^{-7}$**

Table F.7–6. Site-Wide Increased Probability of Latent Cancer Fatalities for Core Receptor Locations (continued)

ACCIDENT ID[a]	ACCIDENT SCENARIO DESCRIPTION	ACCIDENT FREQUENCY (per year)	DOSE (rem)	INCREASED PROBABILITY OF LATENT CANCER FATALITY	DOSE (rem)	INCREASED PROBABILITY OF LATENT CANCER FATALITY
			Sandia Base Elementary School		*Wherry Elementary School*	
NG-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$7.8x10^{-6}$	$3.9x10^{-9}$	$2.4x10^{-6}$	$1.2x10^{-9}$
ECF-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$2.0x10^{-7}$	$9.8x10^{-11}$	$8.3x10^{-8}$	$4.2x10^{-11}$
AM-2	Earthquake - collapse of bridge crane	$7.0x10^{-4}$	$7.5x10^{-5}$	$3.8x10^{-8}$	$6.4x10^{-5}$	$3.2x10^{-8}$
HC-1	Earthquake - building collapse	$7.0x10^{-4}$	$1.4x10^{-3}$	$6.9x10^{-7}$	$1.2x10^{-3}$	$6.2x10^{-7}$
SP-1	Earthquake - building collapse	$7.0x10^{-4}$	$2.1x10^{-4}$	$1.0x10^{-7}$	$1.8x10^{-4}$	$8.9x10^{-8}$
REDUCED OPERATIONS ALTERNATIVE TOTALS			**$1.7x10^{-3}$**	**$8.3x10^{-7}$**	**$1.5x10^{-3}$**	**$7.4x10^{-7}$**
			Coronado Club		*Child Development Center-East*	
NG-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$6.2x10^{-6}$	$3.1x10^{-9}$	$2.6x10^{-6}$	$1.3x10^{-9}$
ECF-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$2.0x10^{-7}$	$9.8x10^{-11}$	$8.3x10^{-8}$	$4.2x10^{-11}$
AM-2	Earthquake - collapse of bridge crane	$7.0x10^{-4}$	$6.4x10^{-5}$	$3.2x10^{-8}$	$6.4x10^{-5}$	$3.2x10^{-8}$
HC-1	Earthquake - building collapse	$7.0x10^{-4}$	$1.2x10^{-3}$	$6.2x10^{-7}$	$1.2x10^{-3}$	$6.2x10^{-7}$
SP-1	Earthquake - building collapse	$7.0x10^{-4}$	$1.8x10^{-4}$	$8.9x10^{-8}$	$1.8x10^{-4}$	$8.9x10^{-8}$
REDUCED OPERATIONS ALTERNATIVE TOTALS			**$1.5x10^{-3}$**	**$7.4x10^{-7}$**	**$1.5x10^{-3}$**	**$7.4x10^{-7}$**
			Veterans Affairs Medical Center		*Lovelace Hospital*	
NG-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$8.2x10^{-7}$	$4.1x10^{-10}$	$8.1x10^{-7}$	$4.0x10^{-10}$
ECF-1	Catastrophic release of building's tritium	$7.0x10^{-4}$	$3.3x10^{-8}$	$1.7x10^{-11}$	$3.3x10^{-8}$	$1.7x10^{-11}$
AM-2	Earthquake - collapse of bridge crane	$7.0x10^{-4}$	$6.4x10^{-5}$	$3.2x10^{-8}$	$5.4x10^{-5}$	$2.7x10^{-8}$
HC-1	Earthquake - building collapse	$7.0x10^{-4}$	$1.2x10^{-3}$	$6.2x10^{-7}$	$1.0x10^{-3}$	$5.1x10^{-7}$
SP-1	Earthquake - building collapse	$7.0x10^{-4}$	$1.8x10^{-4}$	$8.9x10^{-8}$	$1.5x10^{-4}$	$7.4x10^{-8}$
REDUCED OPERATIONS ALTERNATIVE TOTALS			**$1.5x10^{-3}$**	**$7.4x10^{-7}$**	**$1.2x10^{-3}$**	**$6.1x10^{-7}$**

Table F.7–6. Site-Wide Increased Probability of Latent Cancer Fatalities for Core Receptor Locations (continued)

ACCIDENT ID[a]	ACCIDENT SCENARIO DESCRIPTION	ACCIDENT FREQUENCY (per year)	DOSE (rem)	INCREASED PROBABILITY OF LATENT CANCER FATALITY	DOSE (rem)	INCREASED PROBABILITY OF LATENT CANCER FATALITY
			Kirtland Elementary School		*Child Development Center-West*	
NG-1	Catastrophic release of building's tritium	7.0×10^{-4}	3.3×10^{-7}	1.7×10^{-10}	4.3×10^{-7}	2.1×10^{-10}
ECF-1	Catastrophic release of building's tritium	7.0×10^{-4}	1.5×10^{-8}	7.6×10^{-12}	1.9×10^{-8}	9.4×10^{-12}
AM-2	Earthquake - collapse of bridge crane	7.0×10^{-4}	3.0×10^{-5}	1.5×10^{-8}	3.0×10^{-5}	1.5×10^{-8}
HC-1	Earthquake - building collapse	7.0×10^{-4}	5.2×10^{-4}	2.6×10^{-7}	5.2×10^{-4}	2.6×10^{-7}
SP-1	Earthquake - building collapse	7.0×10^{-4}	8.0×10^{-5}	4.0×10^{-8}	8.0×10^{-5}	4.0×10^{-8}
REDUCED OPERATIONS ALTERNATIVE TOTALS			**6.3×10^{-4}**	**3.2×10^{-7}**	**6.3×10^{-4}**	**3.2×10^{-7}**

Source: Original
[a] Facility Accident Descriptors:
Neutron Generator Facility: NG-1
Explosive Component Facility: ECF-1
Annular Core Research Reactor-Medical Isotope Production: AM-2
Annular Core Research Reactor-Defense Programs: AR-5
Hot Cell Facility: HC-1
Sandia Pulsed Reactor: SP-1
Notes: 1) Under the No Action Alternative, the Annular Core Research Reactor can be operated in either the medical isotopes production or Defense Programs configuration. The highest consequence (AR-2) was used.
2) Under the Expanded Operations Alternative, the earthquake for the Annular Core Research Reactor-Defense Programs is not applicable because the location or facility was not selected. It was assumed that the new facility would be designed to withstand the Uniform Building Code earthquake.

the ACRR could be configured in a DP configuration. For the ACRR under the No Action Alternative and in a DP configuration, the highest impact accident is AR-5. In a medical isotopes production configuration, the highest impact accident is AM-2. Under the Reduced Operations Alternative, the highest impact ACRR accident is AM-2 because there are no plans for ACRR operation in a DP configuration. Under the Expanded Operations Alternative, the existing ACRR would only be operated in the medical isotopes production configuration. Any DP requirements for ACRR-type testing would be performed in a new unspecified facility, assumed to be designed to survive an earthquake. The NGF in TA-I and ECF in TA-II could also release radioactive materials during an earthquake, and are included in Tables F.7–4 through F.7–6.

Total consequences for the accidents listed are shown in Tables F.7–4 through F.7–6 for the maximally exposed individual and 50-mile population. Totals are not shown for the noninvolved worker because that receptor's location is not the same for all accidents.

The 50-mi population dose is 160 person-rem (Table F.7–5). The MEI for the earthquake is at the Golf Course and receives a dose of 0.017 rem under the No Action Alternative (Table F.7–6). This dose is the sum of contributions from the individual facilities listed and summed in Table F.7–6.

F.7.4 Chemical Impacts

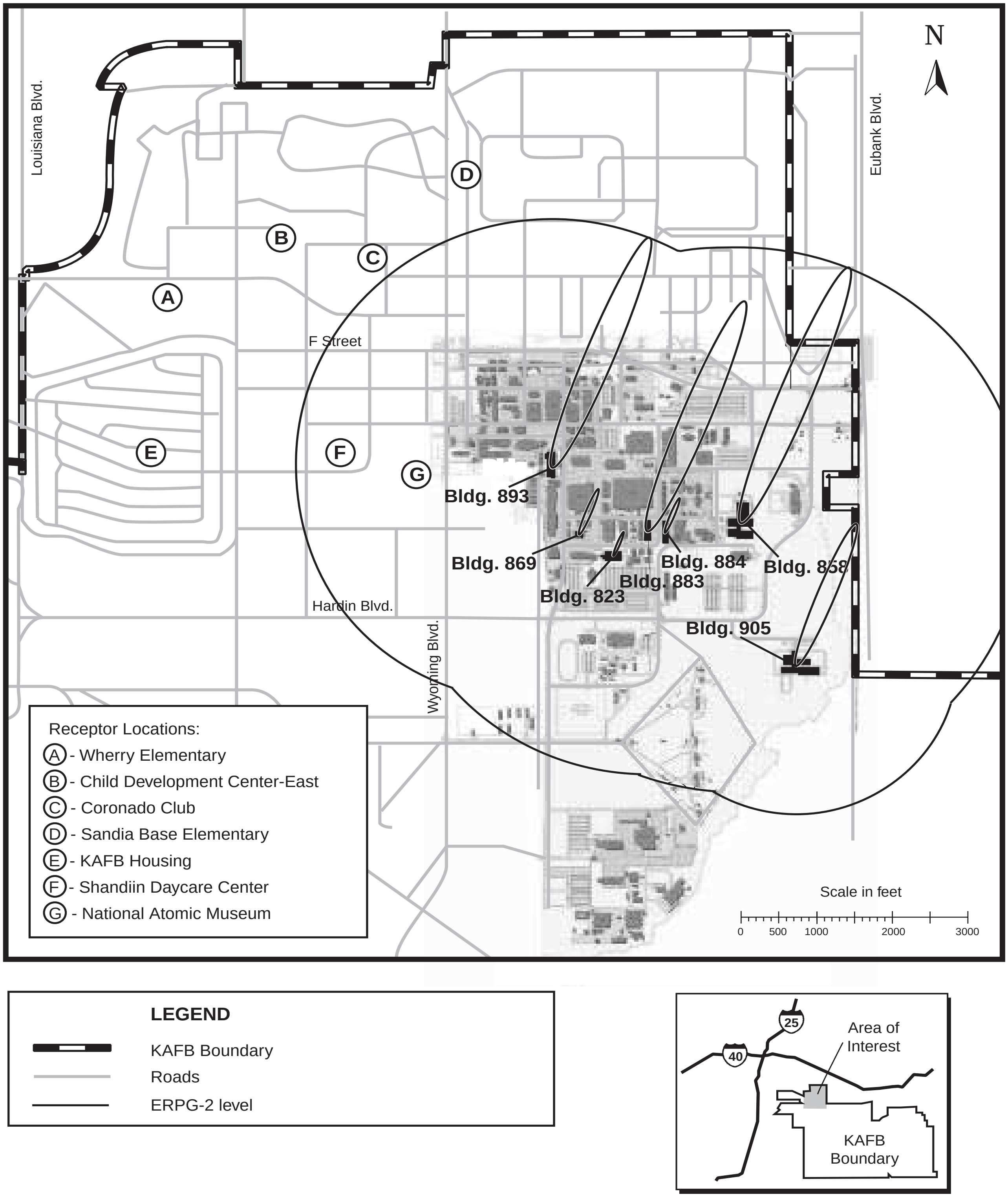
Based on the Paragon life safety study, the following buildings or portions of buildings would fail during a UBC (0.17 *g*) earthquake, releasing the contents of the chemicals stored within the building: Buildings 858, 869, 880, 884, 893, and 905 (Paragon 1997 & 1998). One building, 883, was not included in the Paragon life safety study. It was assumed to fail (see Table F.7–3). Table F.7–7 presents, by chemical, the building and the potential amounts released. It should be noted that for Building 893, the gas storage location would remain intact. In a similar fashion, the clean room in Building 858 would remain intact. If implemented, the MESA Complex clean room is also assumed to remain intact. Therefore, not all chemicals shown in Table F.3–3 would be released during an earthquake. The shaded cells in Table F.7–7 contain the high risk chemical for that building. Figures F.7–1 and F.7–2 show the ERPG-2 plumes, based on the high risk chemicals for each building. It should be noted that the entire area encircled represents locations where approximately 423 people under the No Action Alternative, Reduced Operations Alternative, and Expanded Operations Alternative without the MESA Complex. Under the Expanded Operations Alternative, if the MESA Complex configuration is implemented, 306 people could be exposed to concentrations of chemicals above ERPG-2 levels. The encircled area represents the area potentially affected if the wind were blowing in another direction when the earthquake occurred.

Because there are several chemicals that could be released from one or more buildings, locations of possible overlapping plumes of the same chemical need to be examined. The overlapping areas need to be examined for any that could be above the ERPG-2 concentrations, but that are not already included within the total encircled area. There are only seven chemicals that are released from multiple buildings. Depending on the wind direction, there is a possibility that plumes of the same chemical released from different buildings could overlap. The overlapping area could contain concentrations of the chemical that are below the ERPG-2 level within each plume, but, when combined could yield a concentration above the ERPG-2 level. If this situation existed, the additional area above the ERPG-2 level would be small relative to the area of either contributing plume.

Table F.7–7. Chemicals Released By Failed Building (in Pounds)

CHEMICAL	BUILDING NUMBER						
	858	869	880	883	884	893	905
Ammonia					34.2	31	
Phosphine	4.84			6.8		5	
Hydrogen Fluoride	0.033						0.054
Hydrofluoric Acid			2		10		
Nitric Acid		18.6			9.8	250.9	
Carbon Disulfide		0.03					
Carbon Monoxide					0.78		
Arsine	2						
Bromine						1.37	
Chlorine	106.41						
Hydrochloric Acid						300.5	
Silane	47.1						
Fluorine	0.16						
Diborane	7.7						
Thionyl Chloride							101.1

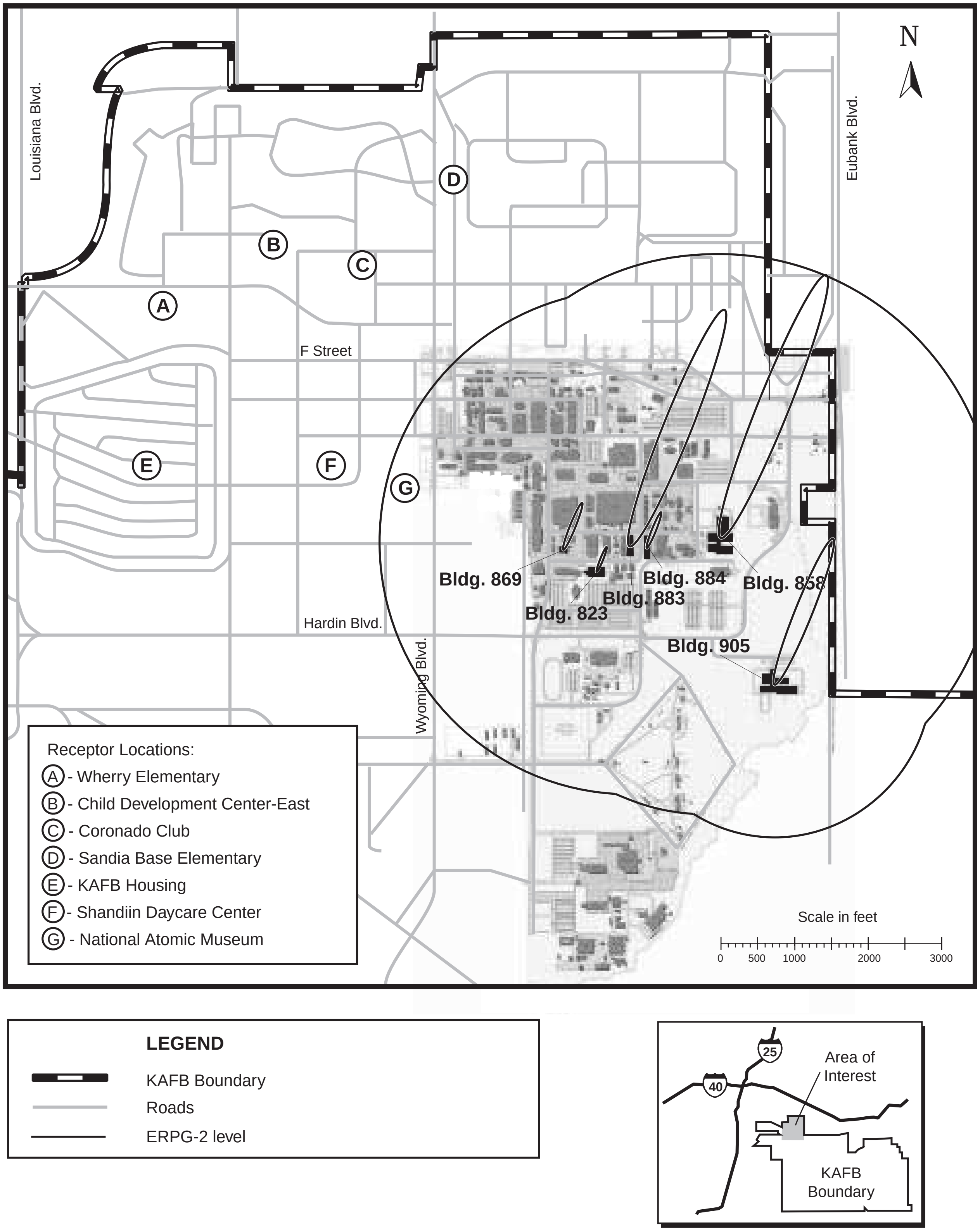
Source: Original
Notes: 1) See Tables F.3–4 and F.7–3
2) Shaded areas identify the high risk chemical for that building.



Source: Original

Figure F.7–1. Areas Above ERGP-2 Levels Resulting from Site-Wide Earthquake for the No Action, Reduced Operations, and Expanded Operations Alternatives Without the Microsystems and Engineering Sciences Applications Complex

The encircled areas represent potential locations that could be above ERPG-2 levels depending upon the wind direction.



Source: Original

Figure F.7–2. Areas above ERGP-2 Levels Resulting from Site-Wide Earthquake for the Expanded Operations Alternative With the Microsystems and Engineering Sciences Applications Complex

The encircled areas represent potential locations that could be above ERPG-2 levels depending upon the wind direction.