PNNL-20113 Rev. 4

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

Air Monitoring Modeling of Radioactive Releases During Proposed PFP Complex Demolition Activities

Report to CH2M HILL Plateau Remediation Company

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October 2016

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Pacific Northwest National Laboratory
Richland, Washington 99352

Summary

This report is part of the planning process for the demolition of the 234-5Z, 236Z, 242Z, 291Z, and 291Z-1 structures at the Plutonium Finishing Plant (PFP) facilities on the Hanford Site. Pacific Northwest National Laboratory (PNNL) supports the U.S. Department of Energy (DOE) and the CH2M HILL Plateau Remediation Company (CHPRC) demolition planning effort by making engineering estimates of potential releases for various demolition alternatives. This report documents an analysis considering open-air demolition using standard techniques. It does not document any decisions about the decommissioning approaches.

Atmospheric dispersion modeling using estimated release rates has been conducted to provide information on the location and levels of radioactive contamination that may be expected as the result of demolition activities. The close proximity of the PFP facilities to each other has the potential to affect dispersion patterns through various meteorological phenomena, including building wake effects. As the structures are demolished, the impacts on dispersion from wake effects will diminish. Hourly meteorological data collected over a 6-year period (2004–2009) were used to examine the effects of wind speed, direction, and stability on projected concentrations of contaminants in air and deposited on nearby surfaces.

The radioactive contamination of concern for the PFP complex is largely transuranic contamination from past operations. Operations are underway to remove a large fraction of this contamination. The source terms modeled in this report are based on the residual contamination levels that are anticipated for the various structures at the time of demolition.

The radiological consequences have been established using the five-factor formula considering material-at-risk, damage ratio, airborne release fraction, respirable fraction, and leak path factor from DOE-HDBK-3010 (DOE 1994). Radioactive contamination emissions have been calculated by release mechanism and demolition area for on-shift and off-shift activities. The emissions from the applicable sources have been combined to provide emissions estimates for each day from each demolition area.

The U.S. Environmental Protection Agency's (EPA's) AERMOD computer code is used to estimate atmospheric dispersion of the released radioactive materials in the immediate vicinity of the demolition activities. The modeling is conducted to be fully representative of the range of the weather conditions that are possible (i.e., uses multiple full annual cycles of meteorological data) and representative of the expected demolition period (i.e., models the hours of the day that demolition activities will occur). The modeling also includes the effects of the local building structures on the near-field atmospheric dispersion due to building wake effects. The derived air concentrations (DAC) are modeled for an array of receptors covering the site fenceline and air monitoring stations. Peak values of air concentrations are evaluated using the 95^{th} percentile of occurrence, with modeling results reported as time-integrated incremental air concentrations in DAC-hours.

Each building in the PFP complex is considered in terms of its construction and suggested target contamination levels. The modeling effort is conducted based on an assumed sequence of the demolition phases. The results in this report are based on the following demolition phases and methods:

- Phase 1: The preferred option assumed is to entirely demolish 236Z with hydraulic shears or mechanical hammer. That activity is simulated in 2 portions: the external frame of the building and the main process cell. The demolition of the external portions of the building is projected to require about 23 working days over about 6 weeks of elapsed time. Several highly-contaminated gloveboxes will be carefully removed prior to demolition. The demolition of the highly-contaminated main cell is projected to require about 46 working days over a subsequent 12 weeks of elapsed time. Forty-one strongbacks are expected to remain within the main cell; they will be removed and size-reduced as part of the cell demolition process. A connecting wall with 242Z would remain.
- Phase 2: The 242Z building roof and walls are assumed to be demolished with a multiprocessor that operates hydraulic shears or mechanical hammer end effectors. Contaminated tanks would be carefully removed during demolition. It is assumed that the overall demolition would require about 7 days over a two-week period. A connecting wall with 234-5Z would remain.
- Phase 3: The various zones of the 234-5Z building are assumed to be demolished using hydraulic shears or mechanical hammer. Certain gloveboxes, ductwork, and piping may remain in the building until the time of demolition; they would be carefully removed as access is available. The entire demolition process for 234-5Z is assumed to require 70 days over a period of about 18 weeks.
- Phase 4: The above-ground portions of the 291Z fan house will be removed using hydraulic shears or mechanical hammer. Contaminated vacuum lines would be cut and capped prior to demolition and removed as access is available. The demolition is assumed to require 18 days over a period of about 5 weeks.
- Phase 5: The 291Z-1 stack is assumed to be toppled with explosives; the stack will be directed to fall onto the ground or into a prepared shallow trench. After being toppled, the stack will be broken up into smaller pieces and removed using a multiprocessor. The entire process is assumed to require 15 days over a period of 4 weeks.

The modeling of demolition activities incorporates some realistic assumptions based on input from CHPRC about release mitigation (i.e., reduce airborne emission by 90%); use of fixatives and misting/spraying is included in all release estimates. Work is assumed to be performed during 10-hour day and swing shifts, with a preference for demolition during the days and rubble removal during swing shifts; however swing shifts are not planned for the 236Z demolition.

The analysis quantifies the potential releases of radioactive material that are anticipated during the demolition of the PFP facilities. The modeling results presented here are closely tied to the details of how the demolition is to be conducted. The results indicate that for the bulk of the PFP facilities the radiological exposures from the planned demolition efforts will be below the designated limits for air exposures to workers. Increases in the measured concentrations at the monitoring stations during the demolition also can be expected. The 95th percentile results show that for 234-5Z, 242Z, and 291Z demolition some of the monitoring stations are unlikely to detect small increases in concentrations; quantities are unlikely to be high enough to be distinguished from the background. The actual concentration levels are expected to be much less.

However, the demolition of the 236Z main process cell has the potential for releases of alpha-emitting radionuclides that will likely result in measureable increments in air concentration being monitored at six monitoring stations located in the immediate vicinity of the demolition activities. For the several months of 236Z demolition, the modeling results indicate that all nearby monitoring stations are likely to see measureable concentration increases. The predicted peaks can occur under relatively infrequent unfavorable dispersion conditions that range to up to about 6 DAC-hours for a 2-week period at the 95^{th} percentile, and an absolute maximum of about 12 DAC-hours for a 2-week period. This implies that workers continuously in the vicinity (two shifts/day) could be exposed to inhalation doses of up to about 30 millirem during the highest 2-week demolition period and perhaps as much as 180 millirem over the entire period of demolition if no respiratory protection were provided.

Acknowledgments

The authors would like to extend their appreciation to Brian Oldfield and Peter Sauer of the CH2M HILL Plateau Remediation Company for financial and technical support of this work. Meteorological data from the Hanford Meteorological Station for the period was provided by Ken Burk, Pacific Northwest National Laboratory. This work was funded by CH2M HILL Plateau Remediation Company under the U.S. Department of Energy Contract DE-AC05-76RL01830.

Acronyms and Abbreviations

AED	aerodynamic equivalent diameter
AERMOD	American Meteorological Society/Environmental Protection Agency Regulatory Model
ARF	airborne release fraction
Bq	becquerel
BPIP	Building Profile Input Program (AERMOD preprocessor program)
CAM	continuous air monitor
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CHPRC	CH2M HILL Plateau Remediation Company
Ci	curie(s)
DAC	derived air concentration
DOE	U.S. Department of Energy
dpm	disintegrations per minute
DR	damage ratio
EF	emission factor
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
FB	Filter Box
FPM	foot per minute
f	fraction
ft	foot (feet)
g	gram
GB	Glovebox
HE	high explosive
HEPA	high-efficiency particulate air (filter)
HMS	Hanford Meteorological Station
HP	health physicist
in.	inch(es)
lb	pound(s)
LF	linear feet
LPF	leak path factor
m	meter(s)
MAR	material-at-risk
MCTE	maintenance
MEI	maximally-exposed individual

NDA	nondestructive analysis
PFP	Plutonium Finishing Plant
PNNL	Pacific Northwest National Laboratory
PRF	Plutonium Reclamation Facility (236Z Building)
PRIME	AERMOD Plume Rise Model
Pu	plutonium
QTY	Quantity
RF	respirable fraction
RMA	Remote Mechanical "A" process line
RMC	Remote Mechanical "C" process line
SF	square feet
ST	source term
TED	total effective dose
TRU	Transuranic (comprised of elements with higher atomic number than uranium)
wt	weight

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1.0 Introduction

The Hanford Plutonium Finishing Plant (PFP), located in the 200 West Area, converted plutonium-bearing chemical solutions to metals and oxides until 1989. The current mission of the PFP requires deactivating and dismantling PFP's systems and structures to the degree determined appropriate by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process, thus eliminating significant hazard to workers, the public, and the environment and minimizing long-term surveillance and maintenance risks and costs. U.S. Department of Energy (DOE) and CH2M HILL Plateau Remediation Company (CHPRC) plans call for eventual demolition of many of the PFP structures.

Pacific Northwest National Laboratory (PNNL) supports the demolition planning effort by making engineering estimates of potential releases for various potential demolition alternatives. Atmospheric dispersion modeling has been conducted using projected release rates to provide information on the locations and levels of radioactivity. This report documents an analysis considering open-air demolition using standard techniques. It does not document any decisions about the decommissioning approaches.

This report is part of the planning process for the demolition of the 234-5Z, 236Z, 242Z, and 291Z-1 structures at the PFP complex; these structures in the state they are anticipated for demolition are shown in Figure 1.0-1; a number of the other structures in the immediate vicinity have been, or will be, removed before demolition of the other structures occurs.

Figure 1.0-1. The Plutonium Finishing Plant Complex in aerial view from the north

The PFP complex shown in Figure 1.0-1 has many large structures that will influence the local atmospheric dispersion. These structures have the potential to affect dispersion and deposition patterns through various meteorological phenomena, including building wake effects. As the structures are demolished, the impacts on dispersion from wake effects will change. Atmospheric dispersion calculations have been made using the AERMOD (40 CFR 51, Appendix W) dispersion model developed by the U.S. Environmental Protection Agency (EPA). AERMOD is the EPA's recommended dispersion model for regulatory applications; the model incorporates the latest understanding of atmospheric dispersion, and it explicitly accounts for building wake effects. The results from the AERMOD calculations are being used to help plan demolition activities that will keep potential contamination within the limits established for the project contamination area and to define exclusion zones.

An analysis was also done using CAP88 (Rosnick 2014). This analysis estimated offsite and onsite Maximally-Exposed Individual (MEI) doses from a 3.68E8 Bq (9.94E-3 Ci) release of Pu-239 as a result of demolition activities at PFP. The analysis assumed the activity is uniformly released over one entire year and is presented in Appendix G.

The 234-5Z building is approximately 152 m (500 ft) long and 55 m (180 ft) wide. The floor levels are the basement, the first floor, the duct level, and the second floor. The frame is structural steel with an outer sheathing of aluminum panels over rock wool insulation and 16-guage sheet metal. There are also 20-cm (8-in.) thick interior reinforced concrete walls, principally running in the east-west direction, and two box-type reinforced concrete stairwells. The stairwells extend to the roof; the reinforced concrete walls stop at the second floor. Contamination levels are quite variable within this large structure; the bulk of residual contamination is expected to reside in the central core and on the duct level.

The 236Z building (also known as the Plutonium Reclamation Facility - PRF) is located south of the southeastern corner of the 234-5Z building and is connected to it by the 242Z building. The building is a four-story structure 24 m (79 ft) by 21.6 m (71 ft) by about 14.5 m (47.5 ft) high, surmounted at the southwest corner by a two-story penthouse 6.9 m (22.5 ft) high. With the exception of the roof, the south end of the process cell, and the fourth-floor ceiling, the building is constructed of reinforced concrete. The roof is constructed of an open-web steel joist frame, a steel deck with rigid insulation of lightweight concrete fill, and gravel-covered built-up roofing. A portion of the south wall is also the 1-ft-thick wall of the process cell. An equipment transfer facility is located against the large south door. The tanks and columns used in the solvent extraction process were located in the process cell—a large three-story room in the center of the 236Z building.

The 242Z building (formerly known as the Waste Treatment Facility) connects the 234-5Z and 236Z buildings. The 242Z building is 12 m (40 ft) wide, 8 m (26 ft) long, and 7 m (23 ft) high. The south wall of the 242Z is reinforced concrete; the remainder of the building has a structural steel frame covered with metal lath and plaster internal walls and external insulating wall panels. The roof is constructed of metal decking covered with built-up asphalt and gravel. A serious accident involving an explosion of an americium separation column occurred in this building in 1976, which resulted in extensive ^{241}Am contamination inside the building.

The 291Z building provides controlled ventilation exhaust for the 234-5Z, 242Z, and 236Z buildings. The 291Z-1 reinforced concrete stack is located adjacent to the 291Z building. The stack is 61 m (200 ft) tall.

Six air-exposure monitoring stations are located in the immediate vicinity of the PFP complex, each of which provides 2-week totals of airborne alpha levels. This report addresses the possibility that the monitoring results during demolition could potentially generate airborne concentration levels that are detectably larger than the background levels historically seen at these stations.

The main report provides a description of the overall analysis approach used to evaluate the air emissions during demolition (Section 2), the predicted incremental air concentrations at the monitoring stations for the major buildings and stack (Section 3), and a discussion of the results (Section 4). The appendices provide the structure-by-structure details of the source-term analysis and atmospheric dispersion modeling. The source-term appendices include the modeling scenarios, source-term inventories, and demolition options. The air dispersion appendices include modeling assumptions as well as the AERMOD input and output file listings. The quality control procedures for conducting these analyses are discussed in Appendix D. Source term and emission rate worksheets are documented in Appendix E. Appendix F documents the contents of selected AERMOD output files. These output files contain listing of both modeling inputs and results.

2.0 Discussion of Analysis Approach

Atmospheric dispersion modeling has been conducted in support of the demolition of the Plutonium Finishing Plant (PFP) complex of buildings using estimated release rates to provide information on the location and levels of radioactive contamination that may be expected as the result of demolition activities. The close proximity of the PFP building structures to each other has the potential to affect dispersion patterns through various meteorological phenomena, including building wake effects (note that as the buildings are torn down, the impacts from wake effects will decrease). Hourly meteorological data collected over a 6-year period (2004–2009) was used to examine the effects of wind speed, direction, and stability on projected concentrations of contaminants in air and deposited on nearby surfaces.

The radioactive contamination of concern for the PFP complex is largely transuranic (TRU) contamination from past operations. Operations are underway to remove a large fraction of this contamination. The source terms modeled in this report are based on the residual contamination levels that are anticipated for the various structures at the time of demolition. Incremental air exposures at each of the monitoring stations are modeled based on these source terms.

The radiological consequences have been established using the methods discussed in DOE-HDBK-3010-94 (DOE 1994). This approach was successfully used for the 233-S Building, 232Z Building (Droppo et al. 2006), 105 KE Basin (Napier et al. 2008), and 224-U and 224-UA Buildings (Napier et al. 2009; Napier et al. 2010; Droppo et al. 2011); concentrations and depositions measured during demolition of those facilities were in the ranges predicted during the modeling.

2.1 Source Term Methodology

The source term may be quantified using the five-factor formula[1]

$$ST = MAR * DR * ARF * RF * LPF \qquad (2\text{-}1a)$$

$$ST = MAR * EF \qquad (2\text{-}1b)$$

where:

Source term (ST) = the total quantity of respirable material released to the atmosphere during the demolition

Material-at-risk (MAR) = the total quantity of radionuclides (in grams or curies of activity for each radionuclide) available to be acted on by a given physical stress

Damage ratio (DR) = the fraction of the MAR actually impacted by the demolition conditions

Airborne release fraction (ARF) = the fraction of a radioactive material suspended in air as an aerosol and thus available for transport due to a physical stress from a specific activity

Respirable fraction (RF) = the fraction of airborne radionuclides as particles that can be transported through air and inhaled into the human respiratory system and is commonly assumed to include particles 10-µm aerodynamic equivalent diameter (AED) and less

[1] The following discussion is adapted from *GENII Computer Code Application Guidance for Documented Safety Analysis*, DOE-EH-4.2.1.4-Interim-GENII, Rev. 1, U.S Department of Energy, Washington, D.C.

Leak path factor (LPF) = the fraction of the radionuclides in the aerosol transported through some confinement system (e.g., facility rooms, ductwork), filtration mechanism (e.g., high-efficiency particulate air [HEPA] or sand filters), and emission mitigation methods (e.g., misters or foggers).

The last four factors are sometimes combined into an Emission Factor (EF) to be multiplied with the MAR, where EF = DR*ARF*RF*LPF.

For these analyses, the MAR is defined as the inventory that is on the surface, within the structural materials being demolished, or within equipment remaining in the facility. While it is permissible to exclude material forms that are considered to be unaffected from the MAR, experience suggests that for these forms the DR is usually best set to zero for the release mechanism. The overall result using either approach is the same. However, by assigning DR values to each combination of inventory form and release mechanism, there is the expectation that each credited form is also reviewed against secondary events and, therefore, less likely to be overlooked.

Through collaboration with CHPRC, a conservative MAR was established which determined masses, fractions associated with different components and differentiated between fixed and removable contamination (i.e. contaminated walls/floors, internally contaminated ductwork, TRU strategic removals, canyon walls, strongbacks, maintenance cell) of the source term provided by CHPRC. For most of the facilities, the primary contamination is on the remaining surfaces of the building. The main input to the computations is thus surface contamination levels, for which the methodology was originally developed. For specific components, contaminant quantities were provided and the release-rate methods were adapted to match the available data. For the PRF canyon, because of the difficulty of measuring the contaminant levels, a bounding assumption of 25 nCi/g of the entire solid structure had initially been assumed; this value was changed to 24.7 nCi/g for the PNNL-20173 Revision 4 analyses based on the results of non-destructive analyses (NDA) (CHPRC-03038, Sauer et al. 2016).

Details of the source term analysis for each component of PFP are presented in Appendix A. Radioactive contamination emissions (STs) have been calculated by release mechanism and demolition area for on-shift and off-shift activities. The emissions from the applicable sources have been combined to provide emissions estimates for each day from each demolition area.

2.2 Air Dispersion Modeling

The U.S. Environmental Protection Agency's (EPA's) AERMOD dispersion model is used to estimate atmospheric concentration of the released radioactive materials in the immediate vicinity of the demolition activities. AERMOD provides hourly estimates for the time periods that demolition is planned by accounting for the ambient meteorological conditions as well as the effect of the nearby buildings on the air flow. The hourly estimates can be used to analyze longer time periods from within AERMOD or through post-processing. The rationale for the selection and use of the AERMOD dispersion model is documented in Appendix B.

The AERMOD dispersion and deposition modeling is based on weekly meteorological patterns identified from 6 years (2004 to 2009) of historical hourly meteorological measurements from the PFP meteorological station (No. 19) and other supporting data from Hanford Station (No. 21). The meteorological data includes wind direction, wind speed, precipitation rate, and data from which to calculate location dependent degree of dispersion. The historical weather patterns are assumed representative of conditions that will occur during the demolition period. Some of the hourly data involved winds at > 15 mph. Even though demolition will only occur when winds are < 15 mph, the high wind speed data was not excluded. This is because the 95% dispersion conditions are based on a cumulative distribution function where only 5% of the cases result in less dispersion. That is, only the upper 5% of the dispersion coefficients impact the final 95% value. Since winds > 15 mph result in less concentrated plumes (greater dispersion), air concentrations computed for those conditions do not impact the final 95% value because they fall in the bottom 95% of the values.

The demolition activities described in Appendix A are listed in a project spreadsheet. A duration (number of shifts) for each activity is estimated. The MAR during each shift is then pro-rated from the total inventory based upon the duration. The MAR is multiplied by the applicable emission factor described in Appendix A, Section A.1, to obtain the source term. The release is assumed to be constant during the activity, which is usually a full shift, although sometimes a half-shift for smaller activities. If multiple activities are simulated to occur simultaneously, the concurrent releases are summed. This provides an hourly estimate of the release rate for the day. The spreadsheet is built so that each day is described, in the assumed order of demolition. The sequential hourly release rates for the entire demolition are then available. This sequence of hourly emissions is assumed to begin on the first day of the available meteorological data and the concentrations of contaminants in the air and depositions on the ground are estimated throughout the domain. The sequence is then repeated assuming the work begins on the second day of the meteorological data, and then the third, etc.

The 95% percentile values are based on each possible 4-day period as described above (since demolition will occur during a 10-hr/day, 4-day work week) in the 6 years of hourly met files used to compute hourly air concentrations from the hourly source terms. AERMOD evaluated each possible four day cumulative outcome (integrated air concentration) and built a cumulative distribution function from each. Because each outcome had the same frequency of occurrence, the values were simply sorted from greatest to lowest. The value where only 5% are higher represents the 95^{th} percentile value.

The 95% air concentrations are modeled for an array of receptors covering the site fenceline and nearby air monitoring locations. The modeling takes into account directionally dependent building wake impacts. That is, the influence buildings have on dispersion depends on the wind direction and those buildings that can intercept the plume. As the buildings (and portions of the larger buildings) are sequentially demolished, their influence on the atmospheric dispersion is removed from the modeling for the remaining facilities. The historical data provides statistics on wind direction which are expected to represent wind patterns during demolition.

Weekly cumulative values of air concentrations are evaluated with modeling results reported as the 95^{th} percentile of time-integrated derived air concentrations (DAC-hours) for air concentrations. As a result, the 95^{th} percentile values for one location are most likely derived from different data than the values for any other location. Thus, the joint results do not represent a single anticipated condition, but rather the most-likely worst case for all locations simultaneously.

The modeling analysis defines the potential levels of air exposures from the proposed demolition activities at measurement locations and control boundaries. Potential air exposures are defined both in terms of the 95^{th} percentile and the distribution of predicted air concentrations.

Using these methods, emission and air dispersion computations were made to assess the potential concentrations from different sets of demolition assumptions. The analysis process consisted of three steps:

1. Estimate the emission rates for the proposed demolition activities - Step 1 starts with an estimate of the amount of contamination in the structure, what form it is in, and where it is located. Demolition methods and associated activities are identified in this step. The combined data on amount, form, location and demolition methods are used to estimate emissions during the various demolition activities.

2. Compute the airborne concentration increments - Step 2 takes the emission rate estimates from Step 1 and uses an air dispersion model to produce estimates of hourly air concentrations. The potential exposure levels are defined as the sum of the predicted concentration increments from demolition activities and representative background concentration values (derived from the monitoring station records).

3. Determine if the potential exposure levels are acceptable - Step 3 uses standards to evaluate the viability of the demolition option that has been modeled. For air exposures, a limit of 12 DAC-hours per week is used. If none of the locations within the selected areas indicate the potential for exposure levels to exceed these limits, then the demolition is deemed clearly viable.

The potential emission rates associated with proposed demolition activities are estimated based on specific methods of execution of the demolition activities. Appendix A provides a detailed definition of those activities including the assumptions and approximations that are required to provide a context for the demolition for each of the PFP components.

The air dispersion modeling with AERMOD also requires a number of assumptions related to model options, source-term input definition, analysis products, time scales, and receptor locations. The details of those assumptions are discussed in Appendix A.

2.3 Airborne Contamination Dosimetry

The dosimetry depends on the mixture of radioisotopes present. The inventories listed in Table 2.4-1 are assumed to represent the contamination present in the various PFP complex buildings and equipment. The spectrum of radionuclides is based on the best information available for each structure.

U.S. Department of Energy (DOE 1998) regulations specify in 10 CFR 835.2, "Definitions," that an airborne radioactivity area means any area accessible to individuals where the concentration of airborne radioactivity above natural background exceeds or is likely to exceed the DAC, or an individual present in the area without respiratory protection could receive an intake exceeding 12 DAC-hours in a week. If radionuclides "A," "B," and "C" are present in concentrations C_A, C_B, and C_C, and if the applicable DACs are DAC_A, DAC_B, and DAC_C, respectively, then the concentrations shall be limited so that the following relationship exists:

$$\frac{C_A}{DAC_A} + \frac{C_B}{DAC_B} + \frac{C_C}{DAC_C} \leq 1$$

For a mixture of radionuclides where the concentrations of each are expressed in terms of a fraction, f, of a total, DAC_T, this can be written as:

$$\frac{f_A \times DAC_T}{DAC_A} + \frac{f_B \times DAC_T}{DAC_B} + \frac{f_C \times DAC_T}{DAC_C} \leq 1$$

This relationship can be used to determine a maximum total concentration that meets the requirements as:

$$\frac{f_A}{DAC_A} + \frac{f_B}{DAC_B} + \frac{f_C}{DAC_C} = \frac{1}{DAC_T}$$

DACs are provided in 10 CFR 835 Appendix A for three absorption classes (F, M, and S). The absorption classes indicate the general time frame for absorption of the materials from the respiratory tract into the blood. The range of half-times for the absorption classes correspond to:

Class F: 100% at 10 minutes;

Class M: 10% at 10 minutes and 90% at 140 days; and

Class S: 0.1% at 10 minutes and 99.9% at 7000 days.

For the PFP plutonium contamination, DACs based on S absorption are applicable (DOE-STD-1128-2013, Section 5.2). The initial nitrate compounds will have mostly oxidized after years of exposure to air. For Am-241, 10 CFR 835 Appendix A only provides an absorption Class M DAC value.

2.4 Summary of Anticipated Radionuclide Inventories

Because the various buildings and rooms within each building have different anticipated contamination levels at the time of demolition, for the purposes of demolition planning the complex has been subdivided into demolition planning zones. The major zones (seven) for 234-5Z are illustrated by numbered areas in Figure 2.4-1. Along the top and left side of this figure, numbers 1-26 and Letters A-J represent the locations of vertical/horizontal lines whose intersection identify the locations of support columns within the 234-5Z building. Although the 236Z structure location is shown in Figure 2.4-1; its planning zones are not explicitly illustrated. These 236Z zones are based on the structure's six floors and main cell; the double-line area indicates the location of the main process cell. Beige lines represent the 291Z fan house, which is connected to the 291Z-1 stack.

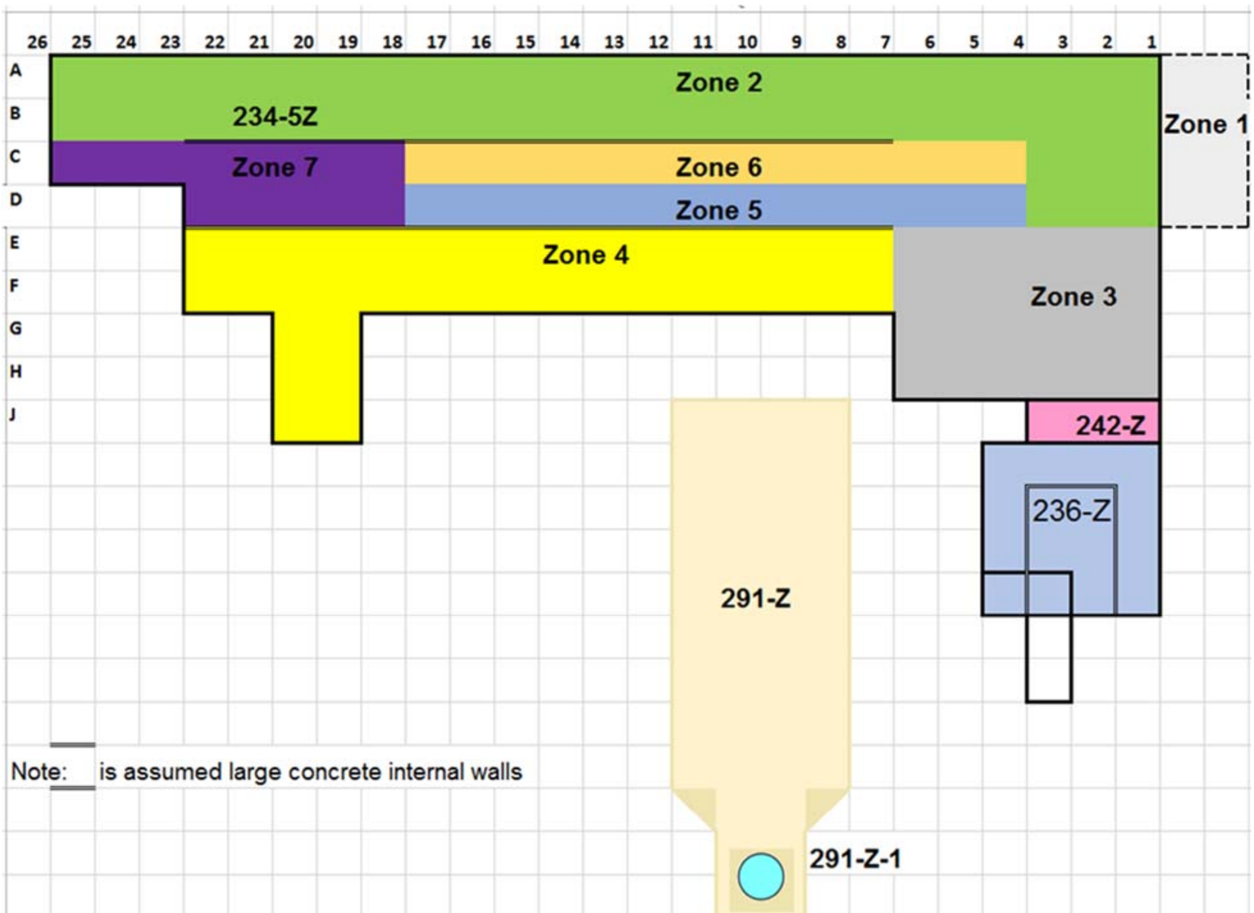

Figure 2.4-1. Demolition Areas and 234-5Z Zones Defined for this Analysis

The radioactive contamination of concern for the PFP complex building demolition is located on surfaces, under paint and tiles, within ducts, and in other inaccessible places. Table 2.4-1 provides a summary of the inventories used in the structure-specific source term analyses in Appendix A. The total inventories are estimated based upon the listed levels of residual contamination within each structure assumed at the time of demolition.

Table 2.4-1. Anticipated Inventory of Radionuclides in Defined Demolition Zones of the PFP Complex

Demolition Sequence			*LLW Contaminated Surfaces*				*TRU Strategic Removals*		
Facility	**Zone**	**Location**	**Debris Wt (lb)**	**Area (SF)**	**α dpm/100cm²**	**Description**	**QTY**	**Unit**	**Pu (g)**
236-Z	SZ-1	236-Z 6th Floor	193228	1216	200,000	Floors & Walls	None		
				229	100	E-3 Shaft and Plenums			
	SZ-2	236-Z 5th Floor	165307	1074	200,000	Floors & Walls	None		
				201	35,000	E-3 Shaft and Plenums			
			162	33	7,500,000	E-4 Ductwork			
	SZ-3	236-Z 4th Floor	1150415	14228	200,000	Floors & Walls	6	E4 Segments, Rooms 42, 43, Corridor 47	4
				549	9,000	E-3 Shaft and Plenums			
			7948	1610	700,000	E-4 Ductwork			
	SZ-4	236-Z 3rd Floor	1050115	2629	200,000	Floors & Walls	None		
				427	1,000	E-3 Shaft and Plenums			
			1778	360	400,000	E-4 Ductwork			
	SZ-5	236-Z 2nd Floor	1094080	8640	200,000	Floors & Walls	11	Gallery GB's/FB's, E4, Pipe stubs	425
				1531	45,000	E-3 Shaft and Plenums			
			28506	3011	900,000	E-4 Ductwork			
	SZ-6	236-Z 1st Floor	1121343	6613	200,000	Floors & Walls	38	Gallery GB's/FB's, Sleeves, E4, stubs	848
				811	10,000	E-3 Shaft and Plenums			
			1244	252	250,000	E-4 Ductwork			
	SZ-7	236-Z Canyon	2064161	7827	24.7 nCi/g	Canyon Walls	4	MTCE Cell	66
							1	Man Basket	29
							41	Strongbacks	643
242-Z	SZ-1	242-Z and 242-ZA	289446	9100	8,000,000	Tank & Control Rooms	9	Tanks	373
234-5Z	SZ-1	234-5ZA	262335	1000	2,600	Floors & Walls	None		
	SZ-2	234-5Z Front Side	5319554	10000	2,600	Floors & Walls			
			118500	8000	5,000	E-3/4 Ductwork			
	SZ-3	234-5Z A Labs	2233034	117344	200,000	Floors & Walls	15	GB's/FB's	29
			474000	32000	2,000,000	E-3/4 Ductwork			
	SZ-4	234-5Z Backside/ PPSL	3323369	196364	200,000	Floors & Walls	17	GB's/FB's	555
			474000	32000	500,000	E-3/4 Ductwork			
	SZ-5	234-5Z RMA Line	1545479	105384	2,000,000	Floors & Walls	9	GB's/FB's	234
			237000	16000	2,000,000	E-3/4 Ductwork	100	LF Ductwork	100
	SZ-6	234-5Z RMC Line	1676105	99908	2,000,000	Floors & Walls	5	GB's/FB's	36
			237000	16000	2,000,000	E-3/4 Ductwork			
	SZ-7	234-5Z RADTU/ Basement	1510281	72496	200,000	Floors & Walls	2	Filterbox	20
			18355	Fire Dam	60 nCi/g	LLW GB's/FB's (5)			
			450000	Epoxy Fill	35 nCi/g	LLW Tunnel Drains	2182	LF TRU Drains	550
291-Z	SZ-1	291-Z Fanhouse	5314936	12000	2,000	Ceiling	724	LF 26" PVS	502
	SZ-2	291-Z-001 Stack	937365	9000	3,000	Stack Interior	None		

*The notation LF denotes "linear feet" of pipes or ducting; GB indicates "Glove box" and FB indicates "Filter box"

2.5 Modeling Demolition Scenarios

The modeling analysis requires definition of representative demolition phases which include the assumed demolition methods and duration (i.e., working days over an elapsed time period). The most-accessible equipment and sections of the buildings are assumed to be removed before less-accessible components. The analyses credit the use of misting, water, and fixatives throughout the demolition and load-out process to minimize airborne contamination spread.

Each building in the PFP complex is considered in terms of its construction and anticipated contamination levels (see details in Appendix A). All demolition and load out will only occur when sustained wind speeds are less than 15 miles per hour. The results, which are presented in Section 3, are based on the sequential demolition phases, durations, and methods described in Table 2.5-1.

Table 2.5-1 Demolition Phases and Demolition Options

Phase	Involved Structures	Duration	Details
1	236Z Plutonium Reclamation Facility	23 days over 6-week period for shell; 46 days over 12-week period for main cell	The 236Z cell with the 236Z structure contains the highest levels of contamination in all of the PFP complex structures. 236Z will be entirely demolished using hydraulic shears and/or mechanical hammer. That activity is simulated in 2 portions: the external frame of the building and the main process cell. The demolition of the external portions of the building is projected to require about 23 working days over about 6 weeks of elapsed time. Several highly-contaminated gloveboxes and galleries will be carefully removed before demolition. The demolition of the highly-contaminated main cell is projected to require about 46 working days over a subsequent 12 weeks of elapsed time. Forty-one strongbacks are expected to remain within the main cell; they will be removed and size-reduced as part of the cell demolition process. A connecting wall with 242Z will remain.
2	242Z Waste Treatment Facility	7 days over two-week period	The 242Z building roof and walls will be demolished with a multiprocessor that operates hydraulic shears or mechanical hammer end effectors. Contaminated tanks will be carefully removed. A connecting wall with 234-5Z will remain.
3	234-5Z	70 days over 18-week period	The various zones of the 234-5Z building will be demolished using hydraulic shears or mechanical hammer. Certain gloveboxes, ductwork, and piping remain in the building until the time of demolition; they will be carefully removed as access is available.
4	291Z Fan House	18 days over 5- week period	The above-ground portions of the 291Z fan house will be removed using hydraulic shears or mechanical hammer. Contaminated vacuum lines will be cut and capped prior to demolition and removed as access becomes available.
5	291Z-1 Stack	15 days over 4-week period	The 291Z-1 stack is assumed to be toppled with explosives; the stack will be directed to fall into a prepared shallow trench. After being toppled, the stack will be broken up into smaller pieces and removed using a multiprocessor.

The analysis assumes that, even with fixatives, misting, and other controls, a certain amount of dust will escape to the environment during the demolition activities. The amount of dust released as a function of time from the start of demolition is shown in Figure 2.5-1. The actual radiation risk is related to the amount of residual radioactive contamination contained in the dust, which varies with the various parts of the facility being demolished. An inventory-weighted plot of the source term is shown in Figure 2.5-2.

A comparison of Figures 2.5-1 with 2.5-2 reveal that the potential daily dust loading does not directly correlate with potential daily radioactivity release rates.

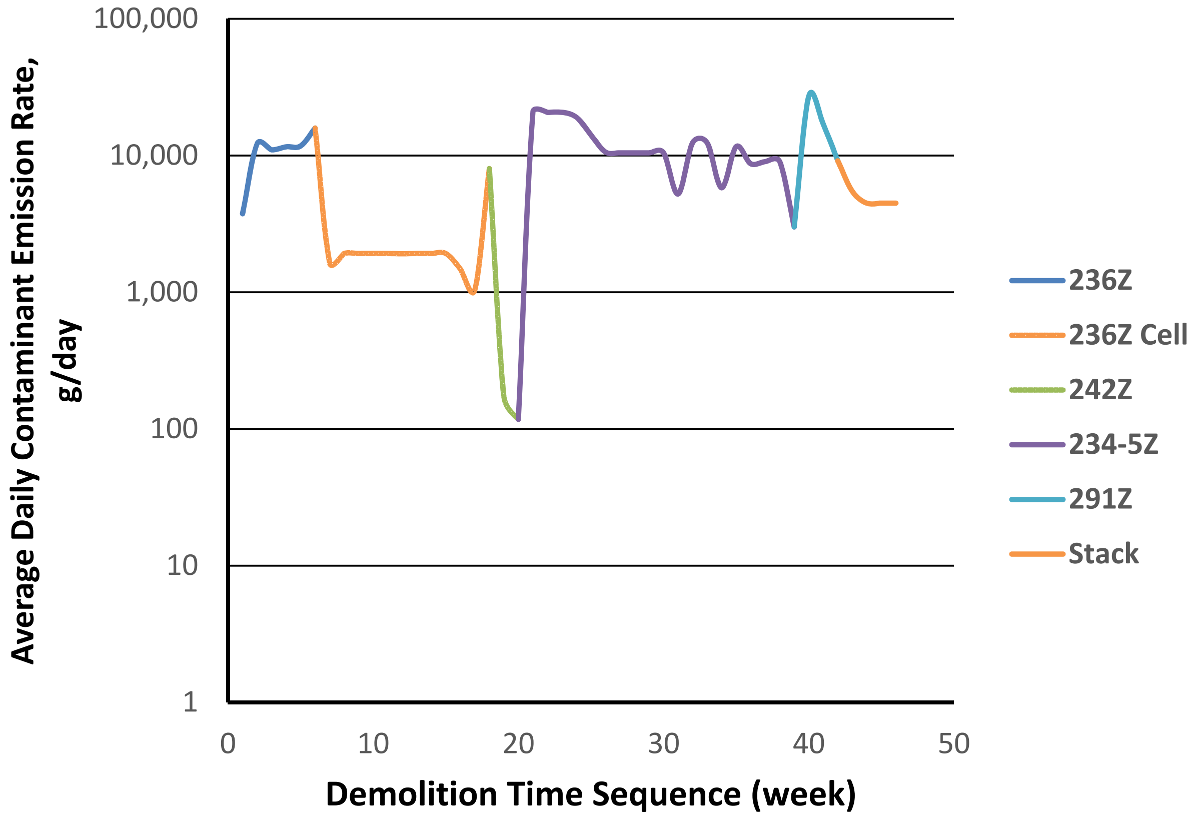

Figure 2.5-1. Weekly-averaged Dust Release Rate during Active Demolition and Load-out Activities

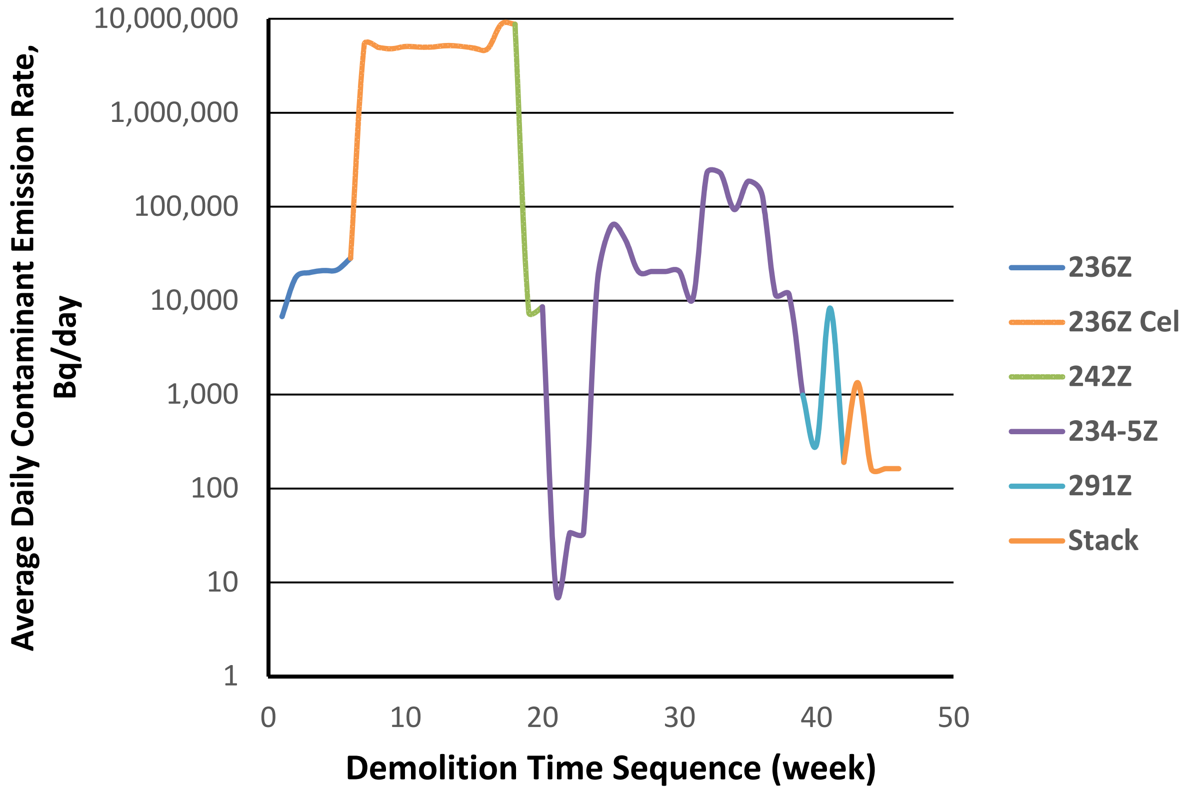

Figure 2.5-2. Weekly-averaged Radioactive Source Term During Active Demolition and Load-out Activities

The modeling assumes that only moderate controls will be applied during the initial portion of the 236Z demolition because of the low radioactive inventory in the associated parts of 236Z – with the exception of the removal of the highly-contaminated galleries. In Figure 2.5-2, it can be seen that the radioactive source term resulting from this portion of the demolition is low until the final week when the galleries are removed.

The Figure 2.5-1 curve associated with the later weeks of demolition is relatively low, but the corresponding pattern in Figure 2.5-2 has a high peak. The latter portions of the demolition of 236Z result in greatest radioactive material releases; this is the largest part of the assumed source term, because of the removal of the portion of the facility with the highest residual contamination levels (i.e., the cell mezzanine and north wall).

The peak in Figure 2.5-2 through most of the period of cell demolition (about weeks 8-18) results from the dust (and radioactive material) released during the demolition of the cell ceiling and dropping of the rubble to the ground combined with the removal and interim-processing of the strongbacks, and finally the maintenance cell, mezzanine, and north wall. All weeks subsequent to the removal of the 236Z cell have radioactive emission rates 1 to 2 orders-of-magnitude or more lower than that of the cell removal period.

The contamination in the remainder of the PFP facilities, including the more highly-contaminated portions of 242Z and the 234-5Z RMA and RMC lines, is substantially lower than that of the 236Z process cell. The dip in the curve of Figure 2.5-1 about week 20 is due to the relatively small amount of material at risk in the 242Z Building tank room and annex. The substantial dip in the curve of Figure 2.5-2 at about weeks 20-22 is a result of the demolition of the relatively uncontaminated office spaces and front face of the 234-5Z building

2.6 Quality Control Procedures and Documentation

The quality control procedures for conducting these analyses are discussed in Appendix D. Source term and emission rate worksheets are documented in Appendix E. Appendix F documents the contents of selected AERMOD output files. These output files contain listing of both modeling inputs and results.

3.0 Predicted Air Concentration Increments

The air concentration modeling efforts were conducted for demolition of all the PFP buildings as described in Section 2, Table 2.5-1. The predicted potential air concentration impacts from demolition of the PFP buildings are presented in terms of time-integrated air exposures. Projected air exposures are presented for 1) least-contaminated PFP structures and 2) the most-contaminated PFP structures.

The air exposure results presented in this section use the PFP facility area map shown using Figure 3.1-1 as a base map. The six air-monitoring stations (N-155, N-165, N-433, N-554, N-555, and N-975) considered in this report are shown in Figure 3.1-1. The map includes the facility fenceline (black), the major roads (brown), and the locations of six nearby air monitoring stations (Hanford pink). The buildings and subsets of buildings being considered for demolition are shown as colored overlays. Structures shown in gray, some of which will be gone at the start of the PFP demolition activities, are not part of structures considered in this report. The structures shown in green (also marked as area 1), including 234-5Z (demolition zones 1 to 7), 242Z, and 291Z, are the buildings in the complex grouped as having lower overall contamination levels. The structures marked in orange (also marked as area 2) including 236Z cell and associated structures are the areas with higher levels of contamination. Figure 3.1-1 also includes the PFP stack (marked in blue), the demolition of which is considered in Section 3.3.

The air monitoring stations will only be able to detect increments in air exposures from demolition if those increments are large enough to be distinguished from the local background. The background for this area is estimated to be on the order of 0.015 and 0.03 DAC-hours for 1-week and 2-weeks, respectively[1]. The air exposure results presented below are the increments predicted to result from the demolition – and as such do not contain the naturally occurring background component.

The air dispersion modeling of the PFP building demolition addresses airborne exposures. Airborne exposures are characterized in terms of modeled air concentrations expressed as DAC-hour exposures summed over work-week time periods.

3.1 Modeling Approach

To evaluate the potential air exposure levels from the planned demolition activity scenarios listed in Table 2.5-1 and detailed in appendices, the local increments of air concentrations were computed for each demolition-hour based on 95% worst case dispersion patterns observed in 6 years' worth of hourly data (2004–2009). This period was selected for comparability with earlier versions of this document. The activities are assumed to occur during the day and swing shifts. Allowing for weekends and holidays, the start-to-finish demolition period for all the demolition activities is projected to be about 11 months.

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1 In an analysis of the routine air samplers (Napier et al. 2010), the mean of background air samples at the Hanford 200-West monitoring stations is shown to be about 1.2×10^{-15} µCi/ml of gross alpha emitters. Most of the background will be natural alpha-emitting radionuclides, primarily progeny of the uranium chain. If the background is assumed to have the same radionuclide spectrum as the contamination of the 236Z Building (which is conservative from a dosimetric sense), the background levels of air concentration are at about 0.0001 DAC; 1-week and 2-week background exposures are estimated to be about 0.015 and 0.03 DAC-hours, respectively.

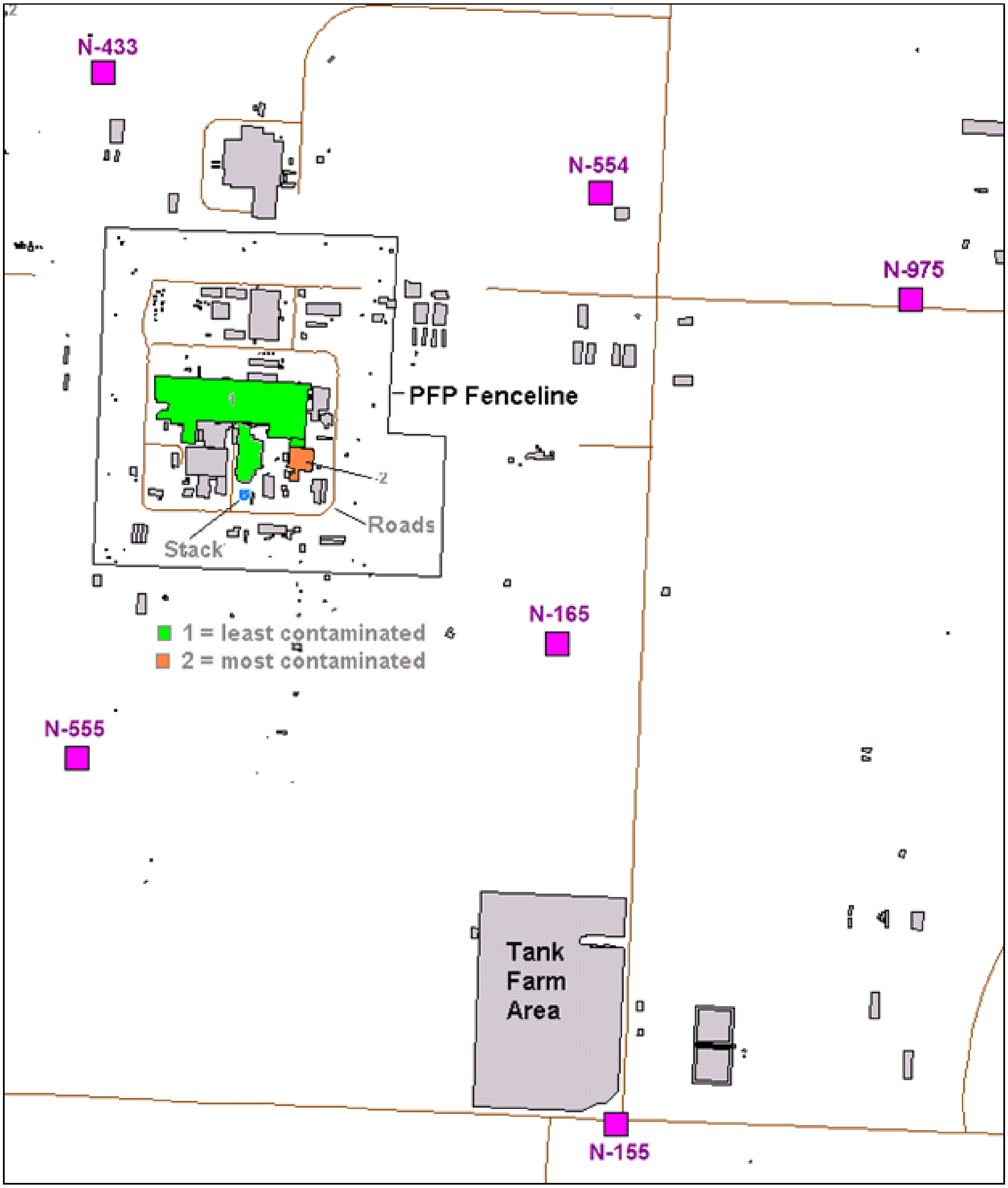

Figure 3.1-1. PFP Demolition Structures, PFP Fenceline, and Nearby Monitoring Stations

The modeling of the potential impacts of this 11-month period of projected activities required characterization of the full sequence of day-to-day demolition activities. Two modeling approaches are used to analyze the potential air exposures using the AERMOD model based on worst case dispersion patterns observed from 6-years of hourly meteorological data. The first approach is to output only the 95th percentile concentrations based on the combination of emissions and air dispersion conditions. Then if needed based on the 95th-percentile-case analysis, a second approach is to output the full distribution of air concentrations modeled for highest-week emissions. The former provides bounding values of potential air exposures. The results of these runs provide a basis for projecting the worst case impacts that could occur during any of the demolition activities based on bounding dispersion conditions. The latter provides a definition of the ranges and likelihoods of potential air exposures.

To maximize the number of time periods used in the climatological definition of peak exposure values, the air quality modeling of climatological peak exposures are conducted using 4-day instead of 7-day weeks. For air concentrations, each 4-day cumulative DAC exposure is the same as what would be computed based on an expanded 7-day period (with no emissions on a 3-day weekend). Or, for 2-weeks air concentrations, an 8-day period is used to evaluate the potential impacts from activities that would occur over 14 days. The demolition activities for all the PFP structures involve about 179 working-days; 65 work-days are projected for the demolition of 236Z structures including the penthouse (23 days) and the cell (46 days).

Maximum impact results for air exposures are presented separately for structures with the least contamination (234-5Z, 242Z, and 291Z, and the 291Z-1 stack) and most contamination (236Z cell and associated structures). These zones are shown in Figure 3.1-1.

3.2 Predicted Air Concentrations – PFP Buildings

Modeling runs have been conducted to define levels of increased airborne activity in the immediate vicinity of the demolition activities. These potential air concentrations are associated with the coincidences of demolition release rates and worst case ambient meteorological dispersion conditions. Although demolition of the PFP structures will extend over many months, the demolition of the more contaminated portions with the highest potential release rates are projected to occur over a relatively short period. To obtain the range of worst-case air concentrations during this short time period, these maximum emission rates are modeled as potentially occurring anytime during the worst case dispersion conditions as indicated from six-years of hourly meteorological data.

Facility Fenceline: The 95th percentile predicted air exposures at the facility fenceline potentially resulting from demolition activities are expressed as weekly total DAC-hours to conform to the practice of considering exposures in a work-week. The largest 4-day source term is used to define the worst-case average daily emission rate. This emission rate is run with AERMOD using 6 years of historical local hourly meteorology measurements. The daily AERMOD concentration outputs are processed to determine the 95th percentile 4-day exposure values at the PFP Facility fenceline.

Thus, for the weekly air exposure figures shown below, the air concentration values listed at each point on the site fenceline represent a weekly exposure value that should occur no more than 5% of the time at that particular point during demolition of the facility – no matter what time of year the demolition actually occurs. The air concentrations that will occur depend on actual conditions during demolition (such as ambient meteorological conditions, actual facility contamination levels, true impacts from mitigation efforts, etc.). The modeling results are expected to bound the actual airborne concentration levels that will occur.

Monitoring Stations: The potential air concentrations at the six monitoring stations shown in Figure 3.1-1 have been predicted from this modeling effort. To match the sampling period at these monitoring stations, the predicted concentrations at these stations are expressed as biweekly total DAC-hours. The source terms derived for the demolition activities indicate several weeks of emission rates that approach the maximum weekly rate. As a result, the average daily emission rate for the maximum week is used to represent the worst-case 8-day (2 working weeks) emission rate for demolition activities. This maximum emission rate is used as an input into AERMOD which models dispersion at the monitoring stations using 6 years of hourly meteorology data. The resulting AERMOD outputs are used to build cumulative distribution functions from which the 95th percentile 2-week exposure values are determined.

Thus, the air exposure isopleths in the figures below define the distribution of potential bi-weekly air exposures predicted to occur at each of the monitoring station locations. These modeling results predict worst case air concentrations resulting from demolition activities.

3.2.1 Demolition of 234-5Z, 242Z, and 291Z

This section presents the air exposure modeling results for the demolition of 234-5Z, 242Z, and 291Z structures with shears or mechanical hammer. These are the PFP structures containing lower levels of contamination (shown in green in Figure 3.1-1).

A plot of the peak-weekly air exposure increments in DAC-hours per week at the facility fenceline is provided in Figure 3.2-1. The location with the largest 95th percentile is highlighted in red; the largest projected value at this location during demolition of these facilities is only 0.5 DAC-hours/week.

The maximum projected 2-week air exposure values (expressed as total DAC-hours) at each of the monitoring locations during demolition of these lower contamination PFP structures are shown in Figure 3.2-2. This plot is based on modeling the activities with the highest projected weekly emission rates (occurs during demolition of Zone 5 – in Figure 2.4-1) for all the 8-day periods (representing 2 weeks of demolition activity) based on 6 years' worth of hourly meteorological measurements. All other demolition activities associated with these facilities are predicted to generate lower peak air concentrations.

The predicted worst-case values for 234-5Z, 242Z, and 291Z are sufficiently low that an additional, more detailed analysis of the distribution of predicted air exposures at the monitoring stations (such as conducted below for the 236Z Cell demolition) is not warranted.

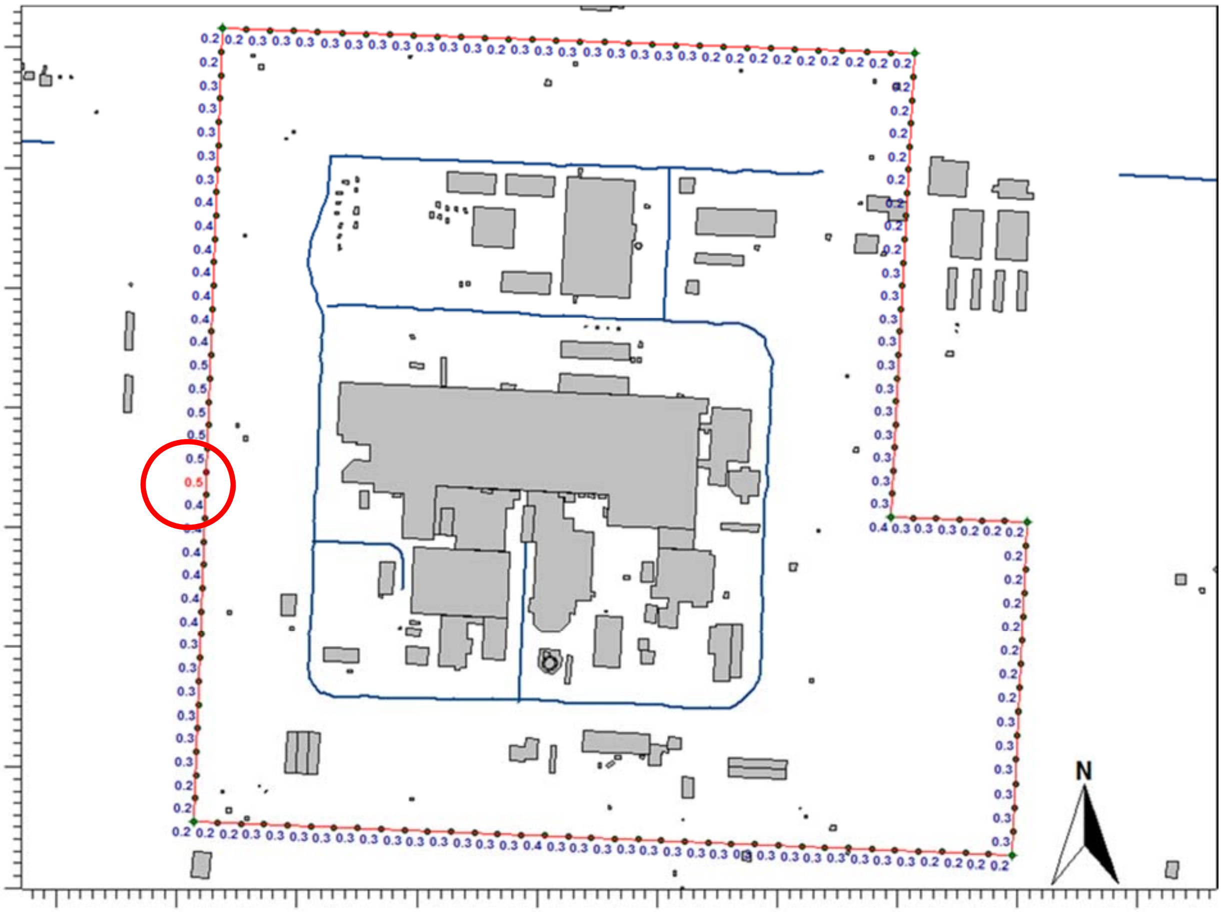

Figure 3.2-1. 95th Percentile Weekly Air Exposures at Site Fenceline for PFP Demolition Excluding 236Z Plutonium Reclamation Facility (DAC-hours). The location noted in red (0.5 DAC-hours) is the location with the largest 95th percentile.

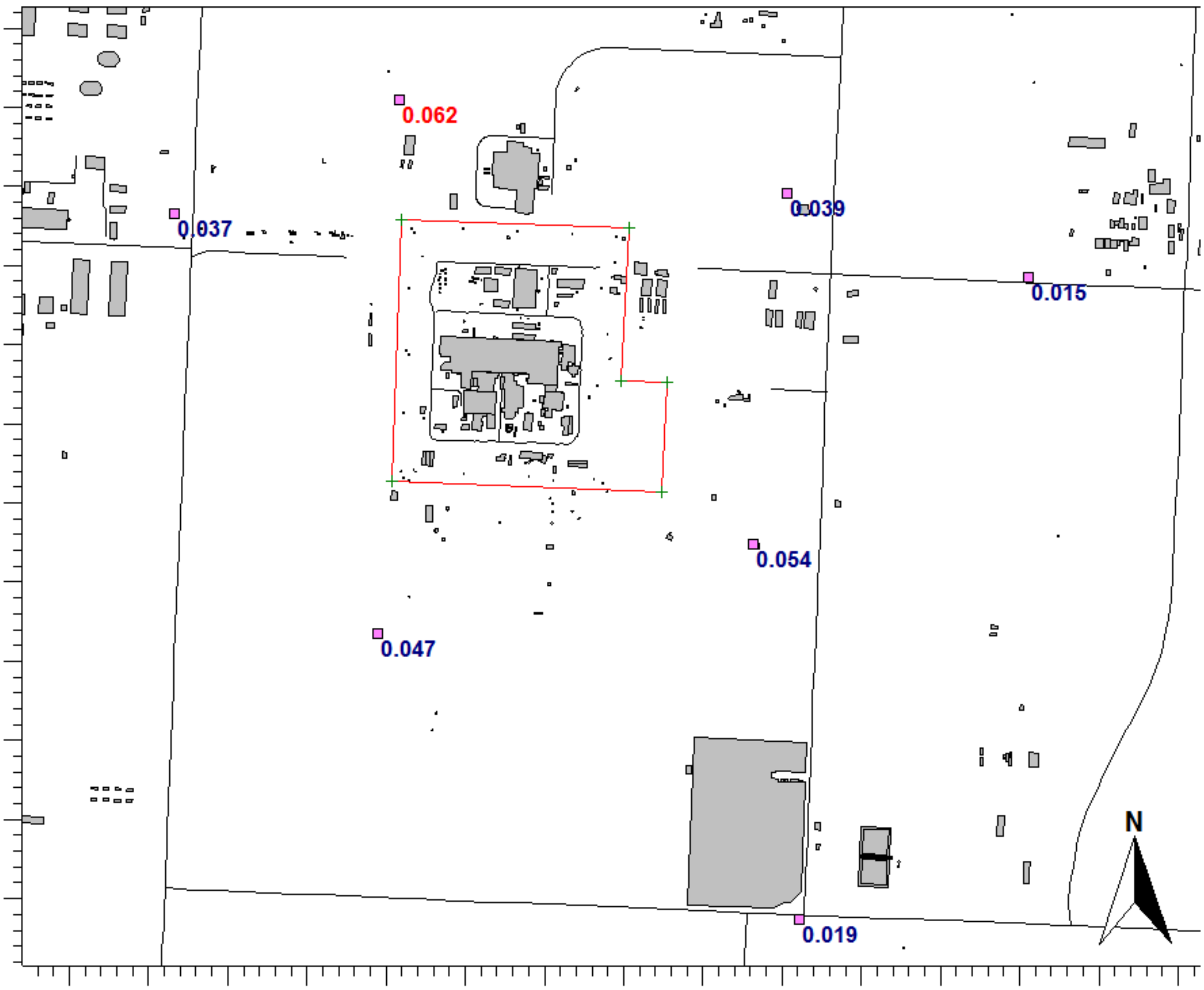

Figure 3.2-2. 95th Percentile 2-Week Air Exposure Values at Monitoring Stations for PFP Demolition Excluding 236Z Plutonium Reclamation Facility (DAC-hours)

3.2.2 Demolition of 236Z Cell and Associated Buildings

This section presents the air exposure modeling results for the demolition of 236Z cell and associated buildings with shears or mechanical hammer. These are the structures with higher levels of contamination that are shown in orange in Figure 2.4-1.

The incremental air exposures at the site fenceline and monitoring stations are modeled for the demolition of the 236Z cell and associated buildings. These structures include areas with the highest contamination levels in the PFP complex. Because the activity-weighed emissions from the 236Z cell alone account for >98% of the projected emissions from demolition of the 236Z cell and associated buildings combined, the 236Z cell results are assumed to fully represent all of the 236Z building demolition activities.

Site Fenceline: A plot of the 95th percentile air exposure increments in weekly total DAC-hours at the facility fenceline for the demolition of 236Z cell is provided in Figure 3.2-3. This plot is based on modeling the weekly activities with the highest projected weekly emission rates (occurs during the demolition of the mezzanine and north wall) for all the four day periods occurring based on six years of hourly meteorological measurements. Peaks in concentrations occur for plumes traveling Northeast and Southeast of 236Z. Monitoring stations N-544 and N-975 are positioned to readily detect any plumes that travel towards the Northeast; and stations N-155 and N-165 for plumes that travel towards the Southeast. Plumes traveling in other directions should generate lower exposure levels. To show the range of predicted fenceline air exposures, a similarly-derived plot of climatologically-based on 50th percentile results for weekly air exposure increment values (expressed as weekly total DAC-hours) is shown in Figure 3.2-4. These are the median values for these locations; half of all measurements would be expected to be above and half below these levels.

Monitoring Stations: Modeling was done to predict bounding 2-week air exposure values at various monitoring stations using the largest projected source term from 236Z cell demolition activities. The predicted values at each station were sorted by magnitude (i.e., an ordered list was created from lowest to highest value). A cumulative frequency distribution was developed by computing cumulative frequency of occurrence for each value starting with the lowest value in the list. Figure 3.2-5 presents the resulting frequency distribution for the 2-week DAC resulting from the bounding source term based on six years of hourly meteorological measurements. Figure 3.2-5 contains a plot for each of the six monitoring stations. The percent occurrence for each value on a curve represents the percent of time that the predicted air concentration at that curve's monitoring location is predicted to equal, or be less than the value during the worst case 236Z cell demolition activity.

The demolition of the 236Z cell is expected to last about 46 days. Because air dispersion climatology[2] varies with season, an additional analysis was conducted to define predicted air exposure distributions at different times of the year. Seasonal[3] summaries of the distributions of 2-week predicted air exposure increments are given in Figure 3.2-6 through Figure 3.2-9. Although the seasonal results show a large difference in the peak air exposures (highest values on the right of the curves), there is much lower seasonal difference in the more likely air exposures (values in the middle of the curves). Monitoring station-based summaries given in Figure 3.2-10 through Figure 3.2-15 compare the predicted monthly distributions of 2-week air exposure increments at each of the monitoring station locations, respectively. These plots show the effects of the annual cycle of air dispersion climatology on the predicted air exposures for each monitoring station location.

2 Air dispersion climatology varies with changes in combinations of wind speed, wind direction, and intensity of atmospheric turbulence. The atmospheric turbulence is often expressed as a function of atmospheric stability.

3 To evaluate seasonal variations in air dispersion conditions, the year was divided in four air dispersion seasons: spring (March, April, and May), summer (June, July, and August), fall (September, October, and November), and winter (December, January, and February).

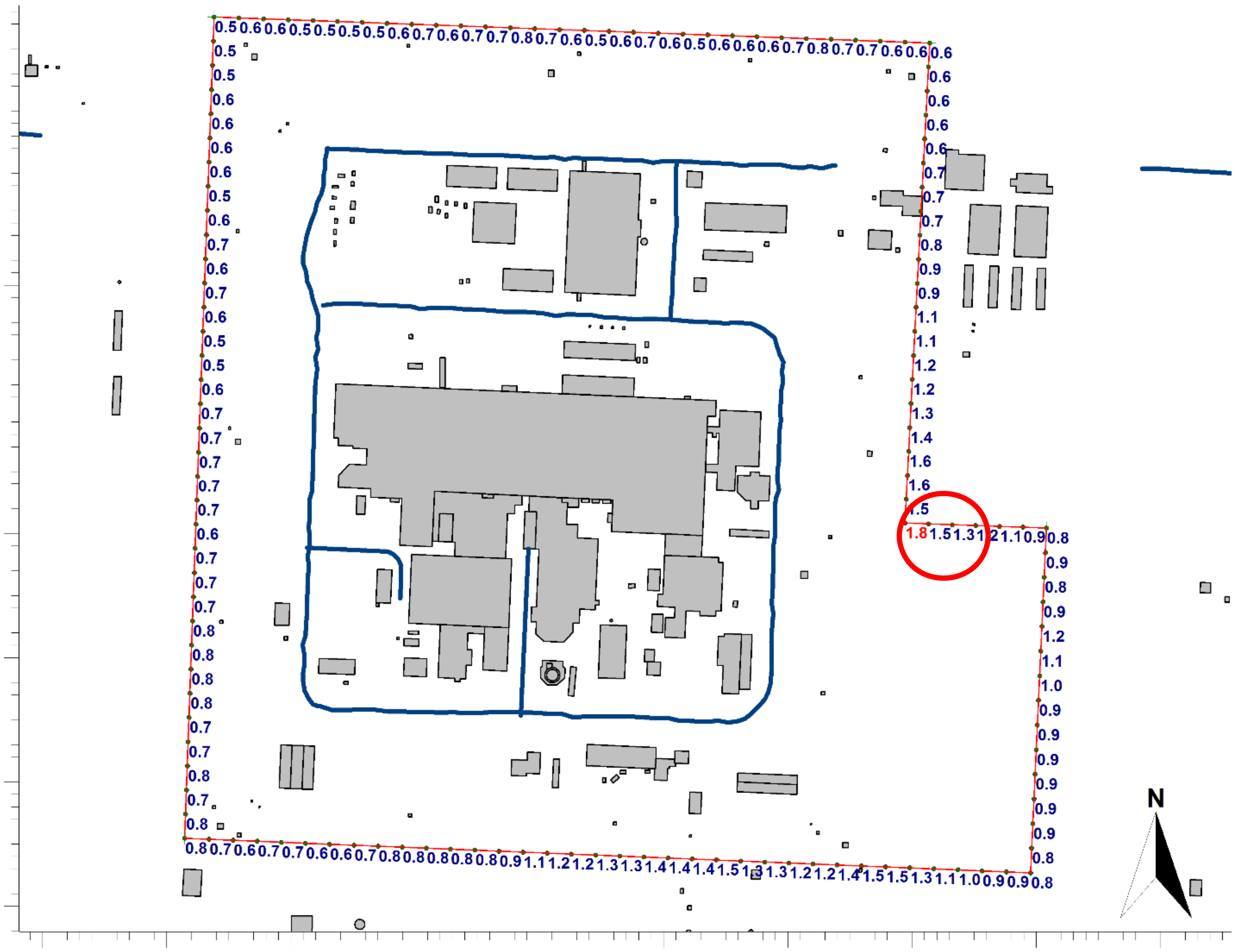

Figure 3.2-3. 95th Percentile Weekly Air Exposures at Site Fenceline for 236Z Plutonium Reclamation Facility Demolition (DAC-hours). The location noted in red (1.8 DAC-hours) is the location with the largest 95th percentile.

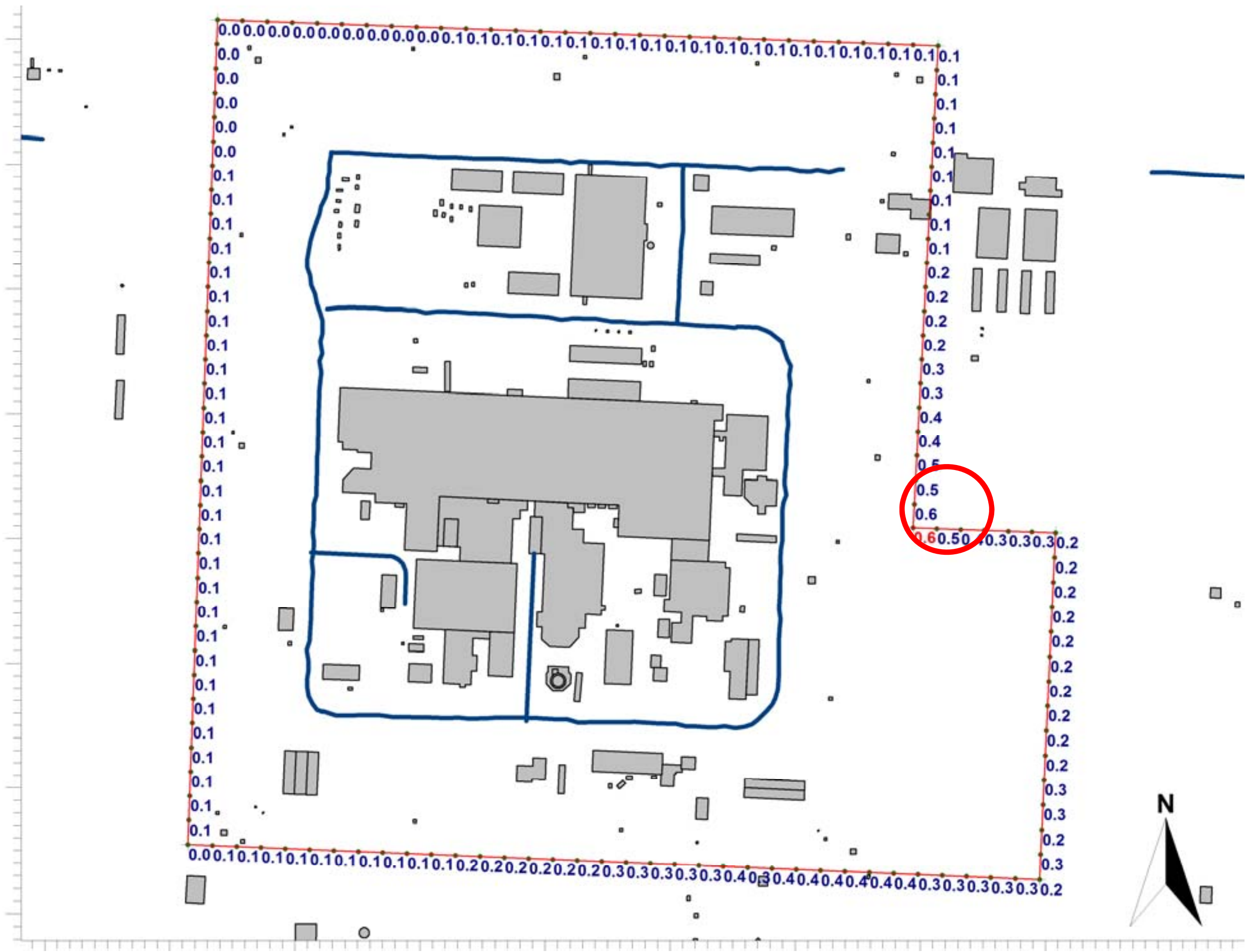

Figure 3.2-4. 50% Percentile for Weekly Air Exposures at Site Fenceline for 236Z Plutonium Reclamation Facility Demolition (DAC-hours). The location noted in red (0.6 DAC-hours) is the location with the largest 50th percentile.

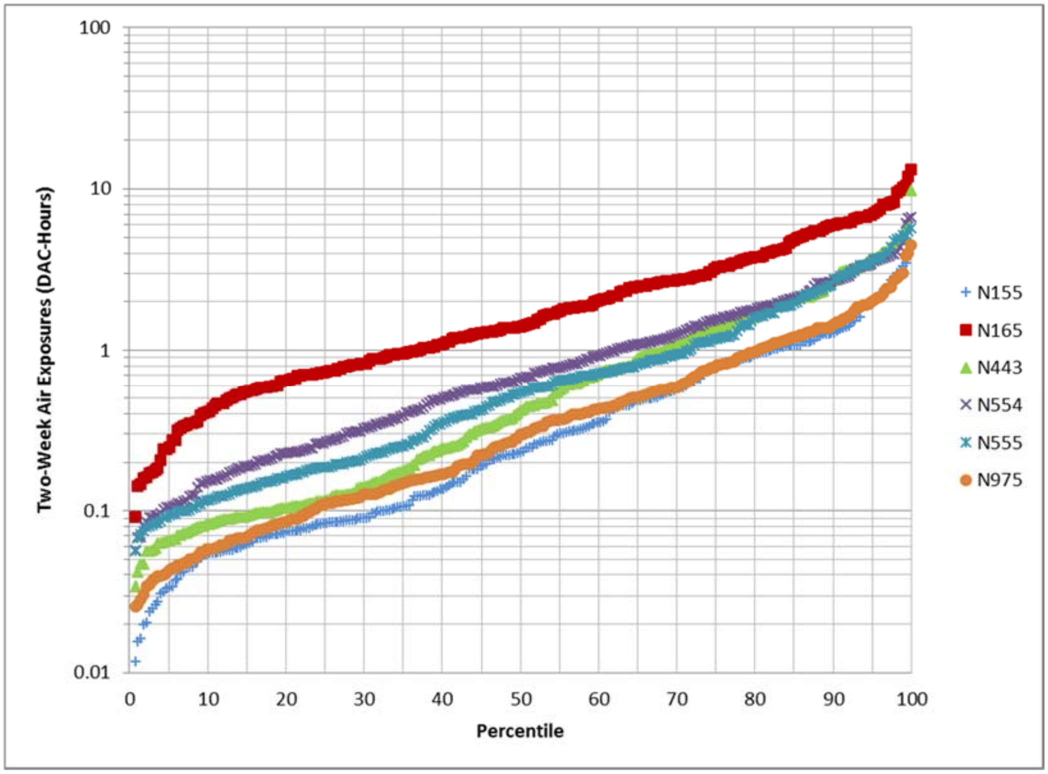

Figure 3.2-5. Distribution of Predicted Annual Air Exposure Increments for 236Z Demolition

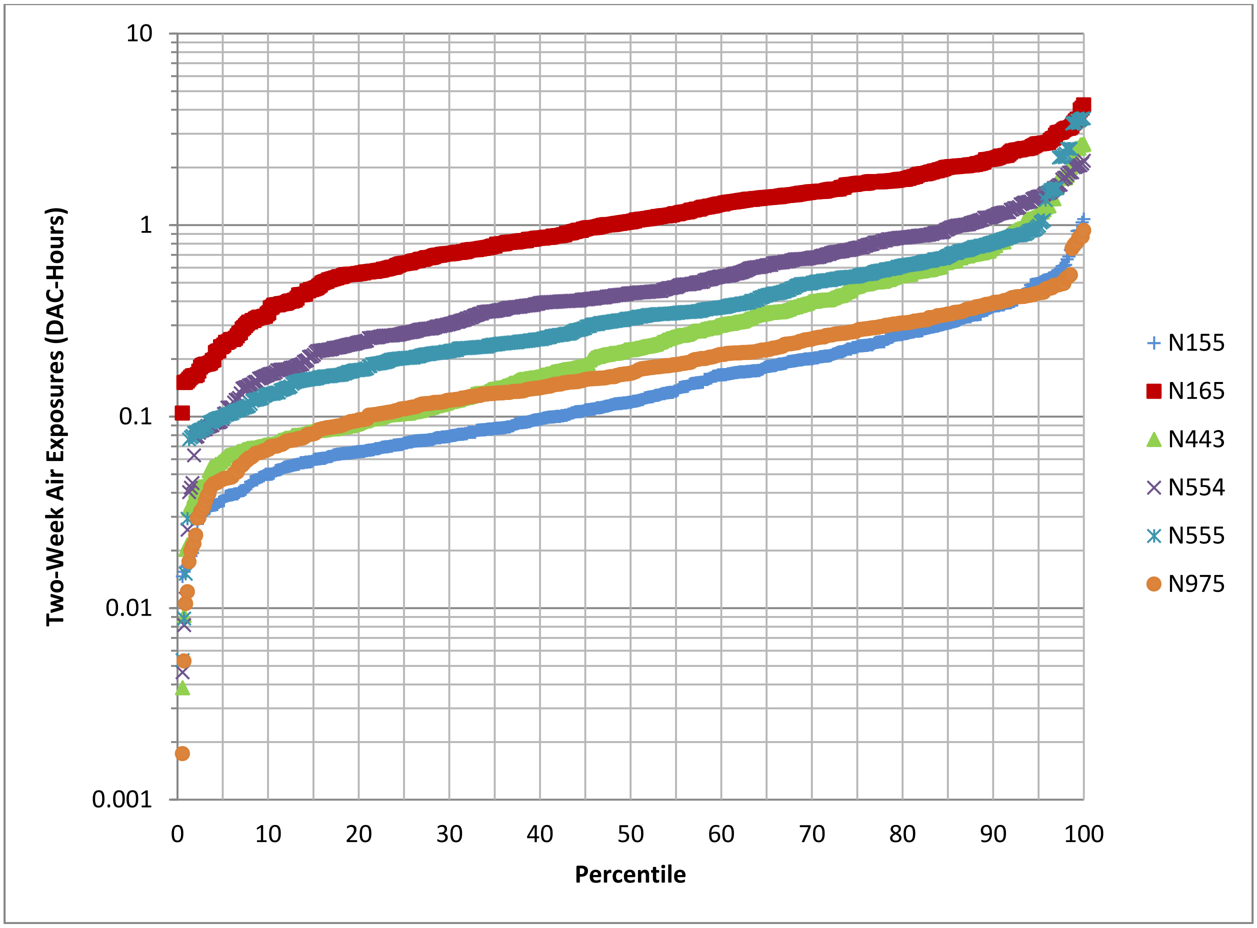

Figure 3.2-6. Distribution of Predicted Spring Air Exposure Increments for 236Z Demolition

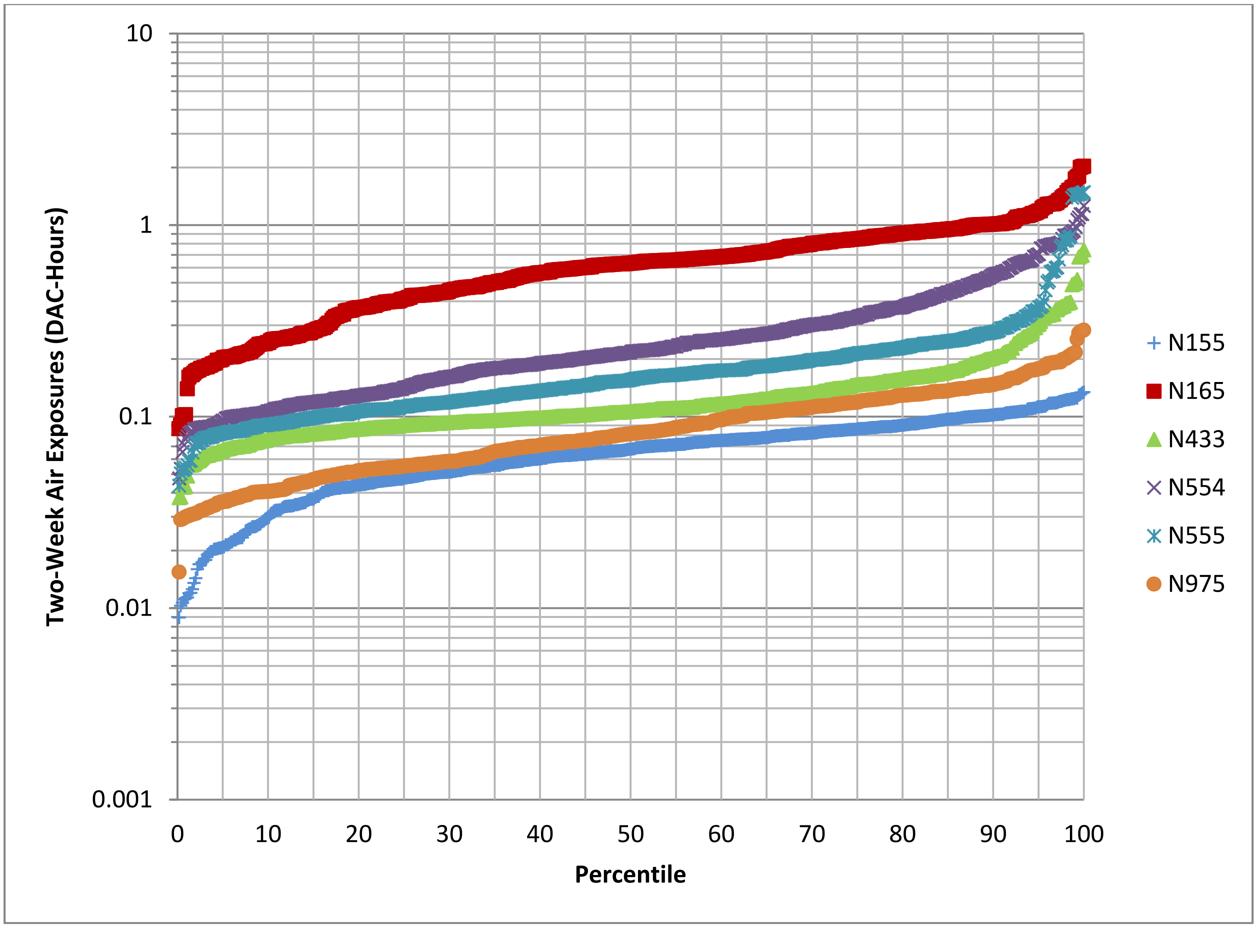

Figure 3.2-7. Distribution of Predicted Summer Air Exposure Increments for 236Z Demolition

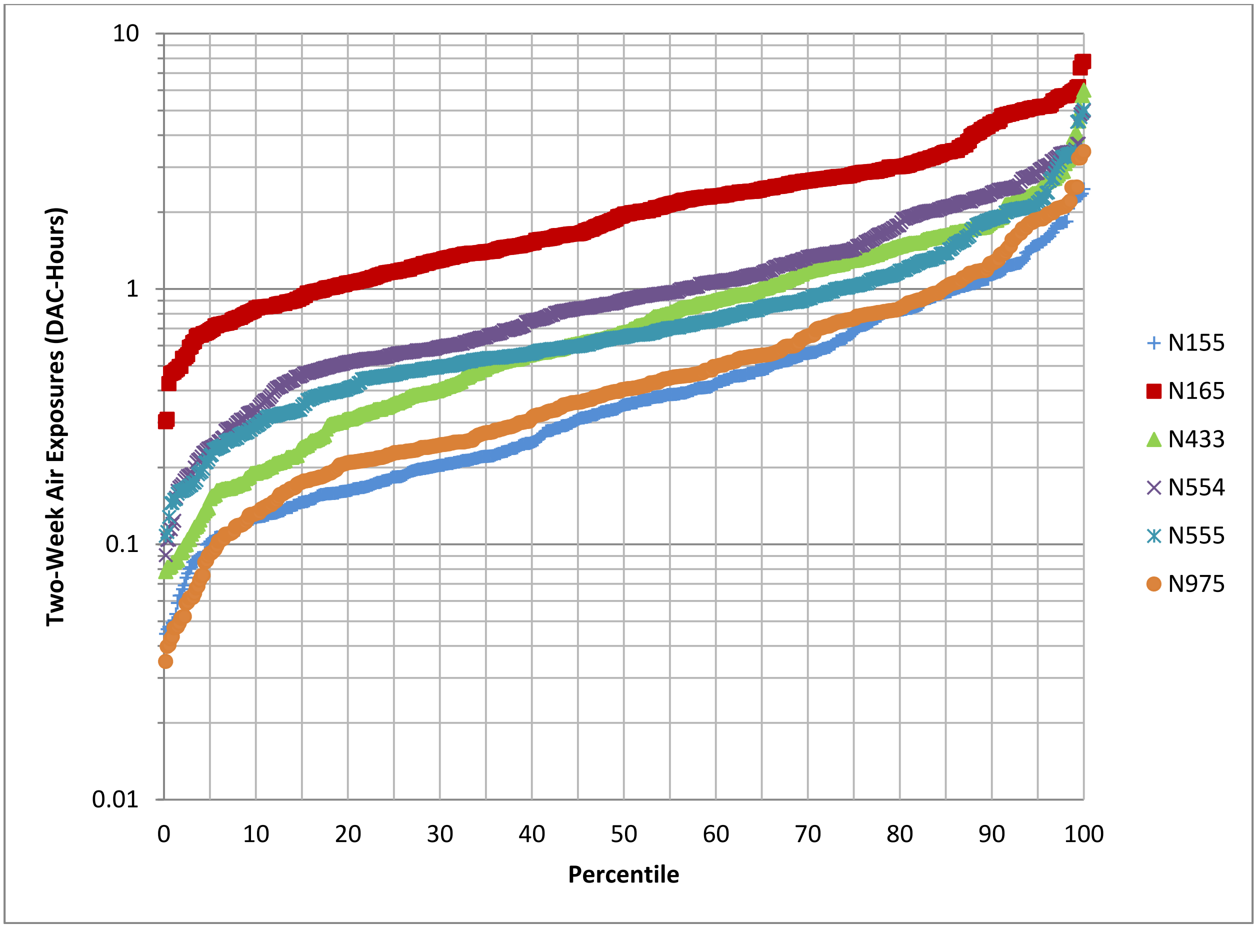

Figure 3.2-8. Distribution of Predicted Fall Air Exposure Increments for 236Z Demolition

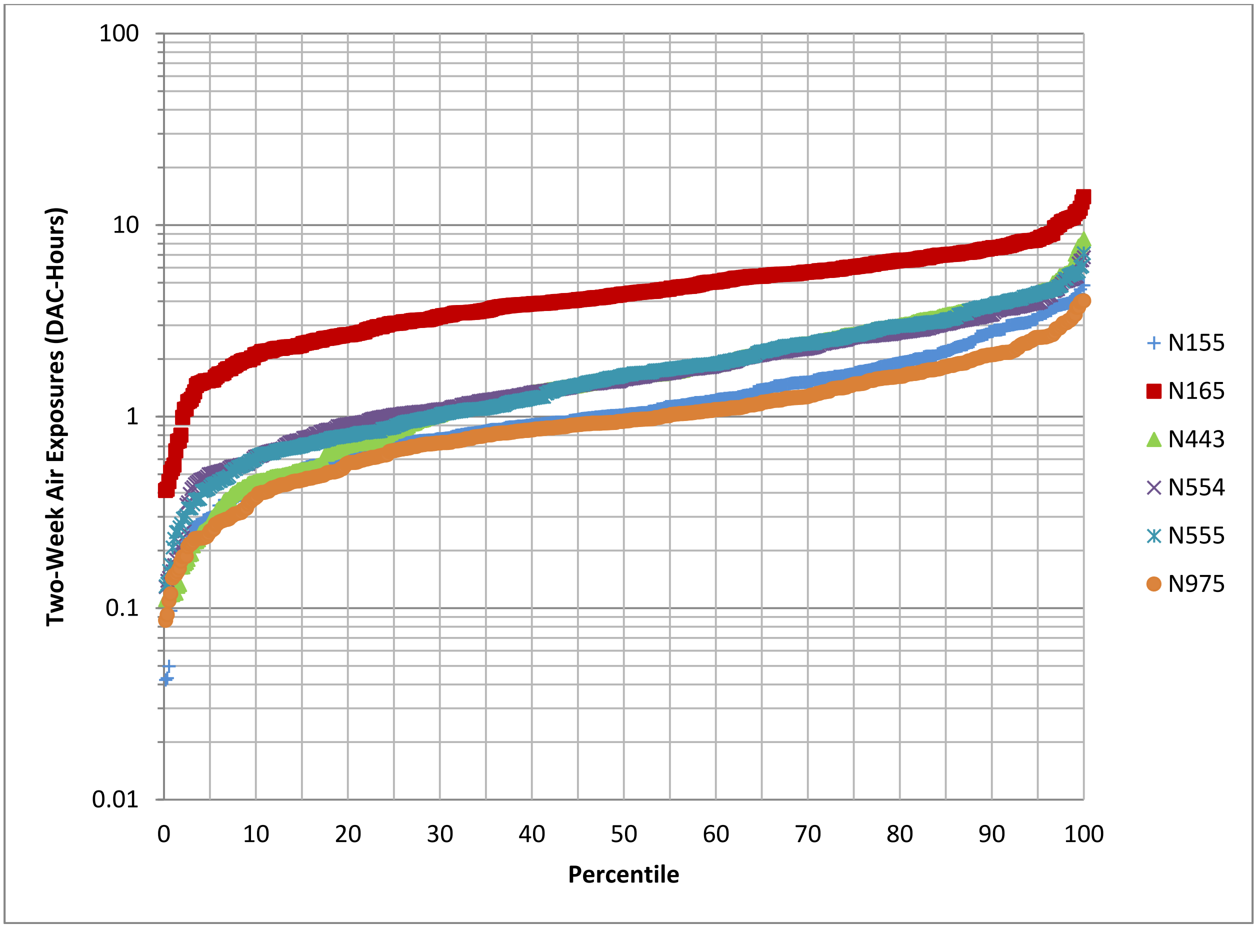

Figure 3.2-9. Distribution of Predicted Winter Air Exposure Increments for 236Z Demolition

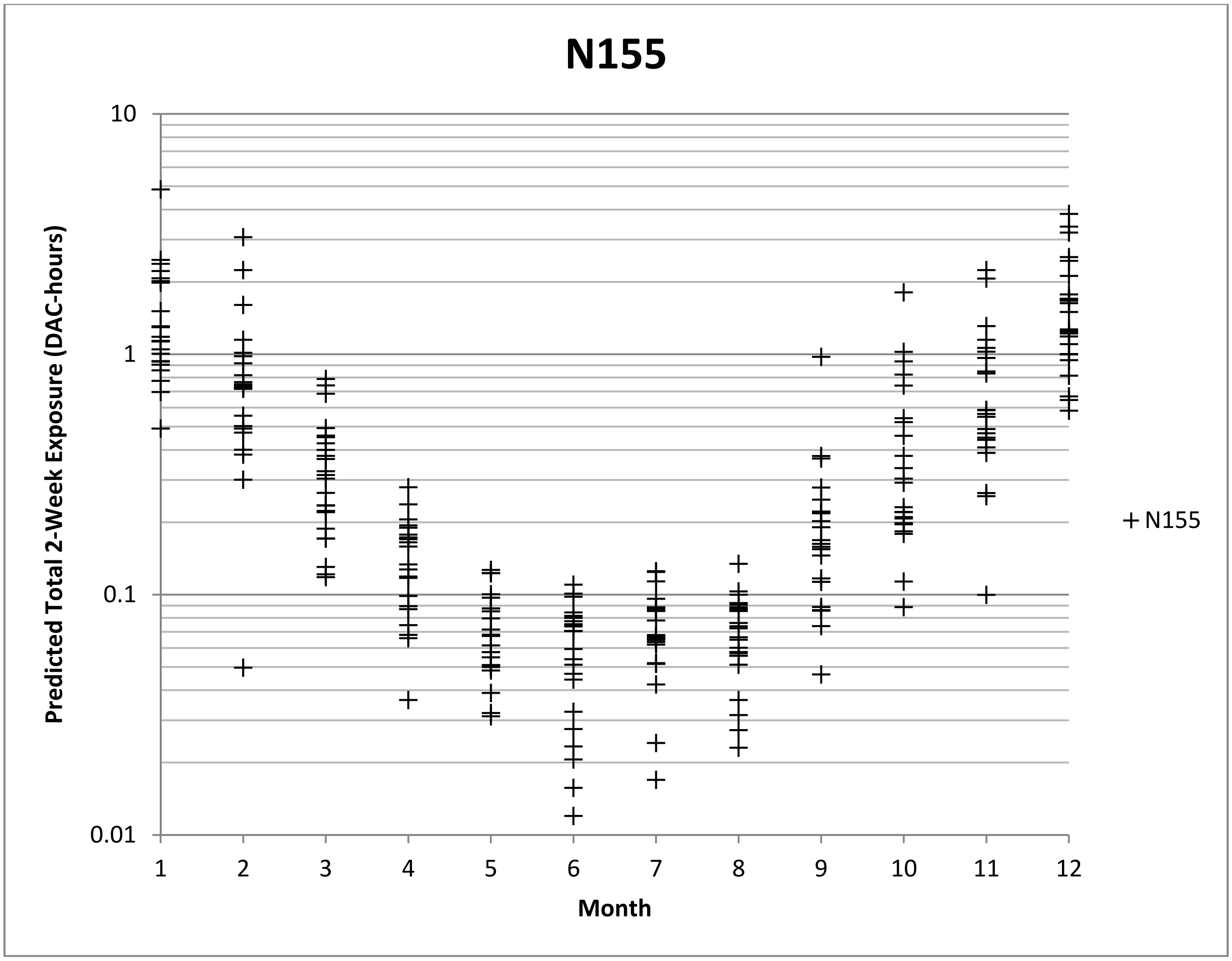

Figure 3.2-10. Monthly Distribution of Predicted Concentration Increments – Station N155

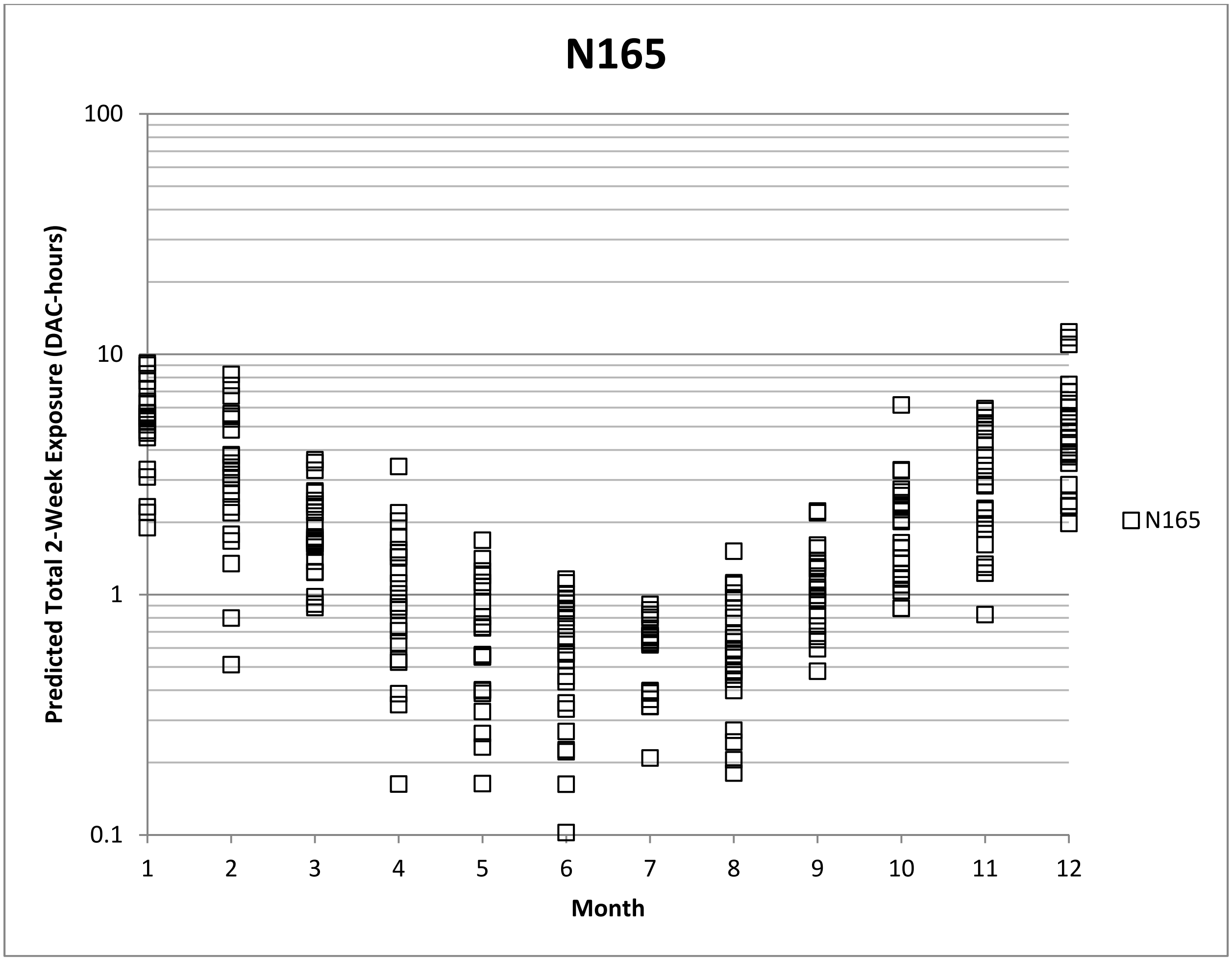

Figure 3.2-11. Monthly Distribution of Predicted Concentration Increments – Station N165

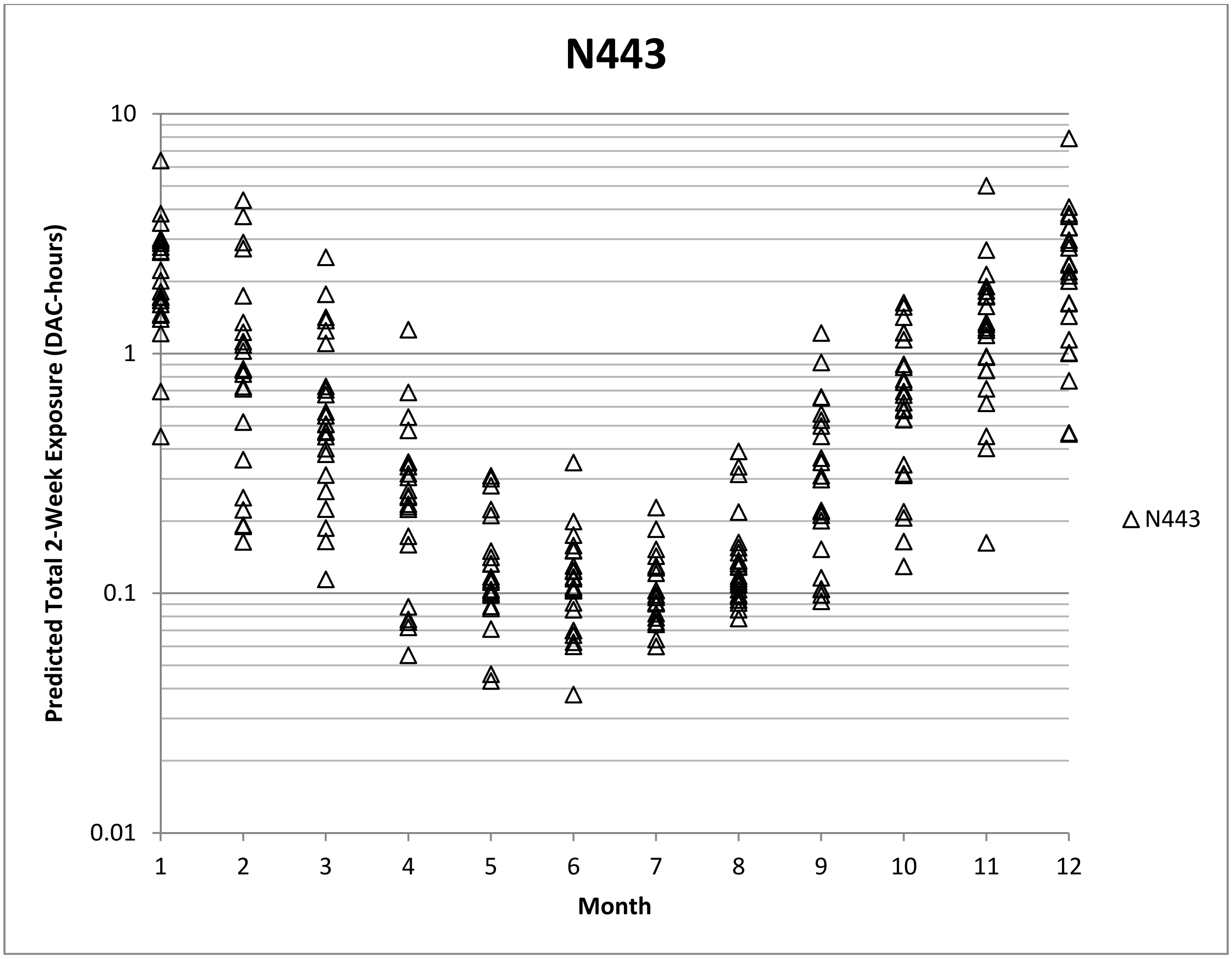

Figure 3.2-12. Monthly Distribution of Predicted Concentration Increments – Station N433

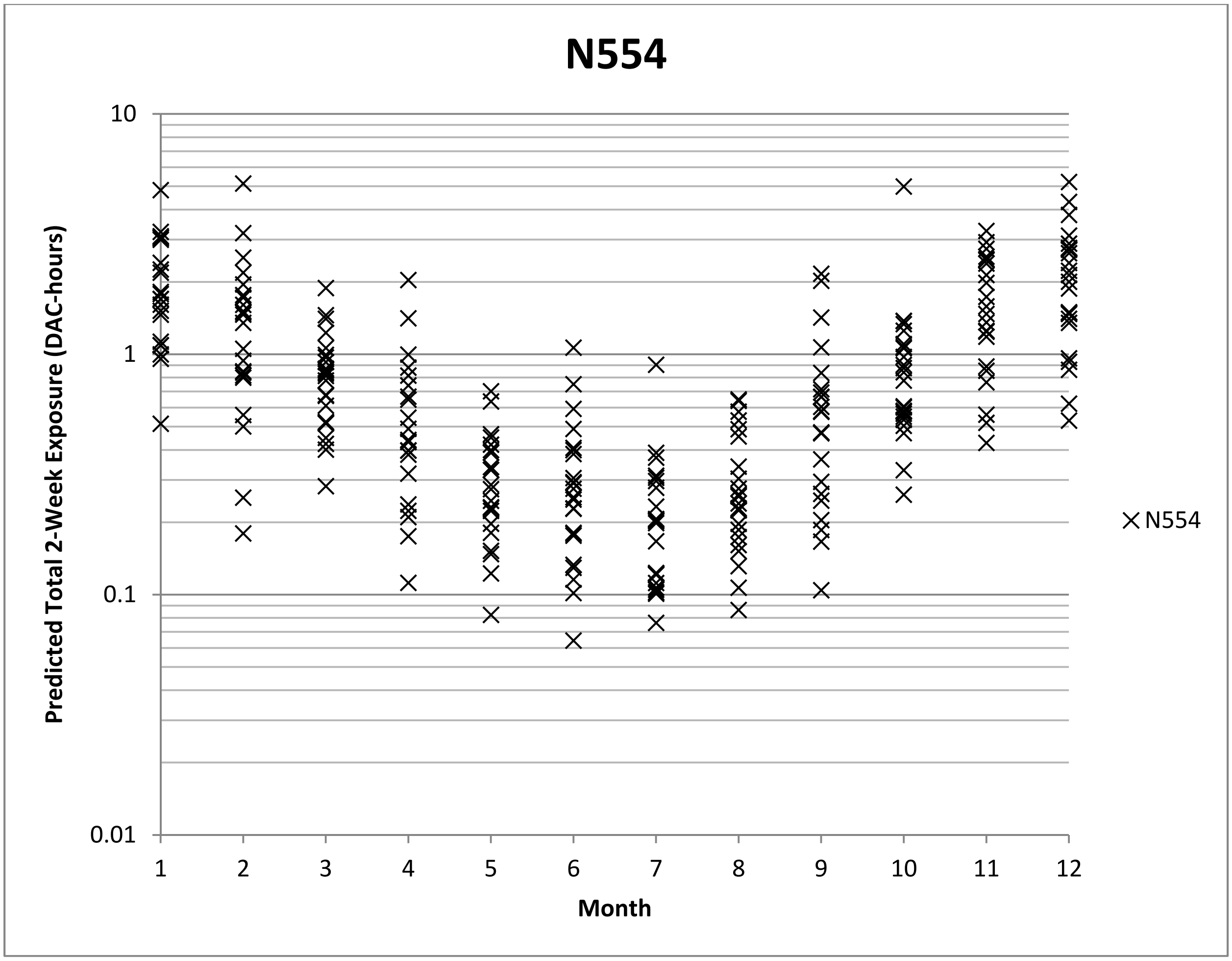

Figure 3.2-13. Monthly Distribution of Predicted Concentration Increments – Station N554

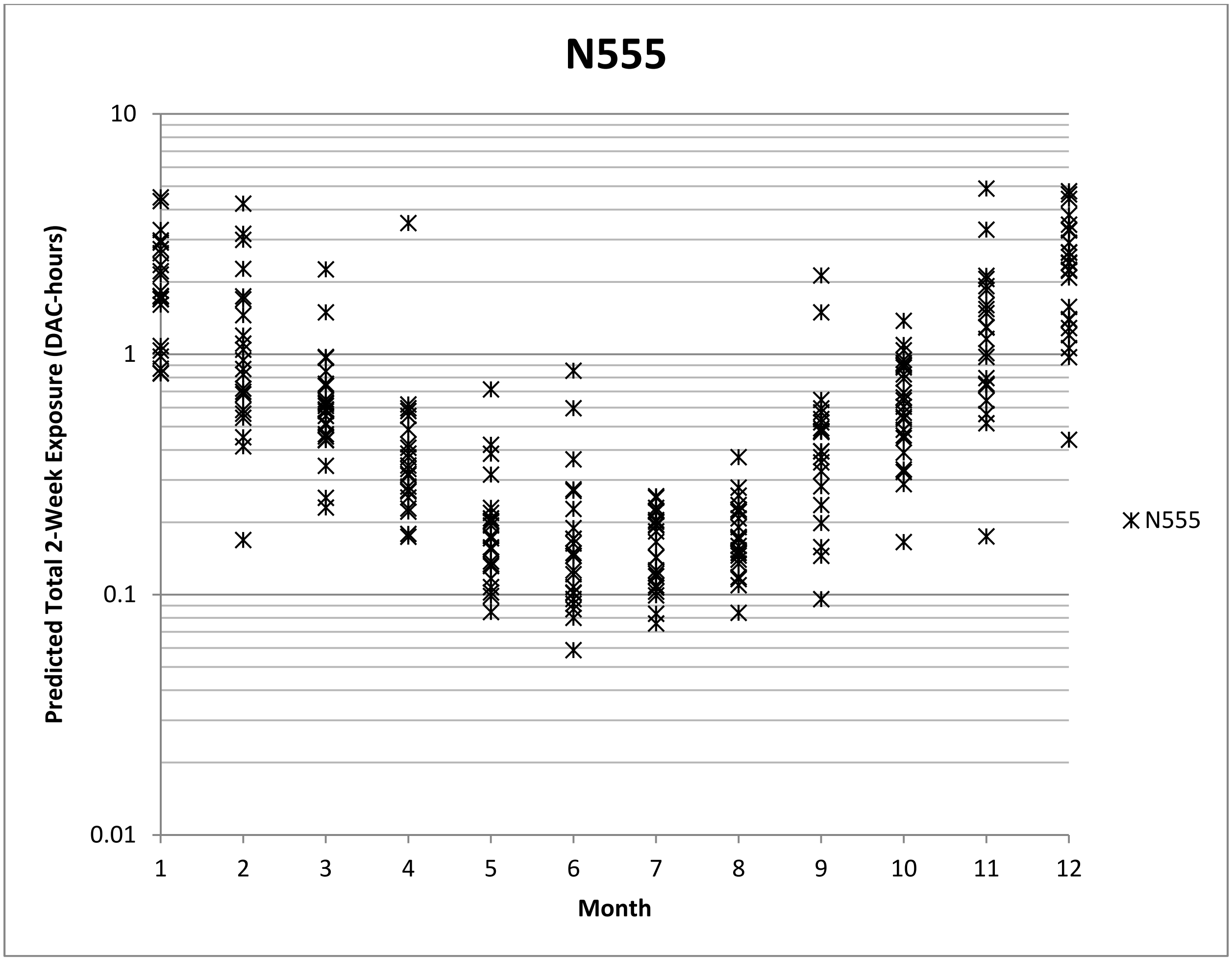

Figure 3.2-14. Monthly Distribution of Predicted Concentration Increments – Station N555

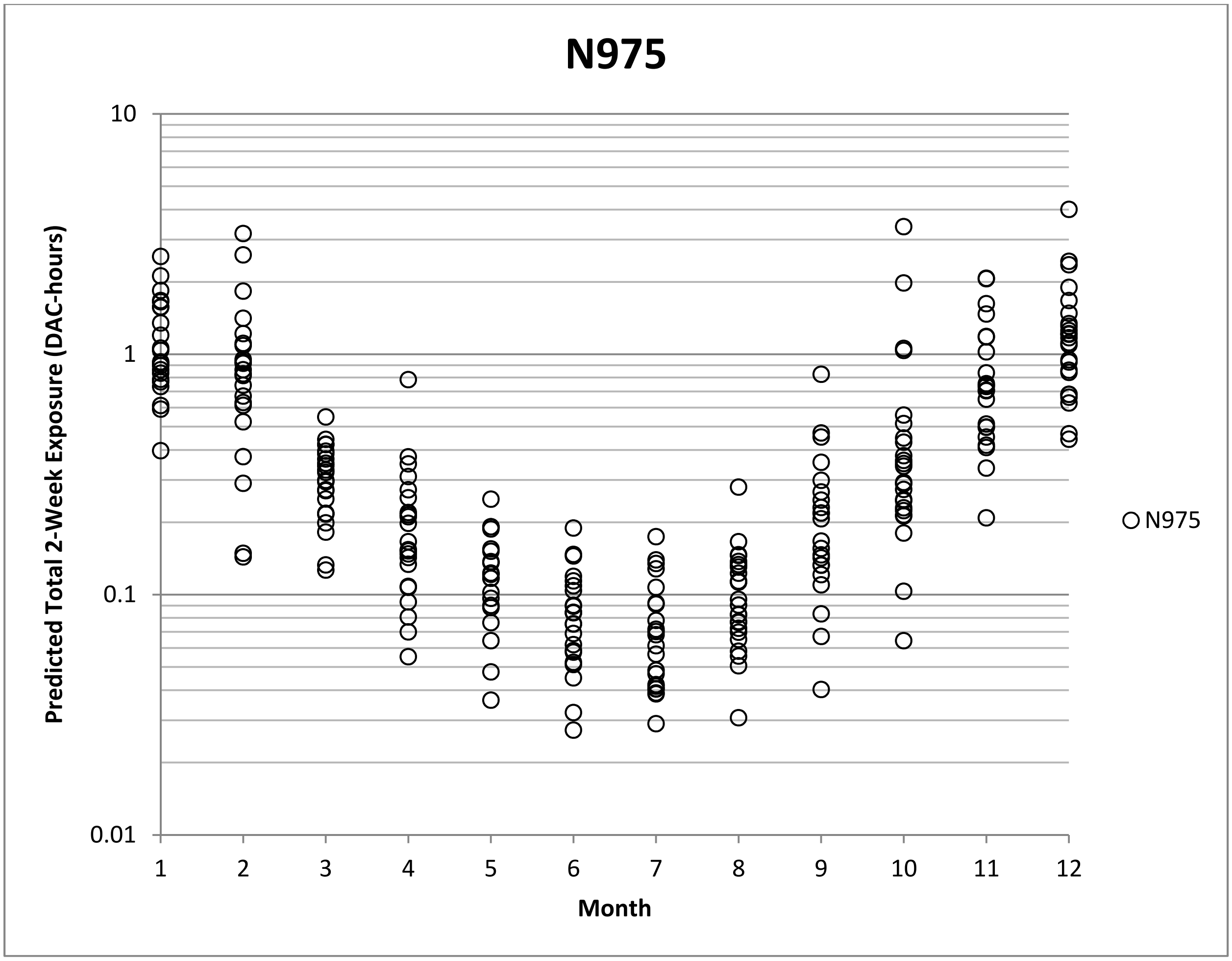

Figure 3.2-15. Monthly Distribution of Predicted Concentration Increments – Station N975

3.3 Predicted Air Concentrations – Stack Demolition

The assumed 291Z-1 demolition process is described in Section 2. The maximum 1-week air exposure (time-integrated air concentration) values potentially resulting from the demolition of the 291Z-1 stack structure were modeled for a local rectangular grid of receptors covering the local area. These computations are based on 6 years (2004–2009) of hourly meteorological observations. Figure 3.3-1 presents the resulting pattern of the highest predicted maximum weekly integrated air exposures. The predicted worse-case air exposure values occur in the immediate vicinity of the demolition activity – and have very low values. Because the modeled air exposures at the monitoring stations will be much smaller than these values in the immediate vicinity, no additional analyses of the potential air exposures were conducted. The modeling indicates that the worst-case 2-week integrated concentration increments from the stack demolition at all the monitoring stations will be much too small to be detectable.

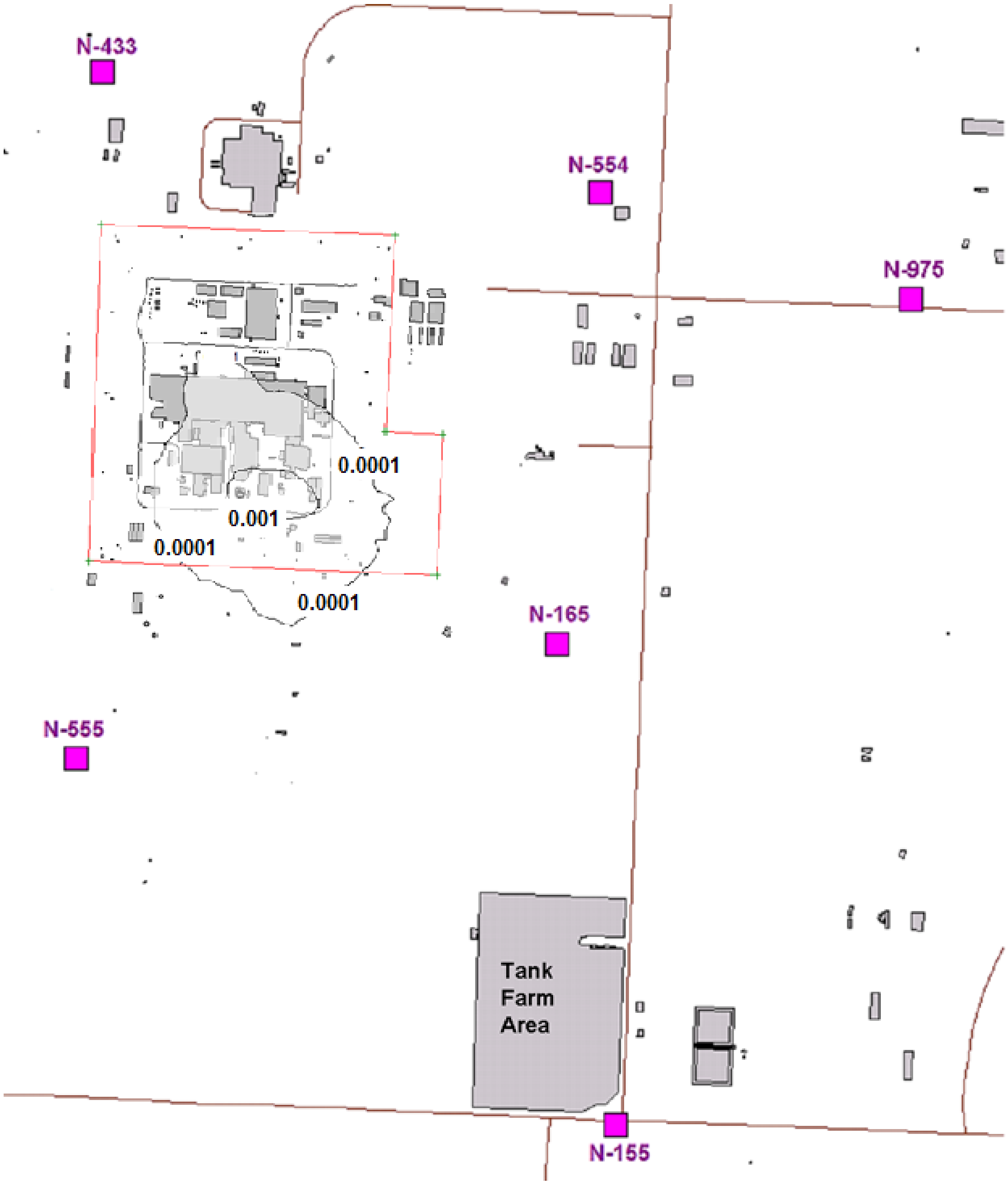

Figure 3.3-1. Predicted Pattern of 95th Percentile Weekly Air Exposures for Stack Demolition, DAC-hours. Detectable amounts at any of the air monitoring stations are not predicted.

4.0 Discussion

The source-term analysis indicates that some releases of radioactive material are to be anticipated during the demolition of PFP facilities. The modeling results presented here are closely tied to the details of how the demolition is to be conducted. The shearing/mechanical hammering option using emission mitigation methods was considered for all the proposed demolition activities. This option represents a standard demolition approach that has been used in several past demolition efforts at Hanford. The results indicate that the radiological exposures from the planned demolition efforts will be below the designated limits for air exposures for the bulk of the PFP facilities.

The releases from 236Z (and in particular the 236Z cell) have the largest predicted air concentration increments from the projected schedule of PFP demolition activities. The modeling results indicate that the demolition of the 236Z main process cell has the potential for releases of alpha-emitting radionuclides that lead to measureable air concentration increments at the monitoring stations. The remaining contamination levels in the 236Z cell are the highest for all of the PFP structures. It is possible that different methods and/or extensive decontamination could reduce the contamination level below this level, and thus reduce the levels of potential exposures.

Based on a previous analysis of the routine air samplers (Napier et al. 2010), the background levels for 1- and 2-week background exposures are estimated to be about 0.015 and 0.03 DAC-hours, respectively. For the 234-5Z, 242Z, and 291Z demolition, the upper range of modeled off-site concentrations are the same order of magnitude as background. The highest predicted 95th percentile 2-week incremental exposure value for the six monitoring station locations is about 0.18 DAC-hours at N-433, which is about 6 times the 2-week background value. The results show that for 234-5Z, 242Z, and 291Z demolition some of the monitoring stations may detect small increases in concentrations; that is, air concentrations may be high enough to be distinguishable from background under unfavorable conditions.

For demolition of the 236Z main process cell, the predicted air concentrations are discernibly above background. The results indicate that incremental air concentrations may be potentially detected at any of the monitoring stations based on the postulated 236Z demolition method, schedule, and assumed concentration methods. Although the distribution of concentrations shows a strong seasonal variation (with the highest values under winter conditions and the lowest under summer conditions), the predicted values are greater than background at all times of the year. The results also indicate that the current locations of the monitoring stations are appropriate for detecting plumes from the 236Z demolition in the directions where the peak maximum concentrations are predicted.

In summary, this report documents anticipated releases and environmental contamination that could be expected for open-air demolition of the PFP facilities using typical demolition techniques and assumed contamination levels and mitigation impacts. This report is provided for planning purposes and does not document any decisions about the decommissioning approaches.

5.0 References

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Appendix A

Facility-Specific Source Term Analyses

Appendix A – Facility-Specific Source Term Analyses

Appendix A provide details on modeling assumptions and details on each of the demolition phases described in Table 2.5-1. As described in Section 2.1, source terms are developed by the five factor formula from DOE-HDBK-3010 involving the source term factors of MAR, DR, ARF, RF, and LPF (Equation 2a) (DOE 1994). Each of the demolition phases include some similar activities and processes (e.g., rubble dropping). For each of these similar activities certain assumptions were made regarding the source term factors and followed in the modeling of each phase. These general modeling assumptions are described in Section A.1.

A.1 General Modeling Assumptions

This section describes general modeling assumptions related to damage ratios, airborne release fractions and respirable fractions that are applicable to all of the demolition phases. Facility specific assumptions are captured in the individual sections covering the five demolition phases (Sections A.2 through A.5).

A.1.1 Damage Ratios

Damage ratio refers to the fraction of MAR available for release. The damage ratio applied depends on the demolition activity.

Shearing DR

Mechanical shears or mechanical hammer will be used to demolish structure (ceilings, walls and floors). This will result in various sized pieces of rubble. Unless otherwise specified, the material at risk (MAR) is the inventory assumed to be evenly distributed over the entire contaminated area being worked on (wall segment, etc.). The damage ratio (DR) is that portion or percentage of the contaminated area acted on by the shear force, or the portion or percentage of the contamination acted on by shear forces. For concrete and plaster-on-lathe structures it is assumed to be 90%; for metal panels it is assumed to be 10%. Shears or mechanical hammer are assumed to fracture, crush, spall, or otherwise impact the surface being sheared.

Fixatives, as the name implies, serve to fix contamination to the surfaces where it is found. In most instances, the particulate contamination becomes integral with the fixative as opposed to merely being shielded or covered. Fixatives are extremely effective in preventing the migration of contamination from surfaces experiencing little or no traffic. When used during demolition, however, one must consider the impact of the demolition method on the fixative surface structure (e.g., the propensity of the demolition method to produce airborne particulates of the fixative surface containing radioactive contaminants). In this analysis, fixatives are assumed to reduce the production of airborne particulates on surfaces not directly involved with the shearing or cutting processes; however, the shearing process breaks up the material so severely that fixatives are assumed to be only 10% effective for concrete shears or mechanical hammer.

The effectiveness of the fixative on the rubblized material (approximately 90% of the sheared concrete/plaster material; 10% of metal panels) will conservatively be considered totally lost (i.e., all of the contamination on these pieces is considered removable). The fixative covering the larger pieces (approximately 10% of the sheared material, essentially all of the cut material) will be considered largely intact and remain effective. All of the material cut by shears or mechanical hammer will be piled on the ground until placed in ERDF boxes.

Thus, the DR is 1.0 for the entire process, but differentiated between removable and fixed contamination as following:

- DR = 0.9 (removable contamination);
- DR = 0.1 (fixed contamination).

Rubble Drop after Shearing DR

All of the contamination associated with rubble is assumed available for release from rubble drop impacts (DR = 1.0).

Resuspension DR

All of the sheared material piled on the ground will be subject to resuspension (DR = 1) with approximately 90% of the sheared material consisting of rubble, while 10% will be subject to resuspension as larger pieces with a lower degree of resuspension.

Surgical Equipment Removal DR

Surgical removal refers to careful precision extraction of intact equipment (such as gloveboxes). Equipment assumed subject to surgical removal includes gloveboxes, filter boxes, pipes, and galleries. Prior to demolition, this equipment is assumed to have been prepared to minimize the potential for releases. For hoods, filters, and piping, the equipment is assumed to be covered internally and externally with fixative to fill voids. Ports and windows are assumed covered with metal plates to prevent them from fracturing when nearby walls and ceilings are removed with shears or mechanical hammer. They may also be wrapped in plastic sheeting. Minor damage from falling materials is assumed to dent and rip portions of the protective coverings.

Because of the care taken the surgical equipment removal DR = 0.01.

Rubble Load Out DR

All of the contamination associated with rubble is assumed available for release from rubble drop impacts (DR = 1.0).

A.1.2 Airborne Release Fraction

ARF refers to the fraction of MAR available for release that becomes airborne. The ARF applied depends on the demolition activity.

Shearing ARF

DOE's factors for impaction stress due to vibration shock were selected as the most representative release fractions for the crushing processes. The ARF factors selected were 1×10^{-3} for removable contaminants and one-tenth that (1×10^{-4}) for fixed contaminants (DOE 1994, Section 5.3.3.2.2).

Surfaces not directly impacted by cutting will be disturbed from a variety of sources, including the cutting process (especially for shear cutting), movement and placement of material, general shaking of the building surface, vibrations from heavy equipment, and vibration from fall of rubble to the floor surface. Releases from these surfaces will be controlled by existing fixative, periodic application of fresh fixative, continually wet surfaces, and water spray/mist in the air. These controls are assumed to be sufficient to prevent any emissions from vibration of noncontact surfaces.

The EPA's (EPA 1995) compilation of airborne release fractions includes a range of uncontrolled release fractions for crushing of ores and rocks that range from 0.012 to 6 pounds per ton of ore, which relates to an ARF of 6×10^{-6} to 3×10^{-3} – these ranges overlap, supporting the selection of the DOE value (Shearing ARF = 1×10^{-3} removable; 1×10^{-4} fixed).

Rubble Dropping After Shearing ARF

As the material falls to the ground from the elevated location on the walls where it originates, it will be subject to entrainment in the air. The EPA considers its emission factor equation for aggregate-handling and storage piles to be applicable to the drop of bulk material onto piles (adapted from EPA 1995). The EPA equation was used to model releases from rubble dropping because it is more compatible with the physical realities of demolition than the DOE-HDBK-3010 method. The DOE handbook does not consider the impact on emission rates from moisture content and wind speed. Also, the PFP contamination is part of the debris matrix; thus modeling drops of free plutonium oxide powder, plutonium nitrate solution, or items with only surface contamination – as applied in the DOE handbook - is not deemed applicable to PFP demolition. The adapted EPA equation is as follows:

$$ARF_{DROP} = 1.6 \times 10^{-6} \left((WS/2.2)^{1.3}\right) / \left((M/2)^{1.4}\right)$$

where: WS = characteristic wind speed over material drop region (m/s) - A characteristic wind speed for rubble drop was calculated using a characteristic wind speed for the site estimated by examining wind climatology from the Hanford Site. A compilation of average wind speeds and direction was provided in the data source. The ARF is more influenced by periods of higher winds (such as wind gusts). The characteristic wind speed for rubble-handling was estimated to be 3.2 m/s; the result is not sensitive to this assumption. Further conservatism was incorporated because the shielding effect of the building walls and the shielded flow around the other PFP buildings are not considered.

M = moisture value associated with dry material (control effectiveness of water spray handled separately) (%). Because water spray and mist are applied to the pile, a moisture value of 2% for a wet construction aggregate was chosen, based on past experience. Small changes in assumed moisture content result in large variation of the resulting ARF,; the ARF decreases more than exponentially with M; the 2% value selected is believed to be conservatively low, resulting in a calculated ARF that should overestimate the releases via this route.

Although the original EPA equation also includes a particle-size multiplier (ranging from about 0.1 to 0.8), the multiplier was set to 1.0 for all particle sizes in the release analysis, and the atmospheric transport of particle sizes is described in Section A.1.4.

Using the values described above (wind speed of 3.2 m/s and 2% moisture), the ARF for rubble dropping = 2.6×10^{-6}.

Resuspension ARF

Surfaces exposed to the atmosphere between shifts will be subject to resuspension processes. A fresh coat of fixative will be applied to all exposed surfaces (covering any gaps and material deposited on the existing fixative) at the end of demolition operations for a day. Moreover, no activities are assumed to occur that will disturb the rubble or otherwise impart energy. Therefore, it is assumed that there is no significant resuspension between shifts ($ARF_{res} = 0$).

Surgical Equipment Removal ARF

The surgical removal process includes complete wrapping of the equipment in non-permeable material. The outer wrapping material is assumed to become contaminated, and during removal the equipment receives a small jolt. Therefore, the ARF is deemed by engineering judgment to be far smaller than that for vibration shock described above for shearing.

Based on engineering judgement, the surgical equipment removal ARF is assigned a value of 1×10^{-6}.

Rubble Load Out ARF

Loading of rubble into transport containers is performed by scooping it up in front loaders and dumping it into the container, while being misted to reduce dust. This process is similar to the rubble drop step described above; a similar value of 2.6×10^{-6} is also used (in some of the analyses, a value of 2.3×10^{-6} was also used).

A.1.3 Respirable Fraction

The respirable fraction refers to the fraction of the material that has become airborne that is in a respirable size (i.e., maximum diameter of 10 µm). The respirable fraction is conservatively assumed to equal 100% (RF = 1.0) for all processes in computing the ground contamination level.

The RF is the fraction of airborne radionuclides as particles that can be transported through air and inhaled into the human respiratory system. The RF is assumed to include particles 10-µm AED and less. In this study, all of the suspendable material is addressed (not just the respirable portion) although it is estimated that most radioactive particles in the contamination are respirable in size. Only the respirable sized particles are used in computing the inhalation dose.

In this study, the radioactive particles are assumed bound to particles of dust from the rubble and transported as a size distribution of particles representative of construction dust. These particulates are removed from the plume and placed on the ground through dry deposition, a process that removes non-respirable particles much more effectively than respirable particles. It is conservatively assumed that all radioactive particles separate from any associated rubble particles upon entry into the respiratory system. The result of these considerations is that transport of radioactive particles is modeled as a mixture of particle sizes representative of dust from the rubble and radioactive materials attached to dust is assumed to impact the respiratory system as all respirable particles.

A respirable fraction of 1.0 is conservatively applied in the Source Term equation because the removal of non-respirable particles from the plume is treated separately as a transport and dispersion function within the AERMOD modeling (see Section A.1.4), and only about 1% of the particles escaping are greater than 10 microns in diameter.

A.1.4 Leak Path Factor

The LPF is the fraction of the radionuclides in the aerosol transported through some confinement deposition or filtration mechanism. For the purpose of this study, the LPF is used to address any controls applied during and after the demolition process. This includes the mitigating effects of water mists, sprays, and fixatives applied to surfaces and rubble during and after demolition.

Shearing LPF

The application of a water mist to contaminated surfaces during demolition serves to reduce the percentage of airborne particulates in the respirable size range. The efficiency of the mist varies with each application and depends on, among other variables, mist particle size, water flow rate, and the size of potential airborne particles. For the purposes of this analysis, water-mist application is assumed to reduce the quantity of airborne particulates by 90%. The efficiency of the water-mist process must be weighed in light of the generated waste stream and the need to confine and capture runoff from the misting process.

LPF for concrete crushing is assumed to be 0.1. This value is slightly lower than that used for the 233-S building (which assumed 0.3), based on observations of the effectiveness of the misting on that facility [(1)] and during demolition of 232Z.

Rubble Drop after Shearing LPF

As the material falls to the ground and is entrained in the air, a separate LPF is used. The EPA has published size-specific control-effectiveness values for mist eliminators. The values for < 250 FPM mist eliminators is used to represent the water/mist spray controls applied to materials-handling operations at the 236Z building. The EPA control-effectiveness values as presented were interpolated to the particles' size ranges identified for this source type. The maximum reported control-effectiveness was assumed for particle sizes larger than those reported in the reference, rather than extrapolating upward from the EPA values. The following LPFs result (EPA 1995):

- 0 – 2.5 µm: 0.95
- 2.5 – 5 µm: 0.60

[(1)] Private communication with Dan Mantooth, 26 May 2004. A continuous application of water from an atomizer (e.g., a "fog cannon") is assumed.

- 5 – 10 µm: 0.30
- 10 – 15 µm: 0.25
- 15 – 30 µm: 0.25
- > 30 µm: 0.25

The particle-size distribution is given by EPA for conventional aggregate-handling and storage piles as shown in Table A.1-1 (EPA 1995). However, a shift in particle size distribution is expected to occur as a result of the mitigation actions. There will be a heavy reliance on misting and spraying to both keep the surfaces wet and to scavenge any dust that is generated. Therefore, very little dust will be assumed released. Because water droplets are highly effective in removing larger particles but ineffective in removing smaller particles there is a large shift in the particle size distribution that is modeled as shown in Table A.1-1. The collection efficiency differences for small droplets changes by almost four orders of magnitude between 1 and 10 micron particles (Slinn 1984). The Table A.1-1 shifted distribution is based on the assumption that mitigation processes will be much more effective for larger particles.

Table A.1-1 EPA Particle Size Percentages and Shifted Percentages from Mitigation Actions

Particle Diameter (µm)	EPA Percentages for Aggregate Handling and Storage Piles (%)	Shifted Percentages due to Mitigation Actions (%)
0 – 2.5	11	73
2.5 – 5	9	24
5 – 10	15	2
10 – 15	13	0.9
15 – 30	26	0.2
> 30	26	0.2

The revised size distribution values from mitigation are AERMOD input parameters that are used for transport and deposition computations. Only the respirable sized particles (maximum 10 µm) are used in inhalation dose computations; whereas all particle sizes are used in estimating ground contamination levels.

The size-distribution shift towards smaller particles reduces the modeled deposition by about an order of magnitude immediately downwind of the demolition activity and increase the modeled deposition at extended distances. The shift also results in slightly higher modeled airborne exposure rates. This size distribution change is consistent with assumptions in a previous similar modeling effort (Droppo et al. 2007). Given the very large experimental differences in collection efficiencies, the actual shift to smaller particles may well be much greater than assumed in Table A.1-1. However, with the lack of experimental data to confirm a larger shift, anything greater is deemed to be inappropriate.

Resuspension Between Shifts LPF

A leak path factor of 0.10 is applied because of water-mist application and/or fixative application are assumed to reduce the quantity of airborne particulates by 90%. A fresh coat of fixative is assumed to be applied to all exposed surfaces (covering any gaps and material deposited on the existing fixative) at the end of demolition operations for a day.

Surgical Removal LPF

A leak path factor of 0.10 is applied because of water-mist application (and fixative applications) which are assumed to reduce the quantity of airborne particulates by 90%.

Rubble Load Out LPF

A leak path factor of 0.10 is applied because of water-mist application (and fixative applications) which are assumed to reduce the quantity of airborne particulates by 90%.

A.2 236Z (Plutonium Reclamation Facility)

The 236Z building (also known as the Plutonium Reclamation Facility – PRF) is located south of the southeastern corner of the 234-5Z building and is connected to it by the 242Z building. The building is a four-story structure 24 m (79 ft) by 21.6 m (71 ft) by about 14.5 m (47.5 ft) high, surmounted at the southwest corner by a two-story penthouse 6.9 m (22.5 ft) high. With the exception of the roof, the south end of the process cell, and the fourth-floor ceiling, the building is constructed of reinforced concrete. The roof is constructed of an open-web steel joist frame, a steel deck with rigid insulation of lightweight concrete fill, and gravel-covered built-up roofing. A portion of the south wall is also the 1-ft-thick wall of the process cell. An equipment transfer facility is located against the large south door.

The tanks and columns used in the solvent extraction process were located in the process cell—a large three-story room in the center of the 236Z building. Most of the residual contamination is expected to be in the process cell and on the outer walls of the process cell, as well as on the strongbacks – metal frames that held the "pencil tanks" used in the processes – that connect through penetrations to the galleries on the first and second stories.

Amounts, locations, and isotopic mixtures of residual contamination in PFP complex buildings including 236Z were provided by a CHPRC team (Brian Oldfield and Peter Sauer) in a series of spreadsheets. These source terms were modified and simplified through discussions with CHPRC staff. Revision 4 of this report adjusts the 236Z Cell inventories based on extensive NDA (documented in Sauer, 2016 – CHPRC-03038). The plutonium is assumed to be in oxide form, and small, dispersed particles (see HNF-SD-PRP-HA-002, Rev.13); although the nature of the activities in the 236Z building – and the residual liquid stains on the walls –indicate that the material in this building was originally largely in the chemical form of soluble nitrates. The nitrates should have oxidized after many years of exposure to air.

Table A.2-1 summarizes the modeling approach for various demolition operations in 236Z.

Table A.2-1. General Modeling Approach for 236Z Demolition Operations

236Z Section	Operation	Demolition Summary	AERMOD Modeling approach	EF
Penthouse	Shearing	Break 10-in-thick walls/ceilings into 1x1 ft pieces with multiprocessor	Emission factor (EF) based on 90% of contaminated surface broken up/exposed, 10% fixative.	EF = 9.0×10^{-5} rem; 1.0×10^{-6} fix.
		Rubble Drop after shearing	Particle sizes divided into 6 size bins, each assigned size appropriate RFs and LPFs to derive a composite	EF = 9.52×10^{-7} rem & fix
	Resus-pension	Surfaces covered with fixative/soil cement	Resuspension considered negligible because of the extensive use of fixative.	EF = 0.00
	Loadout	Scoop and drop into box	Moist rubble treated with EPA method.	EF = 2.3×10^{-7} rem & fix
Outer Building	Shearing	Break 10-in-thick walls/ceilings into 1x1 ft pieces with multiprocessor	Emission factor (EF) based on 90% of contaminated surface broken up/exposed, 10% fixative.	EF = 9.0×10^{-5} rem; 1.0×10^{-6} fix
		Rubble Drop after shearing	Particle sizes divided into 6 size bins, each assigned size appropriate RFs and LPFs to derive a composite	EF = 9.52×10^{-7} rem & fix
	Resus-pension	Surfaces covered with fixative/soil cement	Resuspension considered negligible because of the extensive use of fixative.	EF = 0.00
	Loadout	Scoop and drop into box	Moist rubble treated with EPA method.	EF = 2.3×10^{-7} rem & fix
Glovebox and Filter boxes	Surgical Removal	Hoist “hardened” gloveboxes intact	Minor emission assumed because of the careful removal process.	EF = 1.0×10^{-9} fix
Gallery	Gallery Removal	Detach galleries from walls with multi-processor	Emission factor based on impact on contaminated metal surfaces; Most material fixed and under rubberized fixative. Assume 95% of contamination is fixed and 5% is removable.	EF = 1.45×10^{-7} rem & fix
	Loadout	Segment galleries and fit into box	Emission factor based on impact on contaminated metal surfaces; Most material fixed and under rubberized fixative. Assume 95% of contamination is fixed and 5% is removable.	EF = 1.45×10^{-7} rem & fix
Main Cell - Shearing option	Shearing	Break 2-ft-thick walls into 1x1 ft pieces with multiprocessor	Emission factor (EF) based on 90% of contaminated surface broken up/exposed, 10% fixative. Lower two strongbacks, and then nibble the leading southern edges of walls and ceilings with multiprocessor	EF = 9.0×10^{-5} rem; 1.0×10^{-6} fix.

236Z Section	Operation	Demolition Summary	AERMOD Modeling approach	EF
		Rubble Drop after shearing	Particle sizes divided into 6 size bins, each assigned size appropriate RFs and LPFs to derive a composite	EF = 9.52×10^{-7} rem & fix
	Resus-pension	Surfaces covered with fixative/soil cement	Resuspension considered negligible because of the extensive use of fixative.	EF = 0.00
	Loadout	Scoop and drop into box	Moist rubble treated with EPA method.	EF = 2.3×10^{-7} rem & fix
Strong-backs	Lower to cell floor with multi-processor	Take nearest strongbacks from left and right side of cell, pull from receptacles, and set in temporary jig on floor	Assume entire inventory is evenly distributed amongst all strongbacks. Each strongback inventory is distributed with 20% on the framework and the remaining 80% on 4 blocks with each block containing 20% (with 90% inside the block and 10% outside), and the remaining. Emission postulated from un-fixed surfaces of receptacles and jumpers. Emission factor based on impact on contaminated metal surfaces and exposed surface areas.	EF = 1×10^{-5} rem & fix
	Snip	Segment strongback structure	Emission factor based on impact on contaminated metal surfaces; Most material fixed and under rubberized fixative.	EF = 1×10^{-6} rem & fix per cut
	Process and load	Process and load into interim shipping container for final disposition elsewhere	Minor emissions due to extensive use of fixatives and low impact operations.	EF = 1.00×10^{-9} rem & fix
All Areas during: Off-shift	Resus-pension	Surfaces covered with fixative/soil cement	Set to zero because of fixatives and lack of activity.	EF = 0.00
Rubble and removed Equipment	Loadout	Actions equivalent to scooping and loading	Moist rubble treated with EPA method.	EF = 2.6×10^{-7} rem & fix
	Sort/Size/ Repackage	Actions equivalent to scooping and loading	Moist rubble treated with EPA method.	EF = 2.6×10^{-7} rem & fix

** Rem = removable; Fix = fixed*

The assumed conditions of 236Z prior to demolition include:

- The canyon floor is cleaned and covered with a layer of clean grout (or equivalent) for the duration of the demolition
- all above-grade plutonium nitrate transfer lines and encasements have been removed
- all liquid waste lines that depart the building will have been isolated and capped at sufficient distance from the building and not contribute to the source equations

- The equipment listed in Table A.2-2 are assumed to remain in the building for surgical removal during the demolition process.

Table A.2-2. Equipment Remaining in 236Z Requiring Surgical Removal

Location	Item	QTY	Unit	Pu (g)
4th Floor	Rm 42, 43, Corr 47 E4	6	Sealed E4 Duct	4
2nd Floor	Filter Box 20E	1	Filter Boxes	3
2nd Floor	Filter Box 20W	1	Filter Boxes	7
2nd Floor	2nd East Gallery	4	Gloveboxes	210
2nd Floor	2nd West Gallery	4	Gloveboxes	204
2nd Floor	FB inlets 20E	1	Sealed E4 Duct	1
1st Floor	Filter Box 10E	1	Filter Boxes	13
1st Floor	Filter Box 10W	1	Filter Boxes	1
1st Floor	1st East Gallery	4	Gloveboxes	260
1st Floor	1st West Gallery	5	Gloveboxes	540
1st Floor	Gallery GB Encasements	21	Empty Sleeves	4
1st Floor	FB 10E/W FB inlets	3	Sealed E4 Duct	24
1st Floor	1 E/W Gallery GB Crit	2	Crit drain pipe stubs	6
Canyon	Man Basket	1	Man Basket	29

- The various equipment items are assumed to be prepared with fixatives such as "FireDam-200" (described at http://multimedia.3m.com/mws/media/373702O/3mtm-firedamtm-spray-200-brochure.pdf and viewable on YouTube). The removal process involves preparation and armoring of the various pieces of equipment. As access is provided by demolition of nearby walls or ceilings, the equipment is then lifted from within the building and placed in a nearby disposal container.

Contamination is on surfaces, under floor tile, under paint, etc. The anticipated contamination levels within the building were provided by the CHPRC analysts (workbook dated October 2016 by Peter Sauer). Table A.2-3 summarizes the overall contamination levels, excluding the process cell.

Table A.2-3. 236Z Contamination Levels per Building Zone

Zone	Description	Debris Wt (lb)	Area (ft^2)	Alpha (dpm/100cm^2)	Description
SZ-1	6th Floor	193,228	1,216	200,000	Floors & Walls
			229	100	E-3 Shaft and Plenums
SZ-2	5th Floor	165,307	1,074	200,000	Floors & Walls
			201	35,000	E-3 Shaft and Plenums
		162	33	7,500,000	E-4 Ductwork
SZ-3	4th Floor	1,150,415	14,228	200,000	Floors & Walls
			549	9,000	E-3 Shaft and Plenums
		7,948	1,610	700,000	E-4 Ductwork
SZ-4	3rd Floor	1,050,115	2,629	200,000	Floors & Walls
			427	1,000	E-3 Shaft and Plenums
		1,778	360	400,000	E-4 Ductwork
SZ-5	2nd Floor	1,094,080	8,640	200,000	Floors & Walls
			1,531	45,000	E-3 Shaft and Plenums
		28,506	3,011	900,000	E-4 Ductwork
SZ-6	1st Floor	1,121,343	6,613	200,000	Floors & Walls
			811	10,000	E-3 Shaft and Plenums
		1,244	252	250,000	E-4 Ductwork
SZ-7	Canyon Concrete	2,064,161	7,827	24.7 nCi/g	Canyon Walls

The main process cell has significant amounts of contamination; most of which is fixed within the concrete walls. The cell floor has been covered with a layer of cementitious grout prior to demolition; therefore, the floor inventory is omitted from this analysis. It is assumed that the materials of the concrete cell walls and ceiling are contaminated at 24.7 nCi/gram, with greater gram loading in the maintenance cell and mezzanine area of the canyon. Given the mass of the concrete canyon structure, this is approximately 23.2 curies of alpha emitting radionuclides. NDA results indicate that the mezzanine and maintenance cells have significant amount of contamination, with the highest potential release inventory occurring during the demolition of these structures (Sauer 2016 – CHPRC-03038).

The remaining equipment has the inventories shown in Table A.2-4.

Table A.2-4. Inventory in 236Z Building equipment

QTY	Unit	TRU Pu (g)
1	Maintenance Cell Faces	66
41	Strongbacks	643

The assumed isotopic distribution is based on facility specific details given the historical processes that had occurred and the decay period, as shown in Table A.2-5. The facility DAC (Bq/m^3) is based on the facility isotopic distribution.

Table A.2-5. 236Z Isotopic Distribution

Nuclide	Weight %	Activity %	Specific Activity (Ci/g)	Specific Activity Bq/g Pu	"S" Class* 10CFR 835 DAC Bq/m^3	Activity % to DAC Fraction
Pu-238	0.03%	2.04%	1.71E+01	6.33E+11	1	0.02
Pu-239	92.94%	23.18%	6.20E-02	2.29E+09	2	0.12
Pu-240	6.80%	6.20%	2.27E-01	8.40E+09	2	0.03
Pu-241	0.15%	60.97%	1.03E+02	3.81E+12	100	0.01
Pu-242	0.08%	0.00%	3.96E-03	1.46E+08	2	0.00
Am-241*	0.55%	7.61%	3.43E+00	1.27E+11	0.1	0.76
TOTALS	*100.55%*	*100.00%*			***Facility DAC Bq/m^3***	***1.07***

*Absorption class is "S" for plutonium isotopes and "M" for Am-241.

The demolition schedule assumes that the overall demolition would require about 69 working days (about 18 weeks elapsed time). It is assumed that the 236Z building is the first to be demolished - this schedule essentially works from one end of the complex to the other.

A.2.1 Initial Building Demolition

Demolition will begin on the upper levels of the building. One day is allocated for removal of the top story of the 236Z penthouse structure (because of the height and the necessity to lower debris to ground level). A second day is allocated for removal of the 6^{th} story column hood. Similarly, the 5^{th} story portion of the penthouse requires one day; the portion of the column hood on the 5^{th} story and Filterbox 50 are removed on the 4^{th} day.

Major demolition begins with removal of the main building roof and walls of the 4^{th} story. Three working days are allocated for this demolition. Two more days are allocated for removal of the 4^{th} story gloveboxes and column hood.

A similar 3-day period is allocated for removal of the 4^{th} story floor/3^{rd} story ceiling and walls – with the exception of the ceiling of the main cell, which constitutes part of the 4^{th} story floor. Filterbox 36 is removed during swing shift of the 13^{th} day.

The second story holds a bank of air filters. Most of the ducting is assumed removed prior to major demolition but the filter banks remain. An opening is assumed made and the filters removed essentially intact. This is assumed to take 1 working day. Then the remainder of the 2^{nd} story ceiling/3^{rd} story floor is removed along with walls over three working days. Two days are allocated for careful removal of the galleries located on the second story.

The 19th day is allocated for removal of the bank of filters on the 1st floor. The remainder of the outer portions of the 1st story are removed over a three-day period. Finally, two days are allocated to carefully remove the galleries located on the first floor.

As a result of this work, only the 2-foot-thick walls and ceiling of the main cell remain, along with the 41 strongbacks mezzanine, and maintenance cells contained within. The canyon walls are assumed to be demolished using hydraulic concrete shears or mechanical hammer mounted on a long boom on a track-mounted vehicle from ground level. The maintenance cell is modeled as being removed in a manner similar to that described for the Gallery Gloveboxes. The bulk of the contamination within the 236Z building is associated with the inner and outer walls of the maintenance and main cells along with the mezzanine. Leaks and spills of plutonium solutions have contaminated the insides of the cells and also the back walls of the gloveboxes on both sides on the first and second stories.

As noted above, there are a large number of penetrations through the cell walls on the first and second stories, originally within the galleries on the west and east side walls. These penetrations contained the piping and connectors for the jumpers to the pencil tanks.

A.2.2 Demolition of Cell with Shears or Mechanical Hammer

The cell ceiling and walls will be removed with the multiprocessor hydraulic shears or mechanical hammer. The walls are to be demolished from the south to the north using a large excavator to manipulate the multiprocessor. This device will crush the concrete into roughly 1-foot pieces. (The ERDF acceptance criteria include requirements that the pieces be sized into less than one-foot cubes.) A hypothetical schedule is described, upon which the emissions estimates are based. Misting, water, and fixatives will be used throughout the demolition process and load-out to minimize spread of airborne contamination. Demolition will only occur when sustained wind speeds are less than 15 miles per hour.

In order to make access easier, the south wall is removed. This wall is thinner (1 foot) and contains a 12-foot wide door extending into the second story. The door is topped with a concrete beam; above that construction is of cinder block.

Removal of the southern wall is assumed to allow access to the strongbacks nearest the south. The first strongback (left or right) is gripped by the multi-processor, removed from the receptacles, and lowered to the floor. The strongback is snipped into two or three pieces using the shears. The pieces are prepared for removal (additional fixative applied, sharp ends covered, wrapped) and lifted into packing boxes for transport. The process is repeated for the second (right or left, as remaining) strongback. These removals require a full day shift. On the next day shift, the first few feet of ceiling and side walls are removed using shears.

On subsequent days, an additional pair of strongbacks and associated ceiling and walls are removed. Complete removal of strongbacks and left, right, and top structure requires 38 days. The cell crane maintenance platform and crane are removed next. Finally, the north wall is removed; one day is allocated for this activity, including any final cleanup of the area.

Falling rubble is generally directed into the cell where the debris is sized, sorted and conditioned for waste acceptance, and then directly loaded into ERDF containers staged in a loadout area adjacent to the immediate demolition area. Pick-up of rubble is done with a front loader and thumb-and-bucket on the excavator. No additional containment structures (tents, etc.) are assumed for the rubble loading activity; however, like the demolition itself, misting, water, and fixatives will be used to minimize airborne contamination spread. Demolition and waste disposition activities will only occur when sustained wind speeds are less than 15 miles per hour. The shearing source term factors described in Section A.1 apply.

A.2.3 Surgical Removal of 236Z Building Equipment

Equipment to remain in the 236Z Building includes gloveboxes, filter boxes, pipes, and galleries. Prior to demolition of the building, it is assumed that the equipment will be prepared to minimize the potential for releases. For hoods, filters, and piping, it is assumed that the equipment will be covered internally and externally with fixative to fill voids. Ports and windows will be covered with metal plates to prevent them from fracturing when nearby walls and ceilings are removed with shears or mechanical hammer. They may also be wrapped in plastic sheeting. Minor damage from falling materials is assumed to dent and rip portions of the protective coverings.

The source term factors for surgical removal of equipment other than the galleries are described in Section A.1. The galleries on the 1st and 2nd stories of 236Z are a special case. The galleries are 304L stainless steel boxes affixed to the outer walls of the process cell. These galleries have a large estimated inventory of plutonium contamination. Most of the internal contamination appears to be chemically fixed to the metal lining of the galleries. It is assumed that the inner and outward-facing external surfaces will be covered by a rubberized fixative “FireDam-200” (described at http://multimedia.3m.com/mws/media/373702O/3mtm-firedamtm-spray-200-brochure.pdf and viewable on YouTube). The galleries may be pre-cut so that only small tabs of metal hold them together prior to the demolition of the surrounding structure, or they may be separated using shears via penetration through the diamond-shaped windows. When they are exposed, this will allow them to be gripped by the multiprocessor and pulled off of the cell outer walls.

For the galleries, it is assumed that:

- The fixative prevents suspension from intact surfaces
- Gripping/pulling by hydraulic equipment scratches/gouges ~1% of surface (equivalent to 2 deep scratches 1 cm x 50 cm per square meter). This gives a damage ratio of 0.01 for gallery detachment.
- 95% of Pu material is fixed “pickled” to surface, for this an airborne release fraction of 1×10^{-4} is used.
- 5% of Pu material is loose, for this an airborne release fraction of 1×10^{-3} is used.
- The material released is in small particles, so the respirable fraction is 1.0.
- Water sprays are as effective as normally assumed, resulting in a leak path factor of 0.1.

As a result of these assumptions, the emission factor for materials in the galleries is assumed to be 1.45×10^{-7}. Note that the galleries are affixed/grouted to the back walls (the outer walls of the process cell), which have been assumed to be contaminated to levels similar to the canyon walls. Removing the galleries from the wall will result in spalling the entire surface. Each of the four galleries is about 8 feet tall and 62 feet long. Preliminary calculations indicate that the amount of material made airborne in this activity could be nearly 30 grams of concrete dust, which would contain about 3 μCi of alpha-emitting radionuclides. This would be a small fraction of the total release, so this process has been omitted in the calculations.

A.2.4 Strongbacks

After demolition of the cell's south wall for access, the strongbacks will be sequentially removed via the following three processes:

1. Lowering to cell floor with multiprocessor;
2. Snipping into pieces for TRU packaging. Taller 4-block variants afforded 3 snips; all other 4 and 3-block variants 2 snips, no snips for 2-block variants;
3. Processing, loading into interim shipping container, and removal.

These three processes are assumed to take one-half of a shift for two strongbacks, which will be following by demolition of the cell ceiling and walls.

The strongbacks located in the main process cell, are assumed to contain 643 g of transuranics in 41 strongbacks. The contamination in one strongback is assumed to be distributed evenly as follows:

- 80% on or inside each of the strongback's four blocks (i.e., each block contains 20%), where 90% of each block's inventory is assumed to reside inside.
- Remaining 20% on the framework.

The DRs reflect the above assumed distribution as follows.

- Lowering to the floor uncovers 10% of the contamination associated with the four blocks that did not receive fixative because of being covered (DR of 0.08).
- Snipping impacts the 20% residual on the framework which has been covered with fixative. Thus, the snipping process removes 5% of fixant (DR of 0.01).
- Because additional fixative is assumed to be applied after removal and lowering of the strongbacks to the cell, the DR for this process is 0.01.

ARFs are as follows:

- Lowering strongbacks to the floor and snipping assume $1x10^{-3}$ based on DOE-HDBK-3010 value for unfixed metal surfaces sliding past each other.
- For repackaging strongbacks, assume $1x10^{-6}$

The LPF is 0.1 for all processes because of misting that will occur during the strongback demolition phases.

A.2.5 Summary 236Z Demolition Source Term Factors

Table A.2-6 summarizes the DR, LPF, ARF and RF values assumed for demolition of 236Z.

Table A.2-6 236Z Demolition Source Term Factors

Demolition Activity	Impacted Structure	Type	DR	ARF	LPF	Fraction in Size range (µm: fract.)	RF*	EF
Shearing	Walls and Floors	Rem	0.90	1.0×10^{-3}	0.10	--	1.0	9.0×10^{-5}
		Fix	0.10	1.0×10^{-4}	0.10	--	1.0	1.0×10^{-6}
Dropping of Rubble	Rubble	Rem & Fix	1.0	2.6×10^{-6}	0.95	0 to 2.5: 0.11	1.0	2.72×10^{-7}
			1.0	2.6×10^{-6}	0.60	2.5 – 5: 0.09	1.0	1.40×10^{-7}
			1.0	2.6×10^{-6}	0.30	5 – 10: 0.15	1.0	1.17×10^{-7}
			1.0	2.6×10^{-6}	0.25	10 – 15: 0.13	1.0	8.45×10^{-7}
			1.0	2.6×10^{-6}	0.25	15 – 30: 0.26	1.0	1.69×10^{-7}
			1.0	2.6×10^{-6}	0.25	> 30: 0.26	1.0	1.69×10^{-7}
Composite EF for all Size Ranges								9.52×10^{-7}
Lowering to Floor	Strongback	Rem & Fix	0.1	1.0×10^{-3}	0.10	--	1.0	1.0×10^{-5}
Snipping	Strongback	Rem & Fix	0.01	1.0×10^{-3}	0.10	--	1.0	1.0×10^{-6}
Surgical Removal	Glovebox	Fix	0.01	1.0×10^{-6}	0.10	--	1.0	1.0×10^{-9}
Detachment	Gallery	Rem	0.01	1.0×10^{-3}	0.10	--	1.0	1.0×10^{-6}
		Fix	0.01	1.0×10^{-4}	0.10	--	1.0	1.0×10^{-7}
Composite for Gallery Detachment (95% fixed)								1.45×10^{-7}
Load out	Gallery	Rem	0.01	1.0×10^{-3}	0.10	--	1.0	1.0×10^{-6}
		Fix	0.01	1.0×10^{-4}	0.10	--	1.0	1.0×10^{-7}
	Composite for Gallery Loadout (95% fixed)							1.45×10^{-7}
	Rubble	Rem	1.0	2.3×10^{-6}	0.10	--	1.0	2.6×10^{-7}
	Strongback	Rem & Fix	0.01	1.0×10^{-6}	0.10	--	1.0	1.0×10^{-9}
Sorting/Sizing /Re-loading	Rubble	Rem & Fix	1.0	2.3×10^{-6}	0.10	--	1.0	2.6×10^{-7}
Resuspension – Between Shifts	Rubble	Rem	1.0	0	0.10	--	1.0	0

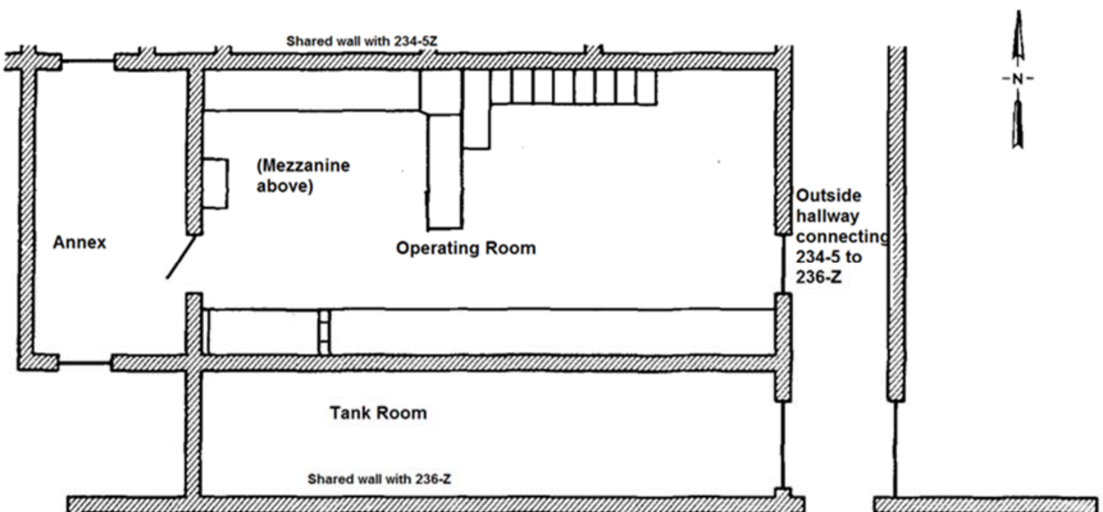
*Respirable Fraction only a factor for inhalation dose computation in which case the values should be 0 for particles >10 µm. However, particle sizes greater than 10 were treated as 10 µm in this analysis (see Section A.1.4), which is conservative.

A.3 The 242Z Waste Treatment Facility

The 242Z Waste Treatment Facility began operation in 1963 to recover plutonium from aqueous waste streams from the PFP. An americium (^{241}Am) recovery process was installed in a glovebox in 242Z and began operation in May 1965. The recovery process was converted from batch to continuous in 1969. In April 1976, the 242Z facility was shut down as a result of a labor strike. In August 1976, during restart, an explosion occurred in a cation ion exchange column that contained approximately 100 g of ^{241}Am. This resulted in substantial internal uptake of americium to a worker and extreme contamination to most of the building. As a result, the 242Z facility was permanently closed. Gross contamination from the explosion was removed. Doors into the operating area were welded shut and re-entry into the facility for final cleanup only began in April 2009.

The 242Z facility is a 1000-square-foot building located on the south side of the southeast corner of the 234-5 building. It is 40 feet wide, 26 feet long, and 23 feet high (Figure A.3-1). The southern portion of the building was 40 feet wide and 10 feet long and consisted of a tank room (tank cell). This room extends the full inside building height. The northern portion was designated the control room, with a mezzanine over its west half for chemical addition tanks. The building is constructed of structural steel with an aluminum panel outer sheath, rock wool insulation and 16-gauge sheet steel. The floor is concrete and the southern wall reinforced concrete. The southern wall is a common wall (shares) with the northern wall of PRF. The rest of the building has plaster inside and insulating material wall panels outside. The roof is slightly peaked and composed of metal decking covered by insulation and built-up asphalt and gravel.

There is an annex on the west side of the building that allows access to 234-5Z. This annex was entered by three people immediately following the accident, who noticed the door open to the operating/control room and left immediately; they were then found to be contaminated. It is assumed that there is some level of contamination in the annex. The operators and HPs exited via the enclosed hallway on the east side of the building; this is also assumed to be contaminated to a low level.



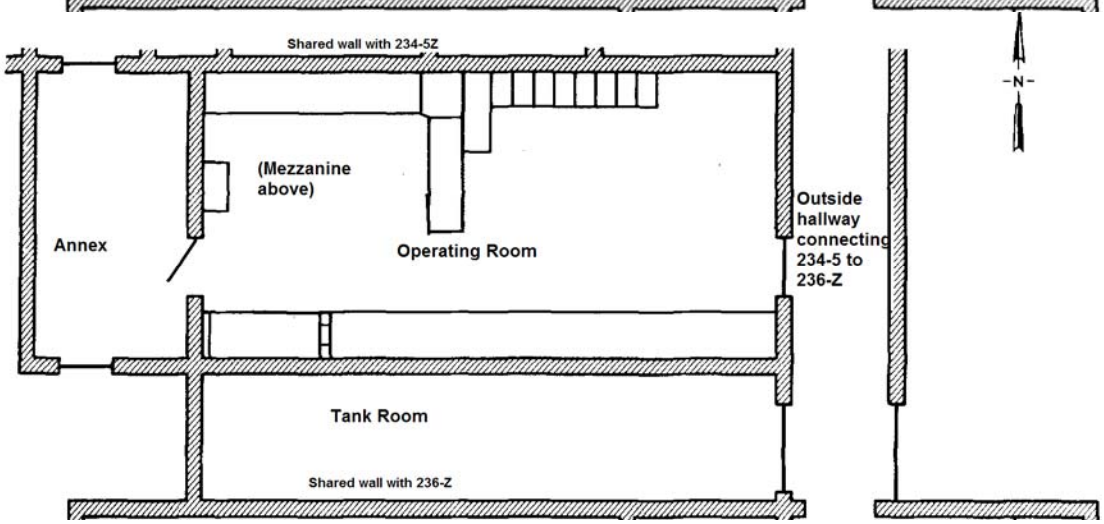


Figure A.3-1. Floor Plan of the 242Z Building and Nearby Structures

Contamination in the 242Z facility is extensive. Teal and Hoyt (2016) (HNF-26042 Rev 0) suggested a total of 10 grams of Pu mixture in the building, excluding residual americium from the explosion. If it is assumed that 99% of the ^{241}Am has been recovered, there is still 1 gram of ^{241}Am remaining. Combined, this would be over 5 alpha curies of radioactive materials. Materials supplied by Oldfield and Sauer (workbook dated 7 July 2016) indicate the contamination levels shown in Table A.3-1.

Table A.3-1. Contamination levels in 242Z Building

Demolition Sequence			*LLW Contaminated Surfaces*				*TRU Strategic Removals*		
Facility	**Zone**	**Location**	**Debris Wt (lb)**	**Area (SF)**	**α dpm/100cm^2**	**Description**	**QTY**	**Unit**	**Pu (g)**
242-Z	SZ-1	242-Z and 242-ZA	289446	9100	8,000,000	Tank & Control Rooms	9	Tanks	373

CHPRC staff have suggested that the 9 tanks from the tank room will be carefully removed during the demolition of the structure by opening a wall at one end and moving them out. The 9 tanks are listed in Table A.3-2.

Table A.3-2. Radionuclide contamination of tanks in 242Z Building

Tank ID	Pu	Tank ID	Pu (grams)
W-1	18	W-6	22
W-2	126	W-12	65
W-3	14	W-13	4
W-4	12	W-15	3
W-5	109		

Contaminated areas, exclusive of removed equipment, are listed in Table A.3-4. The material in Table A.3-1 was modified from that provided by CHPRC to enable detailed analyses of the various components; total areas and contamination levels are the same. The nature of the activities in the 242Z building originally produced material in this building in soluble nitrate forms; these have been assumed to have oxidized to less soluble forms (although the americium remains moderately soluble).

The assumed isotopic distribution is based on facility specific details given the historical processes that had occurred and the decay period, as shown in Table A.3-3. The facility DAC (Bq/m^3) is based on the facility isotopic distribution.

Table A.3-3. 242Z Isotopic Distribution

Nuclide	Weight %	Activity %	Specific Activity (Ci/g)	Specific Activity Bq/g Pu	"S" Class* 10CFR 835 DAC Bq/m^3	Activity % to DAC Fraction
Pu-238	0.12%	1.82%	1.71E+01	6.33E+11	1	0.02
Pu-239	87.09%	4.95%	6.20E-02	2.29E+09	2	0.02
Pu-240	11.84%	2.46%	2.27E-01	8.40E+09	2	0.01
Pu-241	0.57%	53.75%	1.03E+02	3.81E+12	100	0.01
Pu-242	0.39%	0.00%	3.96E-03	1.46E+08	2	0.00
Am-241*	1.78%	37.02%	3.43E+00	1.27E+11	0.1	3.70
TOTALS	*101.89%*	*100.00%*			***Facility DAC Bq/m^3***	**0.27**

*Absorption class is "S: for plutonium isotopes and "M" for Am-241.

Table A.3-4. Contamination Levels Assumed in Portions of 242Z at Demolition

Building Zone	Area (ft^2)	Approximate mass (grams)	Contamination (dpm/100 cm^2)	Inventory (alpha curies)
Control room walls	3070	5.70E+07	8,000,000	1.03E-01
Control room ceiling	730	1.24E+07	8,000,000	2.44E-02
Tank room walls	2590	2.83E+07 (1)	8,000,000	8.67E-02
Tank room ceiling	410	6.94E+06	8,000,000	1.37E-02
Annex walls	1175	1.72E+07 (2)	100,000	4.92E-04
Annex ceiling	325	5.50E+06	100,000	1.36E-04
Hall walls	590	5.59E+06 (3)	2,000	4.94E-06
Hall ceiling	210	3.56E+06	2,000	1.76E-06
Totals	9100	1.31E+08		0.228

(1) excluding common wall with control room and tank room
(2) excluding common wall with control room
(3) excluding common walls with 236Z building and control room

The general modeling approach and overall emission factors are provided in Table A.3-5.

Table A.3-5. General Modeling Approach for 242Z Demolition Operations

242Z Section	Operation	Demolition Summary	AERMOD Modeling approach	EF
Outer Structure; western annex and eastern hallway	Shearing	Tear walls and ancillary roofing into pieces with multiprocessor	Emission factor (EF) based on 10% of contaminated surface broken up/exposed, 90% fixative.	EF = 1.0×10^{-5} rem; 9.0×10^{-7} fix.
		Rubble Drop after shearing	Particle sizes divided into 6 size bins, each assigned size appropriate RFs and LPFs to derive a composite	EF = 8.42×10^{-8} rem & fix
	Loading	Scoop and drop into box	Moist rubble treated with EPA method	EF = 1.0×10^{-7} rem & fix
Ceiling /Roof	Shearing	Tear walls and ancillary roofing into pieces with multiprocessor	Emission factor (EF) based on 10% of contaminated surface broken up/exposed, 90% fixative.	EF = 1.0×10^{-5} rem; 9.0×10^{-7} fix
		Rubble Drop after shearing	Particle sizes divided into 6 size bins, each assigned size appropriate RFs and LPFs to derive a composite	EF = 8.42×10^{-8} rem & fix
	Resus-pension	Surfaces covered with fixative/soil cement	Resuspension considered negligible because of the extensive use of fixative.	EF = 0.00
	Loadout	Scoop and drop into box	Moist rubble treated with EPA method.	EF = 1.0×10^{-7} rem & fix
Main Portion	Shearing	Tear walls and ancillary roofing into pieces with multiprocessor	Emission factor (EF) based on 10% of contaminated surface broken up/exposed, 90% fixative.	EF = 1.0×10^{-5} rem; 9.0×10^{-7} fix
	Resus-pension	Surfaces covered with fixative/soil cement	Resuspension considered negligible because of the extensive use of fixative.	EF = 0.00
	Loadout	Scoop and drop into box	Moist rubble treated with EPA method.	EF = 1.0×10^{-7} rem & fix
Tanks	Surgical Removal	Carefully hoist prepared equipment with minimal disruption of integrity	Minor emissions due to careful removal techniques.	EF = 1.0×10^{-9} fix
All Areas during: Off-shift	Resus-pension	Surfaces covered with fixative/soil cement	Set to zero because of fixatives and lack of activity.	EF = 0.00
Rubble and removed Equipment	Loadout	Actions equivalent to scooping and loading	Moist rubble treated with EPA method.	EF = 1.0×10^{-7} rem & fix
	Sort/Size/ Repackage	Actions equivalent to scooping and loading	Moist rubble treated with EPA method.	EF = 1.0×10^{-7} rem & fix

A.3.1 Demolition Schedule

The demolition schedule is defined to require 7 working days. The 242Z building is a small, metal-frame building. The assumed schedule is provided in Table A.3-5.

Table A.3-5. Demolition Schedule

Day	Building Location
1	West annex
2	East hallway/Pull tanks
3	Roof
4	South wall (residual part of 236Z)
5	East wall
6	Center wall
7	West wall
	(Leave north wall as part of 234-5Z)

A.3.2 Demolition Approach

The building roof and walls are assumed to be demolished with a multiprocessor operating hydraulic shears or mechanical hammer end effectors. The walls are to be demolished from the top down, using a large excavator to manipulate the multiprocessor. This device will rip the metal sheeting and separate the steel framing. Misting, water, and fixatives will be used throughout the demolition process and load out to minimize airborne contamination spread. All demolition will only occur when sustained wind speeds are less than 15 miles per hour.

It is assumed that the lower-contaminated outer structures (annex, eastern outside hallway) are removed first, with a portion of the roof of the tank room. After opening east hallway, the tanks are removed through the open wall.

For structural reasons, the remainder of the ceiling/roof is removed. The floor of the building is assumed to be covered with sand (or a similar substance) to absorb the impact of falling debris and to minimize suspension of floor contamination. This action opens the main room to the atmosphere for the remainder of the demolition activities. The walls are removed in a logical order allowing access. The final wall shared with 234-5Z is left intact to be removed with that building

Mechanical shears or mechanical hammer are assumed to be used to demolish the 242Z structure after it has been extensively prepared. The radioactive material at risk (MAR) is assumed to be evenly distributed over the entire contaminated area being worked on (wall segment, etc.). The damage ratio (DR) is that portion or percentage of the contaminated area acted on by the shear force, or the portion or percentage of the contamination acted on by shear forces. Shears or mechanical hammer are assumed to fracture, crush, spall, or otherwise impact the surface being sheared. Fixative is assumed to have been applied to all of the contaminated surfaces; and large portions of the facility are sheet-metal panels. The fraction of surface from which paints/fixatives are assumed to be removed (scratched, peeled) during shear operations is taken to be 0.1, so that 10% of the surface is treated as removable contamination and 90% is treated as fixed contamination.

The source term factors described in Section A.1 apply to the demolition activities of 242Z except for the ARF which is described below. The surgical removal factors apply to the tanks which will be removed intact.

A.3.3 Airborne Release Fraction

DOE's factors for impaction stress due to vibration and shock for materials that do not brittle fracture (e.g., ductile metal sheeting) were selected as the most representative ARFs for the crushing processes; the factors selected were $1x10^{-3}$ (DOE 1994, Section 5.3.3.2.2) for removable contaminants and $1x10^{-5}$ (based on one percent of 0.001) for contaminants with a double layer of paint/fixative (TRUTech 2001).

Surfaces not directly impacted by cutting will be disturbed from a variety of sources, including the cutting process (especially for shear cutting), movement and placement of material, general shaking of the building surface, vibrations from heavy equipment, and vibration from fall of rubble to the floor surface. Releases from these surfaces will be controlled by existing fixative, periodic application of fresh fixative, continually wet surfaces, and water spray/mist in the air. These controls are assumed to be sufficient to prevent any emissions from vibration of noncontact surfaces.

As the material falls to the ground from the elevated location on the walls where it originates, it will be subject to entrainment in the air. The EPA method for computing the rubble drop ARF described in Section A.1.4 is used. Because sheet metal is less likely to be dusty than pulverized concrete rubble, the ARF for that component was reduced to $1x10^{-6}$. In addition, this release fraction is applied only to the 10% of the material that has had the fixatives damaged.

Surfaces exposed to the atmosphere between shifts will be subject to resuspension processes. A fresh coat of fixative will be applied to all exposed surfaces (covering any gaps and material deposited on the existing fixative) at the end of demolition operations for a day. Therefore, it is assumed that there is no resuspension between shifts.

A.3.4 Summary 242Z Demolition Source Term Factors

Table A.3-6 summarizes the DR, LPF, ARF and RF values assumed for demolition of 242Z.

Table A.3-6 242Z Demolition Source Term Factors

Demolition Activity	Impacted Structures	Type	DR (unitless)	ARF (unitless)	LPF (unitless)	Fraction in Size range (µm:fract.)	RF (unitless)	EF (unitless)
Shearing	Walls and Ceilings	Rem	0.10	$1x10^{-3}$	0.1	--	1.00	$1.0x10^{-5}$
		Fix	0.90	$1x10^{-5}$	0.1	--	1.00	$9.0x10^{-7}$
Dropping of Rubble	Rubble	Rem & Fix	0.10	$2.3x10^{-6}$	0.95	0 to2.5: 0.11	1.00	$2.40x10^{-8}$
			0.10	$2.3x10^{-6}$	0.60	2.5 – 5: 0.09	1.00	$1.24x10^{-8}$
			0.10	$2.3x10^{-6}$	0.30	5 – 10: 0.15	1.00	$1.04x10^{-8}$
			0.10	$2.3x10^{-6}$	0.25	10 – 15: 0.13	1.00	$7.48x10^{-9}$
			0.10	$2.3x10^{-6}$	0.25	15 – 30: 0.26	1.00	$1.50x10^{-8}$
			0.10	$2.3x10^{-6}$	0.25	> 30: 0.26	1.00	$1.50x10^{-8}$
			Composite EF for all Size Ranges					$8.42x10^{-8}$
Surgical Removal	Tanks	Fix	0.01	$1x10^{-6}$	0.10	--	1.00	$1.0x10^{-9}$
Loadout	Rubble	Rem & Fix	1.00	$1x10^{-6}$	0.10	--	1.00	$1.0x10^{-7}$
Sorting/Sizing /Re-loading	Rubble	Rem & Fix	1.00	$1x10^{-6}$	0.10	--	1.00	$1.0x10^{-7}$
Resuspension – Between Shifts	Rubble	Rem	0.01	0	0.10	--	1.00	0

A.4 234-5Z Building

The 234-5Z building is approximately 152 m (500 ft) long and 55 m (180 ft) wide. The floor levels are the basement, first story, duct level, and second story. The frame is structural steel with an outer sheathing of aluminum panels over rock wool insulation and 16-gauge sheet metal. There are also 20 cm (8 in) thick interior reinforced concrete walls, principally running in the east-west direction, and two box-type reinforced concrete stairwells. The stairwells extend to the roof; the reinforced concrete walls stop at the second floor. Contamination levels are quite variable within this large structure; the bulk of residual contamination is expected to reside in the central core and on the duct level.

CHPRC staff have proposed levels of contamination that could remain following planned ongoing cleanout operations for this building (workbook of 7 July 2016 provided by Sauer). The old Recuplex area (current HP office), RMA and RMC lines are the area between columns C-E north/south and 4-18 east/west. This is assumed to continue up into the "Duct Level" because these rooms extend up this high with overlooking mezzanines, etc. The area used as the analytical laboratory is the area between columns E-J north/south and 1-7 east/west. The area that in later years was the development laboratory is roughly the area between columns E-G north/south and 7-22 east/west, and includes the southern office annex. The construction photograph in Figure A.4-1 shows these column lines. These areas are illustrated in the idealized plan view of the building shown in Figure A.4-2.

Figure A.4-1. 234-5Z Building Under Construction, Showing Steel Structure. Building column grid A-J (omitting I) is from right to left in this photo; column lines 1-24 begin at this eastern end and work toward the west. The 242Z and 236Z buildings had not been started when this photo was taken.

A.4.1 Demolition Schedule

An approximate schedule for demolition has been prepared by CHPRC to allow calculations. The building has been divided into "demolition zones." It is assumed that demolition will be completed by zone; additional work will be required to load the rubble into ERDF containers before demolition can commence on the subsequent zone. The demolition zones assumed are illustrated in Figure A.4-2. The schedule that results from these assumptions is given in Table A.4-1.

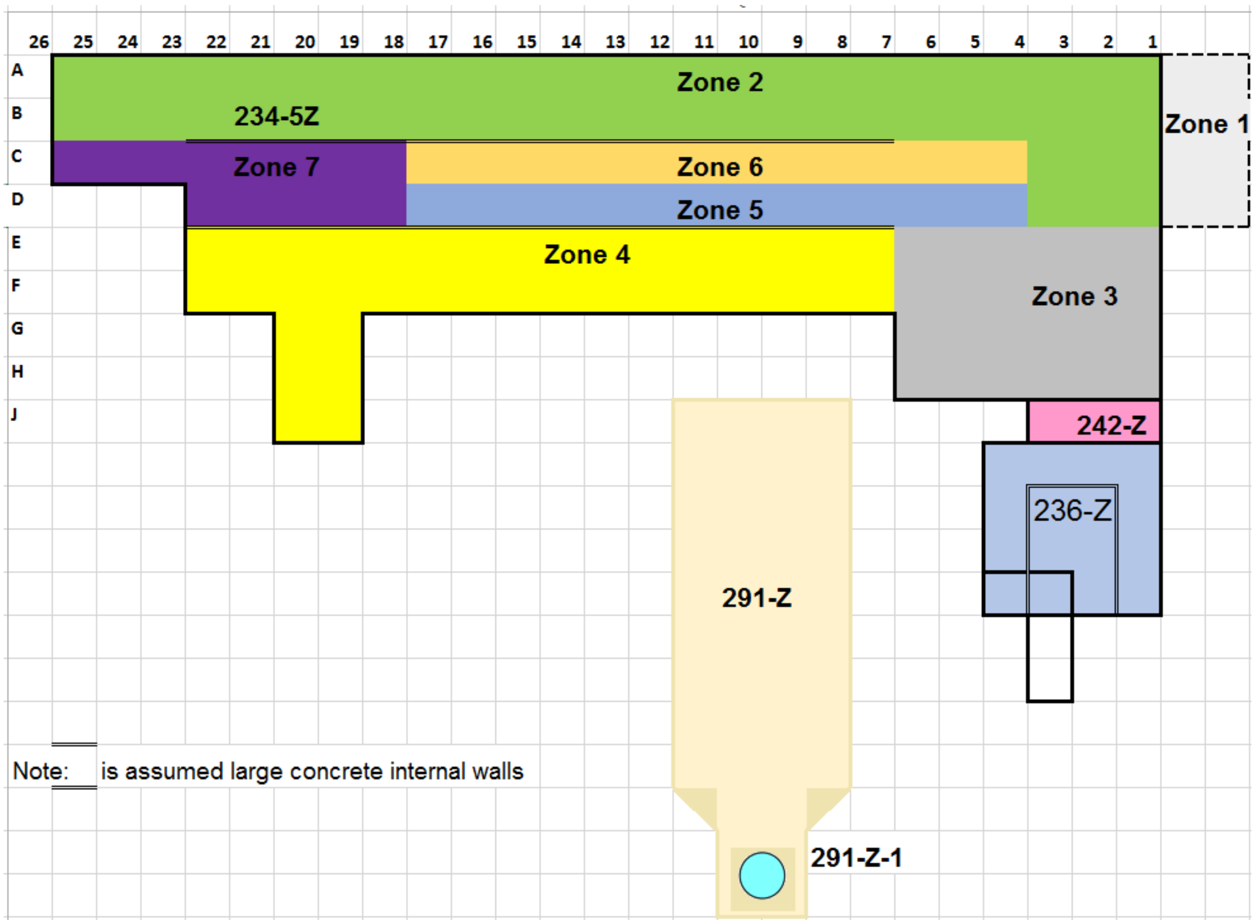


Figure A.4-2. 234-5Z Demolition Zones Assumed for Analysis

Table A.4-1. Demolition Schedule for 234-5Z

ZONE	Area/Glovebox	Day	Swing	Shift
1	Office area	2	2	Shifts
2	North Face	12	12	Shifts
3	Analysis lab area	9	9	Shifts
	145-1, Rm 262 Filter boxes (14)	1	1	Shifts
4	South face	16	16	Shifts
	159-1; 159-2; Pencil tanks; Rm 262 Filter boxes (13)	2	2	Shifts
5	RMA Line	7	7	Shifts
	HC-227-S; HC227-T; HC-18M, Rm 263 Filter boxes (6)	1	1	Shifts
	100 LF Ductwork	1	1	Shifts
6	RMC Line	7	7	Shifts
	HA-46, Vac Pump 10/11, Rm 254 Filter boxes (4)	1	1	Shifts
7	Metalworking Area	8	8	Shifts
	GB-100B, GB-200, GB-300, Rm 235D filter boxes (3)	1	1	Shifts
	Tunnel Drain lines (8 sets in 6 tunnels)	1	1	Shifts
	Subtotal	69	69	Shifts

A.4.2 Demolition Approach

It is assumed that the lower-contaminated outer structures (office area) are removed first.

The building roof and walls are assumed to be demolished with a multiprocessor operating hydraulic shears or mechanical hammer end effectors. The walls are to be demolished from the top down, using a large excavator to manipulate the multiprocessor. This device will rip the metal sheeting, rubblize the lath and plaster walls, and separate the steel framing. Misting, water, and fixatives will be used throughout the demolition process and load out to minimize airborne contamination spread. All demolition will only occur when sustained wind speeds are less than 15 miles per hour. It is assumed that the steel structure will be the final portion of each zone removed, in a manner similar to recent demolition of the 212-R building at Hanford, as illustrated in Figure A.4-3. The piles of rubble will be sorted into ERDF boxes and removed; during the next zone demolition, the ERDF boxes will be placed in locations on the floor of the prior zone for loading.

Figure A.4-3. Assumed Interim Demolition Conditions: Roof and Walls Rubblized Prior to Shearing of Steel Framework (212-R building used as example)

Table A.4-2 summarizes the general modeling approach and provides the final emission factors.

Table A.4-2. General Modeling Approach for 234-5Z Demolition Operations

234-5Z Section	Operation	Demolition Summary	AERMOD Modeling approach	EF
Walls and Ceilings	Shearing	Break walls into 1x1 ft pieces with multiprocessor	Emission factor (EF) based on 90% of contaminated surface broken up/exposed, 10% fixative.	EF = 9.0×10^{-5} rem; 1.0×10^{-6} fix.
		Rubble Drop after shearing	Particle sizes divided into 6 size bins, each assigned size appropriate RFs and LPFs to derive a composite	EF = 9.52×10^{-7} rem & fix
	Resuspen-sion	Surfaces covered with fixative/soil cement	Set to zero because of fixatives and lack of activity.	EF = 0.00 rem
	Loadout	Scoop and drop into box	Moist rubble treated with EPA method.	EF = 2.6×10^{-7} rem & fix
Glovebox	Surgical Removal	Remove building from around closed, FireStop-200 boxes, ducts, and pipes	Minor emissions due to careful removal techniques and they are protected.	EF = 1.0×10^{-9} fix
All Areas during: Off-shift	Resus-pension	Surfaces covered with fixative/soil cement	Set to zero because of fixatives and lack of activity.	EF = 0.00 rem

Table A.4-2. General Modeling Approach for 234-5Z Demolition Operations

234-5Z Section	Operation	Demolition Summary	AERMOD Modeling approach	EF
Rubble and removed Equipment	Loadout	Actions equivalent to scooping and loading	Moist rubble treated with EPA method.	EF = 2.6×10^{-7} rem & fix
	Sort/Size/ Repackage	Actions equivalent to scooping and loading	Moist rubble treated with EPA method.	EF = 2.6×10^{-7} rem & fix
Pipe Trench	Surgical Removal	Fill pipes with epoxy and cut into sizes that fit into burial boxes	Minor emission assumed because of the careful removal process	EF = 1.00×10^{-9} rem & fix

The source term factors described in Section A.1 apply to the demolition activities of 234-5Z except for the DR described below.

A.4.3 234-5Z Damage Ratio

The external walls of the 234-5Z building are sandwiched aluminum panels with insulation and a thin steel inner liner. These external wall panels are assumed to not have been extensively contaminated from historical operations. The mass of the wall panels is about 5 pounds/ft^2. The inner building walls are made up of lath-and-plaster construction. Lath-and-plaster as applied in the late 1940s was a sand-cement layer mortared onto extruded metal mesh.

Mechanical shears or mechanical hammer are assumed to be used to demolish the 234-5Z structure. The radioactive material at risk (MAR) is assumed to be evenly distributed over the entire contaminated area being worked on (wall segment, etc.). The damage ratio (DR) is that portion or percentage of the contaminated area acted on by the shear force, or the portion or percentage of the contamination acted on by shear forces. Shears or mechanical hammer are assumed to fracture, crush, spall, or otherwise impact the surface being sheared.

DOE's factors for impaction stress due to vibration and shock for materials that do not brittle fracture (e.g., ductile metal sheeting) were selected as the most representative release fractions for the crushing processes; the factors selected were 1×10^{-3} (DOE 1994) for removable contaminants and one percent of that (1×10^{-5}) for contaminants with a double layer of paint/fixative (TRUTech 2001).

Surfaces not directly impacted by cutting will be disturbed from a variety of sources, including the cutting process (especially for shear cutting), movement and placement of material, general shaking of the building surface, vibrations from heavy equipment, and vibration from fall of rubble to the floor surface. Releases from these surfaces will be controlled by existing fixative, periodic application of fresh fixative, continually wet surfaces, and water spray/mist in the air. These controls are assumed to be sufficient to prevent any emissions from vibration of noncontact surfaces.

As the material falls to the ground from the elevated location on the walls where it originates, it will be subject to entrainment in the air. The EPA method for determining the airborne emission rate is that described in Section A.1.4. This release fraction is applied only to the 90% of the material that has had the fixatives damaged.

A.4.4 234-5Z Building Surface Areas

Using cleanup criteria based on dpm/100 cm^2 within the building is a simple approach to determining residual contamination. The total inventory of potentially releasable material must then be based on the total surface area of each demolition zone. The total surface areas were estimated on the basis of detailed drawings of the building. Contamination levels, contaminated area, and rubble mass were provided by the CHPRC team of Oldfield and Sauer (workbook dated 7 July 2016). The various demolition zone characteristics are summarized in Table A.4-3.

Table A.4-3. Contamination Levels for the Demolition Zones for the 234-5Z Building

Zone No.	Description	Glovebox contents Pu g	Cont. Level dpm/100 cm^2	Surface Area ft^2	Mass lb	Inventory alpha Ci
1	**Uncontaminated offices**		2,600	1000	262335	1.09E-05
2	**North Face**					
	1st story		2,600	10,000	5,319,554	0.000109
	E-3/4		5,000	8,000	118,500	0.000167
3	**Analysis lab area**					
	Surfaces		200,000	117,344	2,233,034	0.09821
	E-3/4		2,000,000	32,000	474,000	0.267829
	145-1	3				3.54E-01
	Rm 262 Filter Boxes	26				3.07E+00
4	**South face**					
	Surfaces		200,000	196,364	3,323,369	0.16435
	E-3/4		500,000	32,000	474,000	0.066957
	Upper pencil tank	166				1.96E+01
	Lower pencil tank	98				1.16E+01
	159-1	1				1.18E-01
	159-2	1				1.18E-01
	Rm 262 Filter boxes	284				3.35E+01
5	**RMA Line**					
	Surfaces		2,000,000	105,384	1,545,479	0.88203
	E-3/4		2,000,000	16,000	237,000	0.133914
	HC-227-S	30				3.54E+00
	HC-227-T	30				3.54E+00
	HC-18M	76				8.97E+00
	Rm 263 Filter Boxes	98				1.16E+01
	1000 LF Ductwork	50				5.90E+00
6	**RMC Line**					
	Surfaces		2,000,000	99,908	1,676,105	0.83619
	E-3/4		2,000,000	16,000	237,000	0.133914
	HA-46	1				1.18E-01
	Vacuum Pump Cols	2				2.36E-01
	Rm 254 Filter boxes	34				4.01E+00

7	**Metalworking Area**					
	Surfaces		200,000	72,496	1,510,281	0.06068
	GB-100B	1				1.18E-01
	GB-200	1				1.18E-01
	GB-300B	1				1.18E-01
	Rm 235D Filter Boxes	21				2.48E+00
	Tunnel piping	550				6.49E+01

The assumed isotopic distribution is based on facility specific details given the historical processes that had occurred and the decay period, as shown in Table A.4-4. The facility DAC (Bq/m^3) is based on the facility isotopic distribution.

Table A.4-4. 234-5Z Isotopic Distribution

Nuclide	Weight %	Activity %	Specific Activity (Ci/g)	Specific Activity Bq/g Pu	"S" Class* 10CFR 835 DAC Bq/m^3	Activity % to DAC Fraction
Pu-238	0.06%	2.13%	1.71E+01	6.33E+11	1	0.02
Pu-239	90.65%	12.13%	6.20E-02	2.29E+09	2	0.06
Pu-240	8.75%	4.28%	2.27E-01	8.40E+09	2	0.02
Pu-241	0.34%	74.53%	1.03E+02	3.81E+12	100	0.01
Pu-242	0.21%	0.002%	3.96E-03	1.46E+08	2	0.00
Am-241*	0.94%	6.92%	3.43E+00	1.27E+11	0.1	0.69
TOTALS	*100.94%*	*100.00%*			***Facility DAC Bq/m^3***	1.25

*Absorption class is "S" for plutonium isotopes and "M" for Am-241.

A.4.5 Summary 234-5Z Demolition Source Term Factors

Table A.4-5 summarizes the DR, LPF, ARF and RF values assumed for demolition of 236Z.

Table A.4-5 234-5Z Demolition Source Term Factors

Demolition Activity	Impacted Structures	Type	DR (unitless)	ARF (unitless)	LPF (unitless)	RF (unitless)	EF (unitless)
Shearing	Walls and Ceilings	Rem	0.90	$1x10^{-3}$	0.1	1.00	$9.0x10^{-5}$
		Fix	0.10	$1x10^{-4}$	0.1	1.00	$1.0x10^{-6}$
Dropping of Rubble	Rubble	Rem & Fix	0.10	$2.6x10^{-6}$	See Table A.4-2	1.00	$9.52x10^{-7}$
Surgical Removal	Gloveboxes	Contents	0.01	$1x10^{-6}$	0.10	1.00	$1.0x10^{-9}$
	Pipe Trench	Rem & Fix	0.01	$1x10^{-6}$	0.10	1.00	$1.0x10^{-9}$
Sorting/Sizing /Re-loading	Rubble	Rem & Fix	1.00	$2.6x10^{-6}$	0.10	1.00	$2.6x10^{-7}$
Resuspension – Between Shifts	Rubble	Rem	0.01	0	0.10	1.00	0

A.5 291Z Fan House and Stack

The 291Z building houses the final exhaust plenum, fans, and 200-foot discharge stack for the 234-5Z (PFP), 232Z (incinerator – previously decommissioned), and the 236Z (plutonium reclamation) buildings. Exhaust from the three facilities enters a large (15-ft x 20-ft) central concrete plenum. Several stainless steel centrifugal fans located on both sides of this central plenum draw air from the central plenum and move the air into two lower plenums on each side of the central plenum below the fans. The two plenums join together downstream of the fans at a V shape junction and the combined flow enters the base of the 291Z-1 stack (Figure A.5-1). The stack is a concrete structure 200 ft high with an inside diameter of 16.5 feet at the base and 13.5 feet at the top. An access door is located near the base of the stack, and a sampling system with constant air monitors (CAMs) that alarm at pre-set levels and record samplers for data collection is located at the 50-foot level. The stack interior surfaces received two coats of paint preventing contamination from imbedding into the concrete.

The 291Z-1 stack, attached to the 291Z building, began operation in 1949. Residual contamination is assumed to be covered with fixatives inside the stack.

The residual contamination levels provided by the CHPRC Team (Oldfield and Sauer, workbook dated 7 July 2016) are listed in Table A.5-1.

Table A.5-1. Contamination levels in the 291Z Fan House

	Location	Debris Wt (lb)	Area (SF)	dpm/100 cm^2	QTY	Unit	Pu (g)
SZ-1	291-Z Fanhouse	5314936	12000	2000	724	LF 26" PV Lines	502
SZ-2	291-Z-001 Stack	937365	9000	3000	None		

The assumed isotopic distribution is based on facility specific details given the historical processes that had occurred and the decay period, as shown in Table A.5-2. The facility DAC (Bq/m^3) is based on the facility isotopic distribution.

Table A.5-2. 291Z Fan House and Stack Isotopic Distribution

Nuclide	Weight %	Activity %	Specific Activity (Ci/g)	Specific Activity Bq/g Pu	"M" Class* 10CFR 835 DAC Bq/m^3	Activity % to DAC Fraction
Pu-238	0.06%	2.13%	1.71E+01	6.33E+11	0.2	0.11
Pu-239	90.65%	12.13%	6.20E-02	2.29E+09	0.2	0.61
Pu-240	8.75%	4.28%	2.27E-01	8.40E+09	0.2	0.21
Pu-241	0.34%	74.53%	1.03E+02	3.81E+12	10	0.07
Pu-242	0.21%	0.00%	3.96E-03	1.46E+08	0.2	0.00
Am-241*	0.94%	6.92%	3.43E+00	1.27E+11	0.1	0.69
TOTALS	*100.94%*	100.00%			***Facility DAC Bq/m^3***	0.59

*Absorption class is "M" for plutonium isotopes and Am-241. This is conservative.

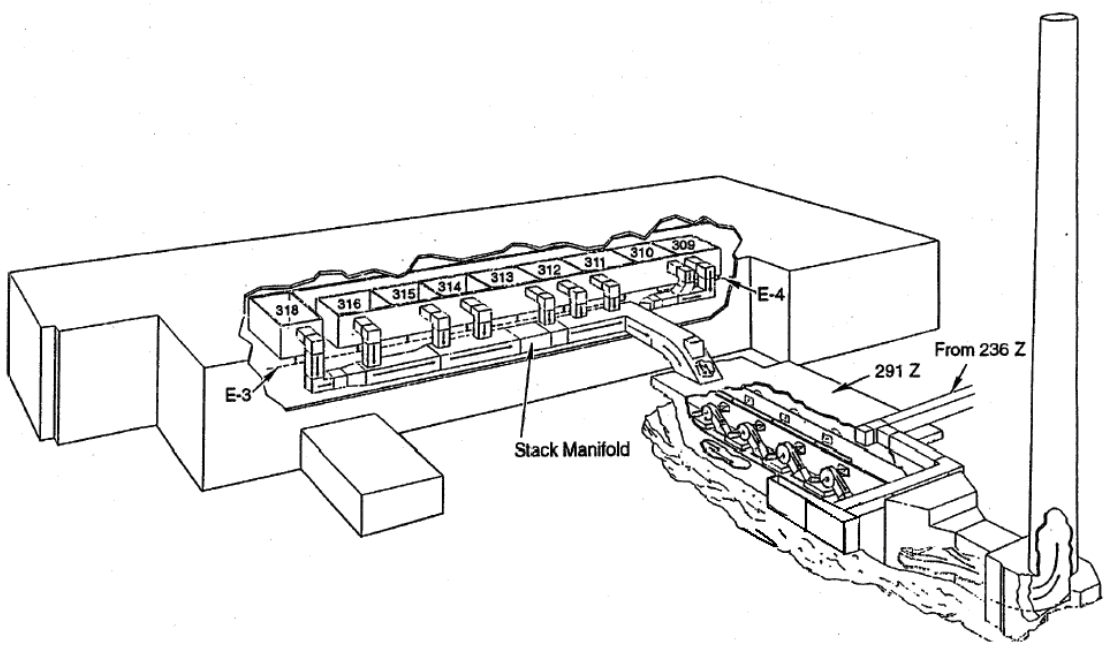


Figure A.5-1. Cutaway View of 234-5Z and 291Z Ventilation Exhaust System, including 291Z-1 stack (adapted from Mahoney et al. 1994)

A.5.1 Demolition Schedule

The demolition schedule was provided by CHPRC staff. The demolition of the fanhouse is assumed to require 18 days. Details of the demolition are provided in Table A.5-3.

Table A.5-3. Demolition Schedule for 291Z

	Demo/day	Loadout/swing
Remove roof of Rms 500, 501	3	3
Room 501 Vacuum pump inlet: 73'	1	
Room 501 Vacuum pump exhaust: 37'		1
Remove roof of Rms 502, 503, upper plenum	2	2
6" East Vacuum Line 89'	1	1
4" East Process Vacuum Line to Room 501: 74'	1	
4" Process Vacuum Line 36.5'		1
6" West Vacuum Line 100'	1	
4" West process vacuum line east fan gallery to 501: 79'		1
6" process vacuum Line 11.5'	1	
6" Sample vacuum line by filters : 12'		1
Demolish mid-section of plenum to access bottom	2	2
6" top process vacuum line in plenum : 53'	1	1
4" east process vacuum line in plenum: 53'		1
4" west process vacuum line in plenum: 53'	1	
6" bottom process vacuum line in plenum : 53'	1	1
Demolish remaining above-ground portions	3	3

The 291Z-1 stack is a 200-foot-tall, slip-formed reinforced-concrete structure. Most similar large stacks at Hanford have been removed by explosive demolition, toppling the more-or-less intact stack to the ground and then disposing of the pieces at ground level. It is assumed that this will also happen to the 291Z-1 stack. The assumed schedule is provided in Table A.5-4.

Table A.5-4. Demolition Schedule for 291Z-1

Day	Building Location
1	Topple stack
2-15	Size-reduce concrete
2-15	Load rubble into ERDF boxes

A.5.2 Demolition Approach

For the 291Z fanhouse, demolition is assumed to be conducted with a hydraulic shear or mechanical hammer mounted on a tracked vehicle. The roofs of the eastern rooms 500 and 501 are assumed to be removed first. The Room 501 vacuum pump inlet and exhaust are assumed to be carefully removed (surgical extraction). The roofs of Rooms 502 and 503 and the contiguous upper inlet plenum are assumed removed next. A set of seven vacuum lines are carefully removed (surgical extraction). The mid-section of the plenum between the inlet and outlet is then sheared and removed, providing access to an additional 4 vacuum lines which are carefully removed. Any remaining above-ground portions of the side walls are then removed.

It is assumed that, after some preparatory weakening of the stack base, a small explosive charge is used to weaken the stack so that it falls into a prepared shallow trench in the neighboring soil. A charge of 5 kg of high explosives is assumed. It is assumed that demolition occurs on a day of "favorable" (stable) weather.

When the stack has been brought to ground level, a multiprocessor with jackhammer or shear end effector is assumed to break the reinforced concrete into approximately 1-foot by 1-foot pieces. These pieces and associated rubble are loaded into ERDF boxes located nearby with front-end loaders.

Table A.5-5 summarizes the general demolition approach and provides the final emission factors.

Table A.5-5. General Modeling Approach for 291Z Fan House and Stack Demolition Operations

291Z Section	Operation	Demolition Summary	AERMOD Modeling approach	EF
Walls and Ceilings	Shearing	Break walls into 1x1 ft pieces with multiprocessor	Emission factor (EF) based on 90% of contaminated surface broken up/exposed, 10% fixative.	EF = $9.0x10^{-5}$ rem; $1.0x10^{-6}$ fix.
		Rubble Drop after shearing	Particle sizes divided into 6 size bins, each assigned size appropriate RFs and LPFs to derive a composite	EF = $8.42x10^{-7}$ rem & fix
	Loadout	Scoop and drop into box	Moist rubble treated with EPA method.	EF = $2.3x10^{-7}$ rem & fix
Pipe/ Vacuum Line	Surgical Removal	Remove building from around closed, FireStop-200 or grouted/epoxied boxes, ducts, and pipes	Minor emissions due to careful removal techniques and they are protected.	EF = $1.00x10^{-9}$ fix
All Areas during: Off-shift	Resus-pension	Surfaces covered with fixative/soil cement	Set to zero because of fixatives and lack of activity.	EF = 0.00 rem
Rubble Handling	Loadout	Actions equivalent to scooping and loading	Moist rubble treated with EPA method.	EF = $2.3x10^{-7}$ rem & fix
	Sort/Size/ Repackage	Actions equivalent to scooping and loading	Moist rubble treated with EPA method.	EF = $2.3x10^{-7}$ rem & fix
Stack	Knock Over	Blow Base and then it collapses into a trench while the base cracks	During the blast, model a point puff release. The Base cracks and the rest falls into a trench. Releases from the collapsed stack modeled as a puff release from a 200 ft long line source.	$8.16x10^{-6}$ (explosives, rem & fix) $1.0x10^{-5}$ (hit ground; rem & fix)

Table A.5-5. General Modeling Approach for 291Z Fan House and Stack Demolition Operations

291Z Section	Operation	Demolition Summary	AERMOD Modeling approach	EF
	Shearing	Break remaining collapsed stack into 1x1 ft pieces with a multiprocessor.	Emission factor based on 50% of contaminated surface broken up/exposed, 50% fixative.	$9.0x10^{-6}$
	Resus-pension	Surfaces covered with fixative/soil cement	Set to zero because of fixatives and lack of activity.	EF = 0.00
	Loading		Moist rubble treated with EPA method	$2.3x10^{-7}$

The source term factors described in Section A.1 apply to the demolition activities of 291Z except for unique aspects associated with the stack which are described below.

A.5.3 Unique Source Term Factors for 291Z Stack Demolition

The small portion of the stack at ground level that is cut with explosives will be extensively pulverized. However, only the inner surface is contaminated, so the release of radioactive material will be minimal. It is assumed that the amount of dust generated is 1-for-1 with the mass of high explosive (HE) used (DOE 1994), so about 5 kg of dust will be generated. If the area impacted by the explosion is one-half of the stack circumference to a height of 1 foot, the impacted mass is about 150 lb/ft^3 * 29 feet * 1 foot thick * 1 foot high. The ratio of the dust to the total mass is about 0.0014.

Mechanical shears or mechanical hammer are assumed to be used to demolish the 291Z-1 stack after it has been toppled. The radioactive material at risk (MAR) is assumed to be evenly distributed over the entire inner surface of the stack. The damage ratio (DR) is that portion or percentage of the contaminated area acted on by the shear force, or the portion or percentage of the contamination acted on by shear forces. Shears or mechanical hammer are assumed to fracture, crush, spall, or otherwise impact the surface being sheared. The damage ratio (DR) is that portion or percentage of the contaminated area acted on by the shear force, or the portion or percentage of the contamination acted on by shear forces. Shears or mechanical hammer are assumed to fracture, crush, spall, or otherwise impact the surface being sheared. The fraction of surface rubblized during shear operations is taken to be 0.5 based on past operations on other stacks.

The effectiveness of the fixative on the rubblized material (approximately 50% of the sheared material) will conservatively be considered totally lost, i.e., all of the contamination on these pieces will be considered removable. The fixative covering the larger pieces (approximately 50% of the sheared material, essentially all of the cut material) will be considered largely intact and remain effective. All of the material cut by shears or mechanical hammer will be piled on the ground until placed in the ERDF boxes. Approximately 50% of the sheared material will be subject to resuspension as rubble, while 50% will be subject to resuspension as larger pieces.

DOE's factors for impaction stress due to vibration shock were reviewed as the most representative ARFs for the explosive demolition (DOE 1994); the factor of $1x10^{-3}$ is very similar to that derived above of $1.4x10^{-3}$ on the basis of dust generation.

For the initial explosive puff, no credit is given for water sprays; for this step the LPF is 1.0. The application of a water mist to contaminated surfaces during demolition serves to reduce the percentage of airborne particulates in the respirable size range. The LPF for shearing is assumed to be 0.1, as discussed for similar activities in Section A.1.

A.5.4 Summary 291Z Fan House and Stack Demolition Source Term Factors

Table A.5-6 summarizes the DR, LPF, ARF and RF values assumed for demolition of 236Z.

Table A.5-6 291Z and Stack Demolition Source Term Factors

Demolition Activity	Impacted Structures	Type	DR (unitless)	ARF (unitless)	LPF (unitless)	RF (unitless)	EF (unitless)
Explosives	Stack	Rem & Fix	$5.8x10^{-3}$	$1.4x10^{-3}$	1.00	1.00	$8.16x10^{-6}$
Hitting Trench	Stack	Rem & Fix	1.00	$1x10^{-4}$	0.10	1.00	$1.0x10^{-5}$
Shearing	Stack	Rem & Fix	0.90	$1x10^{-4}$	0.10	1.00	$9.0x10^{-6}$
	Walls and Ceilings	Rem	0.90	$1x10^{-3}$	0.1	1.00	$9.0x10^{-5}$
		Fix	0.10	$1x10^{-4}$	0.1	1.00	$1.0x10^{-6}$
Dropping of Rubble	Rubble	Rem & Fix	1.00	$2.3x10^{-6}$	See Table A.4-2	1.00	$8.42x10^{-7}$
Surgical Removal	Box/Pipe Vacuum Line	Contents	0.01	$1x10^{-6}$	0.10	1.00	$1.0x10^{-9}$
Loadout	Rubble	Rem & Fix	1.00	$2.3x10^{-6}$	0.10	1.00	$2.3x10^{-7}$
Sorting/Sizing /Re-loading	Rubble	Rem & Fix	1.00	$2.3x10^{-6}$	0.10	1.00	$2.3x10^{-7}$
Resuspension – Between Shifts	Rubble	Rem	0.01	0	0.10	1.00	0

A.6 References

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Appendix B

Atmospheric Model Selection

Appendix B – Atmospheric Model Selection

Releases of contaminants to the air during the demolition activities described in Appendix A potentially can have impacts in terms of the resulting increases in air and soil concentrations. An atmospheric dispersion modeling analysis has been conducted to generate estimates of these concentrations.

The air dispersion model AERMOD was selected for doing simulations of the potential air and soil exposures from the proposed demolition of the structures at the Plutonium Facility Plant (PFP). The AERMOD modeling system is the preferred/recommended air dispersion model to be used in almost all circumstances, including for State Implementation Plans (SIP) revisions for existing sources and for New Source Review (NSR) and Prevention of Significant Deterioration (PSD) programs. In addition to being a recommended model, AERMOD also has modeling capabilities needed to address the dispersion from the proposed demolition of the PFP structures. AERMOD includes formulations for addressing air dispersion in the immediate vicinity of air emission sources. The model has dry deposition algorithms that account for the particle-size distribution and density as well as local surface and meteorological conditions. Important in the selection of AERMOD for this application is its ability to address building wake effects; the current version of AERMOD incorporates the building wake formulations developed by EPRI.

A potential limitation of AERMOD for Hanford applications is the model's use of straight-line trajectories for the modeled airborne plumes. This model feature means that the model cannot account for downwind changes in wind direction. The Hanford Site does have complex wind patterns and AERMOD may not be an appropriate model for modeling potential concentrations at far-field distances (i.e., beyond the Hanford Site boundary). However, AERMOD is quite appropriate for near-field plume simulations being conducted in this effort.

Appendix C

Air Dispersion Modeling Assumptions

Appendix C - Air Dispersion Modeling Assumptions

AERMOD information and documentation is available on the U.S. Environmental Protection Agency's (EPA's) website for regulatory air models (EPA 2008). The most recently released version of AERMOD was used. AERMOD is considered a commercial model. For Hanford Site applications, such a model must be tested to ensure it is operating correctly in its current implementation (Project Hanford Management System 2002). A series of test cases distributed with AERMOD obtained from the EPA website (EPA 2008) was run and compared with the official versions. The AERMOD runs were conducted using a single computer (PNNL property number WE28738) with the Windows 7 operating system with recent updates installed. Test case results showed the code to be working correctly before and after the production runs.

After the potential source terms are defined, the second step in the PFP complex emissions analysis is to compute the airborne and deposited concentrations using the AERMOD air dispersion model. This appendix documents the air dispersion modeling approach, assumptions, and input data.

C.1 Air Dispersion Modeling Approach

The various phases of the demolition of the PFP facilities will generate fugitive dust emissions that are expected to have low levels of particulate transuranic content. The AERMOD air dispersion model is used to assess air quality resulting from complex onsite fugitive dust emissions accounting for the combination of ambient transport and dispersion dust and building wake effects.

The air dispersion modeling approach is designed to provide output products that are useful in the PFP demolition planning process in terms of providing an understanding of the air and soil impact levels projected for a given demolition option. An approach is needed that can address the potentially very large number of permutations and combinations of ambient weather conditions and the multi-faceted demolition options for each of the components of the PFP facilities.

The approach is to consider each major demolition component of the PFP facilities separately (see Table 2.5-1). These computations are used to build a cumulative picture of potential environmental contamination from the full demolition of the PFP facilities. The air exposure analysis is independent of the demolition start date. Because the deposition analysis is based on the summation of the impacts of a series of events, the deposition analysis requires an assumption of a postulated start date and definition of a period of time elapsed during the year for the demolition of each component.

In addition to emission rates from the source term analysis being highly dependent on the demolition options that are selected, the location and size of those emissions are also defined for each of the selected demolition options.

As the result of their different measures of exposure levels, different approaches are used for the air concentration exposures and soil deposition totals. The concern for air exposures is based on the potential levels of air concentration during the demolition of each component. The concern for soil exposures is based on the total deposition not exceeding a specified surface concentration.

C.2 Airborne Exposures

Airborne exposures (time-integrated air concentrations) are evaluated in terms of weekly total exposures. A total weekly exposure limit is defined as 12 DAC-hours/week. For the evaluation of potential air exposures, the duration of the demolition activities is important only in terms of what activities are expected to occur in a one-week time frame. Thus, assuming that the demolition of each component of the PFP complex does not overlap within the same week, the potential air exposures can be independently evaluated for each component.

The analysis determines the weekly air exposures downwind of the demolition activities accounting for the week-to-week variations in potential release rates and ambient meteorological conditions. The demolition activities involving the largest estimated release rates are evaluated first. These results define the largest potential air exposures. Calculations are performed to develop a distribution of potential concentrations; these are sorted to obtain the value that is not exceeded more than 5% of the time (the 95^{th} percentile). The results for the air dispersion modeling are presented as maps of maximum potential weekly air exposures (at the 95^{th} percentile level) computed over some meteorological time span (annual, seasonal, etc.). The results for the air modeling are presented in terms of 95^{th} percentile potential weekly air exposures at selected environmental locations.

C.3 Deposition Exposures

Deposition exposures (cumulative depositions) are evaluated in terms of total accumulations on ground level surfaces downwind of the demolition activities. A total alpha deposition concentration limit of 20 dpm/100 cm^2 is used. For the evaluation of potential deposition exposures, the duration of the demolition activities is important. That is, the deposition patterns from the sequential demolition of each of the various components of the PFP facilities must be cumulatively added to evaluate the potential total deposition exposure.

The analysis of each component structure determines the total potential deposition exposures resulting from the demolition of that component alone. The demolition activities involving each of the components are evaluated. To allow logical sequencing of the deposition results, the demolition of each component is assumed to occur over some specific period of elapsed time that represents the “window” during a year that demolition is assumed to occur. The order of deposition analyses follows the air exposures analyses. Assuming the deposition results for each component are less than the air exposure limit, then the potential total deposition exposures from all components are computed.

For each facility or facility component, the soil deposition results are presented as maps of potential total deposition amounts from all of the demolition activities.

The patterns of total deposition for a demolition activity are computed for the demolition period using the average emission rate for that demolition activity. These deposition patterns are evaluated for some appropriate period of meteorological data. The results for the air dispersion modeling are presented as maps of total maximum potential deposition exposures computed for activities during the component’s period of elapsed time.

C.4 AERMOD Modeling Assumptions and Input Data

The modeling of potential exposures accounting for building wake effects with AERMOD requires the use of point source releases. Area sources such as walls and ceilings are approximated by a grid of point sources. The use of points to approximate an area is useful in that it does allow, if needed, the analysis to account for concentration variations over those areas.

Source Characteristics: The main sources for air emissions will be the building structure demolition and waste loading activities. These sources were modeled as a matrix of point sources. The AERMOD runs were configured to directly produce maximum hourly concentration and deposition values for the days associated with the demolition activities.

Meteorological Data: The air dispersion analysis used multiple years of local meteorological data to define the local dispersion climatology. Six recent years of meteorological data records (calendar years 2004 to 2009) were obtained from the Hanford Meteorological Station (HMS) database for the analysis.[1] This period was selected for comparability with earlier versions of this report. Surface meteorological input data to AERMOD consisted of a merged dataset containing surface data incorporating wind speed and direction data from the Hanford telemetry station number 19 located in the 200W area combined with meteorological surface observations from the central HMS station. Vertical structure input data to AERMOD consisted of radiosonde data from the meteorological station at the Spokane airport.[2]

Figure C.4-1 shows a wind rose plot[3] based on all conditions for this six years of record. Reflecting the modeling assumption that all demolition activities occur either during the day shift (6am to 4pm) or during swing shift (4pm to 2am), Figures C.4-2 and C.4-3 show a summary of the wind conditions for those two time periods, respectively. Figures C.4-4 and C.4-5 show how the wind conditions vary as function of the time of year for the morning and afternoon shifts.

The year 2009 is used to demonstrate inter-annual variability. Figures C.4-5 to C.4-10 correspond to the 1-year average values shown in Figures C.4-1 to C.4-5. Comparison of these figures shows the major features are essentially the same between the six- and one-year plots.

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[1] Ken Burk, Hanford Meteorological Station, Email dated 12/13/2007 defining link for Hanford meteorological data.
[2] Forecast Systems Laboratory (FSL)/National Climatic Data Center (NCDC) Radiosonde Database Access, http://raob.fsl.noaa.gov/ for radiosonde data for Spokane, Washington.
[3] Meteorological convention is used, which defines winds by direction from which they come.

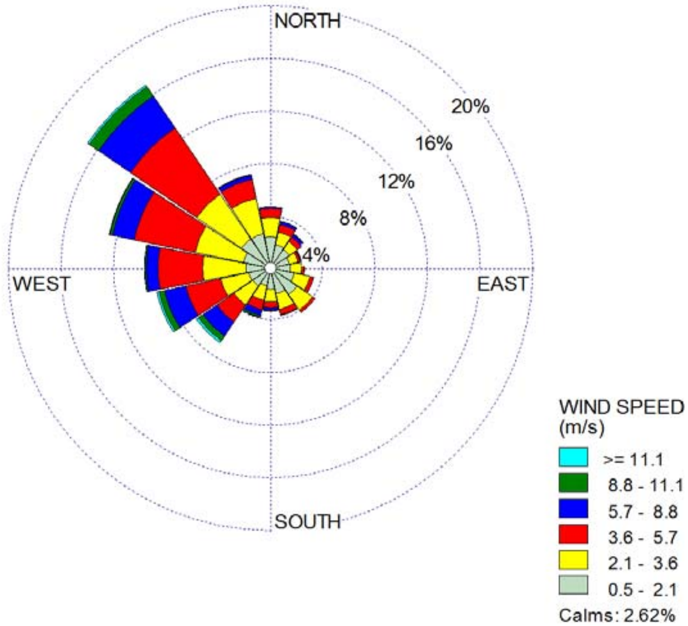


Figure C.4-1. Average Six Year (2004–2009) Wind Rose – All Conditions

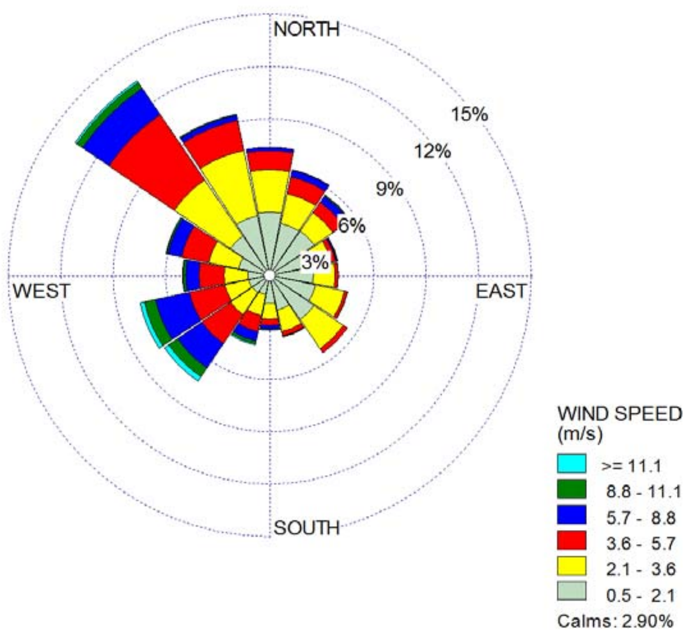


Figure C.4-2. Average Six Year (2004–2009) Wind Rose – Day Shift Conditions

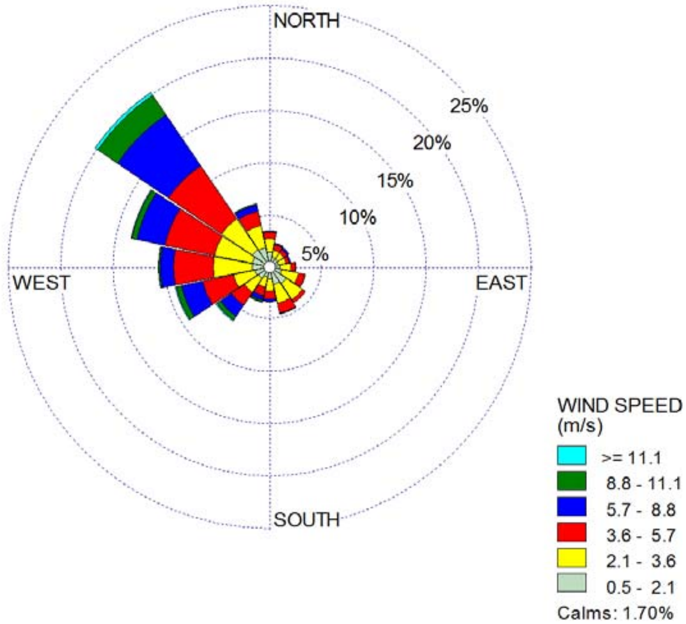
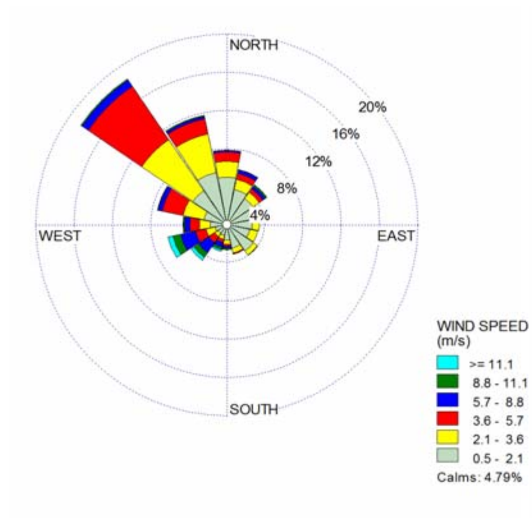
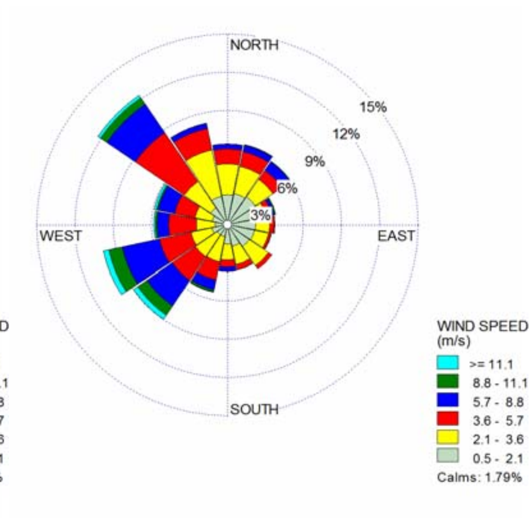


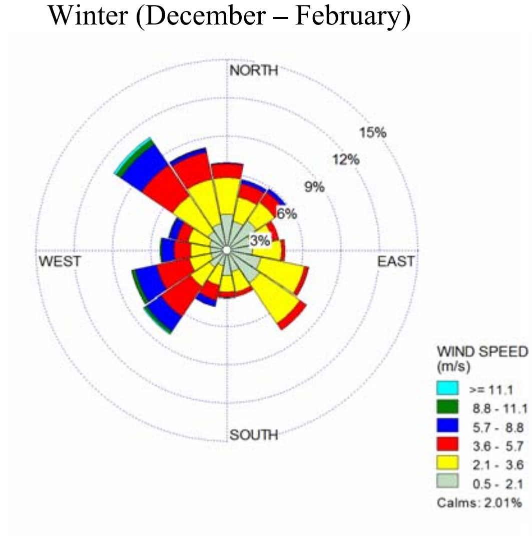
Figure C.4-3. Average Six Year (2004–2009) Wind Rose – Swing Shift Conditions



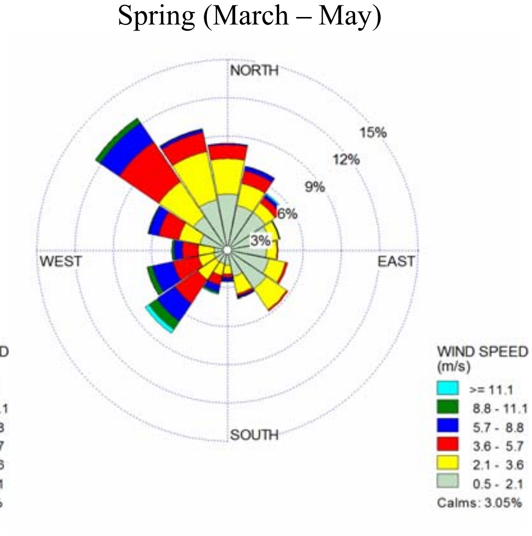
Winter (December – February)



Spring (March – May)

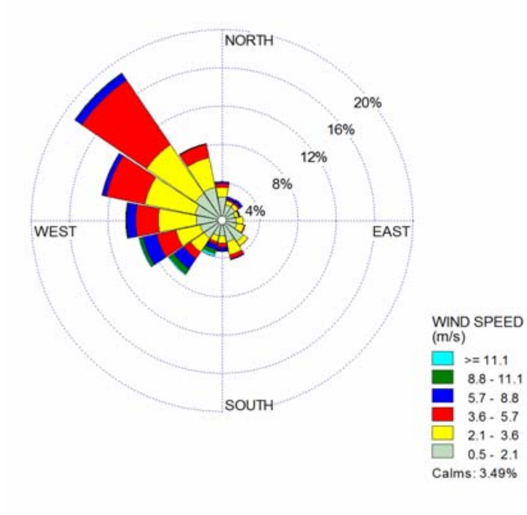


Summer (June – August)

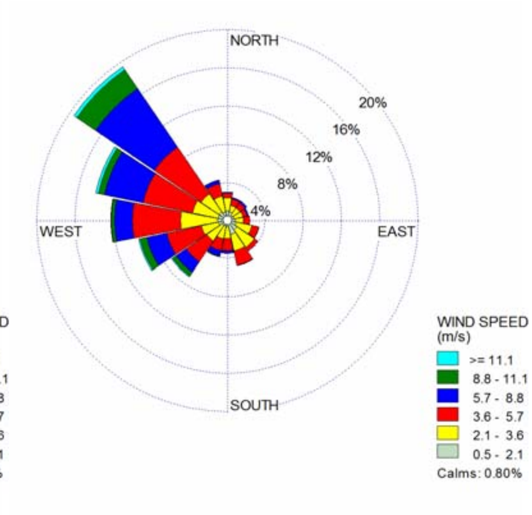


Fall (September – November)

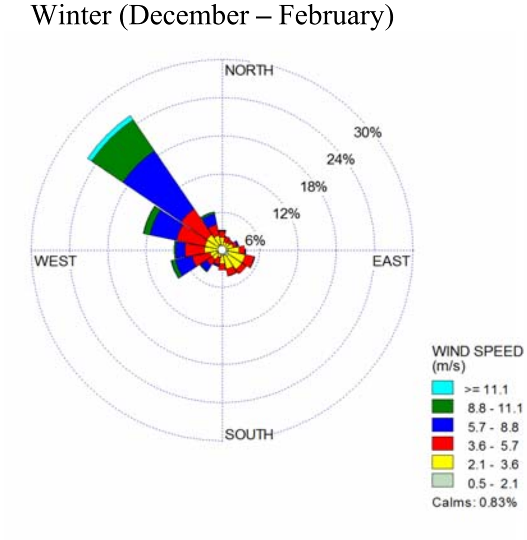
Figure C.4-4. Seasonal Average Six Year (2004–2009) Wind Rose – Day Shift Conditions



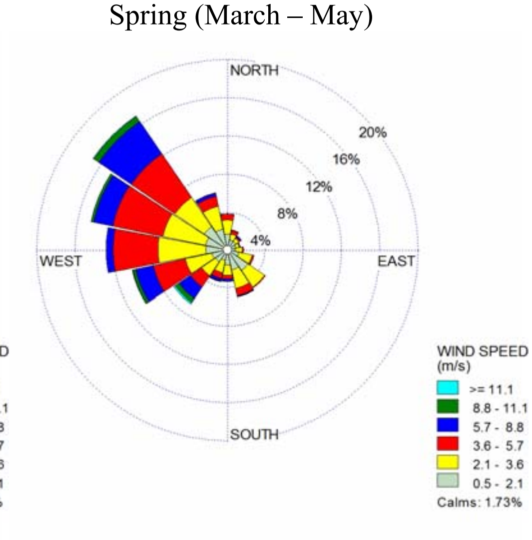
Winter (December – February)



Spring (March – May)



Summer (June – August)



Fall (September – November)

Figure C.4-5. Seasonal Average Six Year (2004–2009) Wind Rose – Swing Shift Conditions

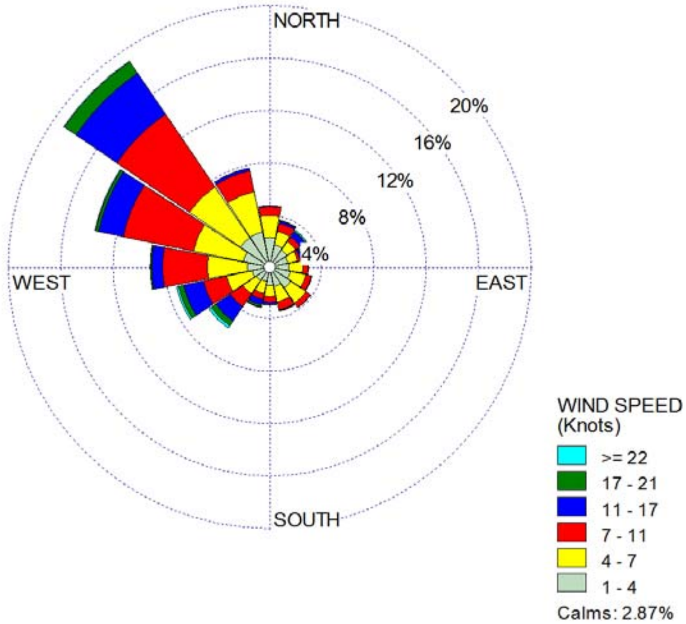


Figure C.4-6. Annual (2009) Wind Rose – All Conditions

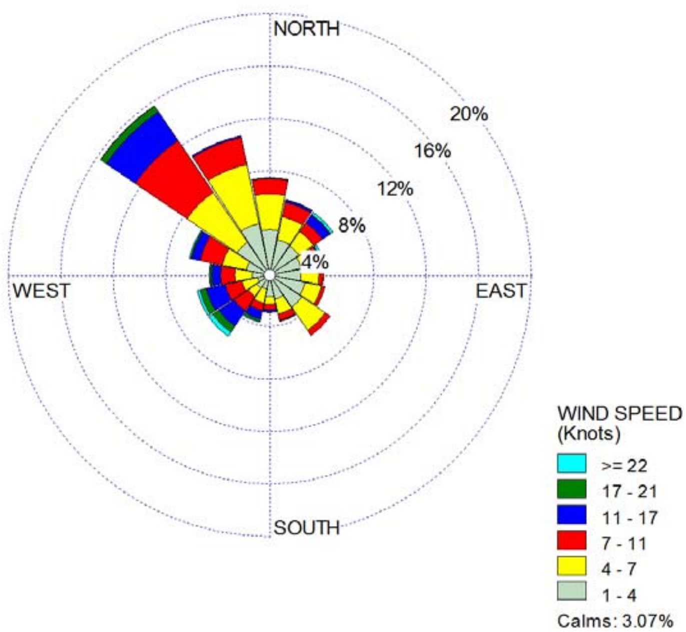


Figure C.4-7. Annual (2009) Wind Rose – Day Shift Conditions

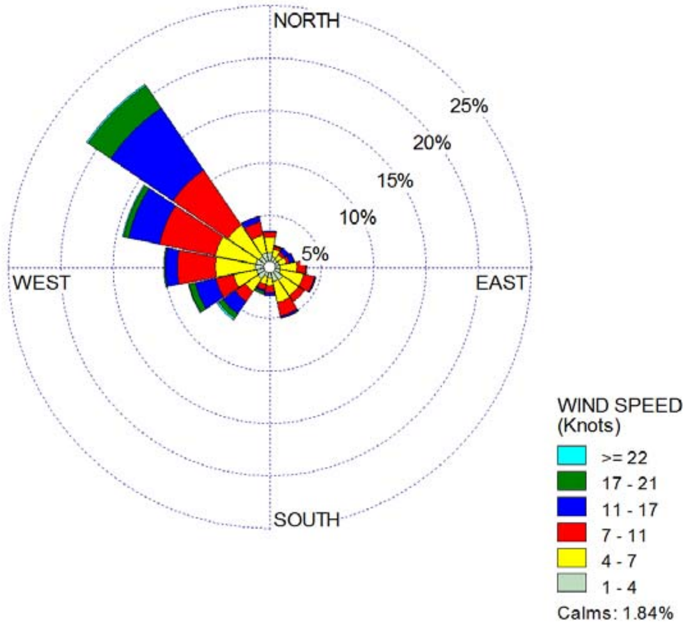
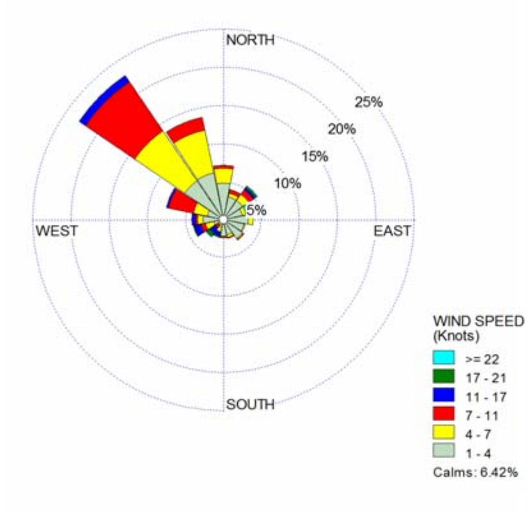
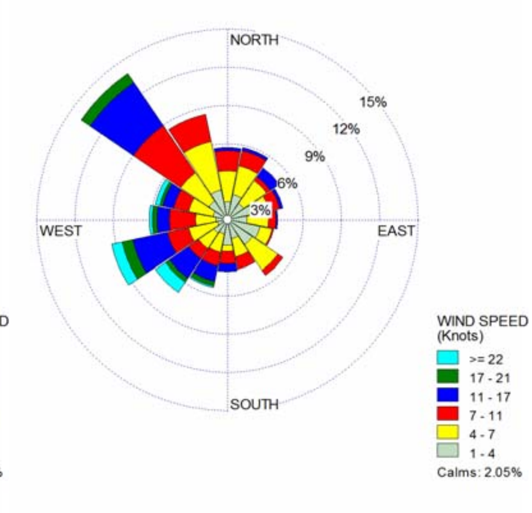


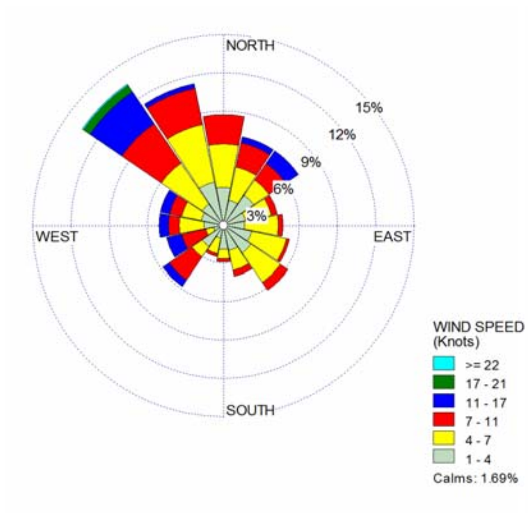
Figure C.4-8. Annual (2009) Wind Rose – Swing Shift Conditions



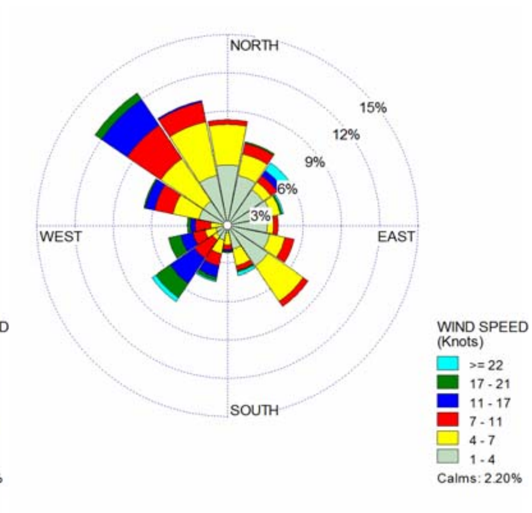
Winter (December – February)



Spring (March – May)

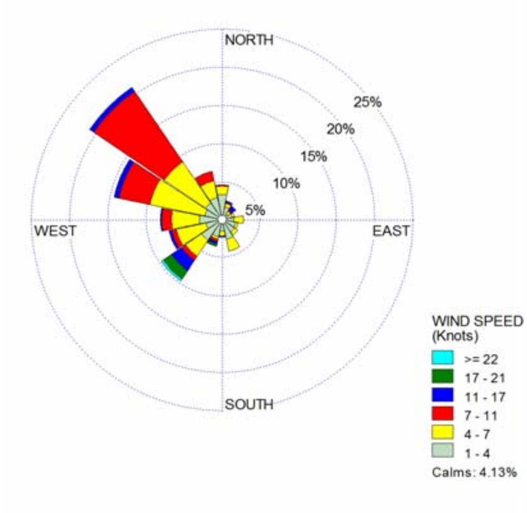


Summer (June – August)

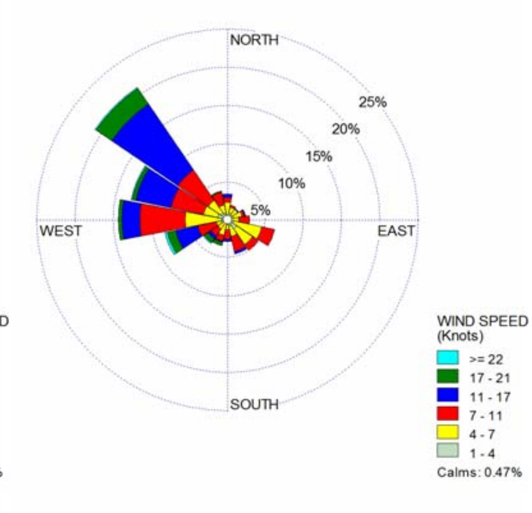


Fall (September – November)

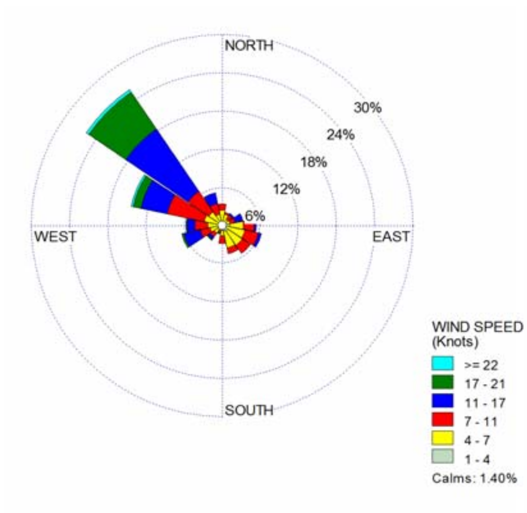
Figure C.4-9. Seasonal Annual (2009) Wind Rose – Day Shift Conditions



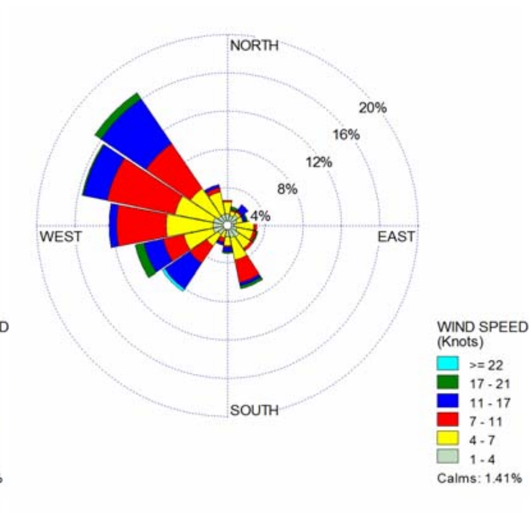
Winter (December – February)



Spring (March – May)



Summer (June – August)



Fall (September – November)

Figure C.4-10. Seasonal Annual (2009) Wind Rose – Swing Shift Conditions

Modeling Approach: The demolition activities are to occur during the day and swing shifts. The worst-case scenario resulting in the highest air concentrations is for the majority of the release to occur over a short time period. To evaluate the potential exposure levels from the planned demolition activities, the local patterns of potential peak air concentrations and soil deposition were computed as though the estimated release from each of the buildings occurred during one hour. By looking at the potential peaks for all the hours during the planned work periods, the worst case values are defined. The two proposed 3-month time periods for the demolition activities are included in this annual bounding computation.

Receptor Grids: Computations were made for a rectangular receptor grid appropriate for defining the spatial patterns of the locations of the maximum air concentrations and deposition amounts.

C.5 References

EPA – U.S. Environmental Protection Agency. 2008. Technology Transfer Network Support Center for Regulatory Air Models, http://www.epa.gov/scram001/(Access last checked 12/22/2015).

Project Hanford Management System. 2002. *Computer Software Management*. HNF-PRO-309. October 24, 2002. Fluor Hanford, Inc. Richland, Washington.

Appendix D

Quality Control Procedures

Appendix D – Quality Control Procedures

D.1 Overview

QA requirements specified by PNNL were followed. A QA review of computations and results was conducted. Special aspects of QA requirements for this project are:

1. All modeling computations will be performed with commercial software: either by EXCEL or by AERMOD codes.
2. The equations for all computations in EXCEL will be documented in the project report.
3. The AERMOD model will be tested with the AERMOD distribution test cases to assure the AERMOD model is operating as expected. Documentation of run time options will be documented in the project report.
4. The versions of EXCEL and AERMOD, the computer platforms, and the computer operating system versions will be documented in the final report.
    a. Rishel: Excel 2010 Version 14.0.7173.5000, Lakes AERMOD View Version 8.8.9, operating on computer WE28738 running under Windows 7 Enterprise Service Pack 1.
    b. Napier: Excel 2013 Version 15.0.4859.1000, operating on computer WE31256 under Windows 7 Enterprise Service Pack 1.
5. Electronic copies of all EXCEL spreadsheets and AERMOD run files used in the project results will be stored in the project file.

Descriptions of the details of this approach relative to conducting simulations with AERMOD are given below.

D.2 AERMOD Simulations Validation and Verification Approach

The following guidance documents the approach used by PNNL for validating and verifying model runs made in the EPA's AERMOD dispersion model. In short, the guidance ensures that the appropriate model version is being used, the modeling system is functioning as expected, and the model inputs are reasonable and correct for the scenario. A checklist has been developed to aid the modeler in validating and verifying model inputs; the checklist can be completed and submitted along with the model report to document validation and verification procedures used in performing the AERMOD model run.

1. Determine which model is appropriate for the current modeling application:
    a. The AERMOD modeling system is the preferred/recommended dispersion model to be used in almost all circumstances, including for State Implementation Plans (SIP) revisions for existing sources and for New Source Review (NSR) and Prevention of Significant Deterioration (PSD) programs.
    b. Alternative models (e.g., ISC) can be used in regulatory applications, but require case-by-case justification from the reviewing authority.
2. Verify the latest regulatory version of the modeling system is being used:

a. The EPA releases new versions of the AERMOD modeling system to correct known issues or to implement new features in the model. Verify the correct regulatory version of AERMOD modeling system is being used by contacting the software distributor (e.g., www.breeze-software.com, www.lakes-envirionmental.com) or by reviewing the model change bulletins available on the EPA's website: http://www.epa.gov/scram001/dispersion_prefrec.htm.

b. If necessary, download and install the regulatory version of the AERMOD modeling system from the vendor or the EPA.

3. Validate the modeling system is working properly:

   a. The AERMOD modeling system should be validated to ensure it is working properly prior to using it for the intended application. Test cases are installed by the model vendor (e.g., www.breeze-software.com, www.lakes-envirionmental.com) and should be run to make sure the model output agrees with the original output. File comparison software, such as "Beyond Compare" available from PNNL's Managed Software, make comparison of the model output files a simple process.

      i. If the file output differs, further investigation will be required to determine the source (e.g., model version) of the difference and determine if the results are acceptable.

   b. The EPA provides model test cases on its website, http://www.epa.gov/scram001/dispersion_prefrec.htm, which can also be used to validate the modeling system is running properly.

4. Enter all model inputs applicable to the modeling scenario. If using vendor software (e.g., BREEZE, Lakes Environmental), model entry will be performed through a Windows interface (preferred). If using the EPA's DOS version, model entry will be performed via a formatted text input file. AERMOD input is echoed to the primary output file; these inputs should be verified and validated to ensure entered values are correct. Key issues to consider when creating model scenarios include:

   a. Terrain - if terrain is to be considered, source and receptor locations should be entered using the proper Universal Traverse Mercator (UTM) coordinates. The latest regulatory version of AERMAP should be used, along with the appropriate digital elevation model (DEM) files, to determine terrain heights for model objects.

   b. Building Downwash – point sources (e.g., stacks) on or near buildings may be subject to building downwash. Include all downwash structures in the modeling analysis, including structures not located on the facility's property if applicable. Downwash structures outside of 5L may be excluded from the analysis (note: "L" is defined as the lesser of the height or maximum projected width for a particular tier or structure). All non-downwash structures should be excluded from the modeling analysis. Non-downwash structures include lattice-type structures such as switchyards, water towers, and elevated storage tanks. Perform a building downwash analysis using the latest version of the Building Profile Input Program (BPIP-PRIME). Downwash calculations should not be performed until all point sources and buildings have been entered into AERMOD *and* terrain has been imported; this ensures that all model objects have the correct relative heights.

   c. Receptors – receptor spacing of sufficient coverage and density should be chosen to ensure sufficient density to determine worst-case predicted ground level concentrations in off-property areas not controlled by the applicant. Predicted concentrations should decrease near the edges of the receptor grid(s).

   d. Meteorology – meteorological data should be processed by a qualified meteorologist using the latest regulatory version of AERMET. Selection criteria for the choice of the meteorological station(s) and surface characteristics should be documented by the analyst processing the meteorological data in AERMET. In general, the latest years of meteorological data should be used in the dispersion modeling analysis. However, the modeler should seek approval from the regulator prior to using the meteorological dataset in a specific application.

5. Verify the echoed model inputs in the AERMOD output file: After completing a model run, the model inputs—which are echoed to the primary AERMOD model output file—should be reviewed to verify values have been entered correctly. Model output should be reviewed to determine if output concentration and/or deposition values are reasonable.
6. Verify the AERMOD modeling system continues to perform as expected: To ensure the AERMOD modeling system performed as intended, the modeler can re-run the model test cases and verify test-case model outputs continue to agree (see Step 3a, above).

A checklist is used to verify and validate AERMOD model runs being used to support compliance-related work. The checklist can be completed by the modeler and affixed to the model report as supporting documentation on model verification and validation. Use of this checklist will ensure a consistent modeling approach has been followed. In addition, the checklist will help to identify and avoid common modeling errors such as:

- Emission rates or stack parameters that are unacceptable and require revision.
- Modeled emission rates or parameters that do not match the permit application.
- Buildings/property boundary/emission unit locations that do not match the plot plan.
- Inconsistent base elevations for buildings and stacks.
- Incorrect source inputs and dimensions.
- Sources with horizontal or obstructed exhaust modeled with an incorrect exit velocity.
- Terrain elevations missing or incorrect.
- Receptor grid extent is insufficient.
- Meteorological data are not appropriate.
- Use of the incorrect model or model version.

Appendix E

Input Data for PFP Building Simulations

(Included on CD only)

Appendix F

AERMOD Output File Listing

(Included on CD only)

Appendix G

CAP88-PC Dose Calculations for PFP Demolition Activities

Appendix G

CAP88PC Dose Calculations for PFP Demolition Activities

CAP88-PC Version 4.0.1.17 (Rosnick 2014) was used to determine the offsite and onsite Maximally-Exposed Individual (MEI) doses, as well as a B Reactor receptor dose. Evaluation of annual release estimates from the demolition activities at PFP included 2.58E+08 Bq (6.98E-03 Ci) Pu-239 total release from PFP, and a 2.53E+08 Bq (6.85E-03 Ci) Pu-239 release from 236Z Cell. In all cases evaluated, dose estimates from the total PFP release were equal to or greater than receptor impacts from the 236Z Cell release.

Emissions included Pu-238, -239, -240, -241, and -242, as well as Am-241 but the activity was conservatively assumed to be entirely Pu-239. The demolition was assumed to release material at a low effective release height (10 m). The CAP88-PC model assumes a uniform release rate (Ci/sec) over the entire year.

The methods used to calculate the dose are consistent with that of DOE/RL-2006-29 (Snyder and Rokkan 2016). Three receptors were evaluated: one Offsite receptor and two Onsite receptors. Offsite receptor dose includes inhalation, external exposure, and ingestion dose where food is grown and harvested at the receptor site. Onsite receptor dose includes inhalation and external exposure dose at the receptor site plus average regional (within 50 mi of 200 Areas) food dose. Fulltime occupancy (8760 hr/yr) at each receptor location is assumed within CAP88-PC. Consistent with DOE/RL-2006-29 assumptions, a 50-year build-up time was implemented. This essentially assumes the same annual release occurs every year for 49-years and then during the 50^{th} year the dose to the receptor is calculated. While such a release scenario and long term regional soil-deposition of emissions would not be applicable to the PFP demolition activities, the dose result will be conservative (over-estimating).

The Offsite MEI was located at the 200-West offsite receptor location of DOE/RL-2006-29 (Snyder and Rokkan 2016), in the region of the Yakima River Horn (▲ Figure G-1). The onsite receptors were located at the 200-West onsite receptor location (same reference) at LIGO (① in Figure G-1) and at the B Reactor (② in Figure G-1). The distances to the receptors were determined using Google earth© 2015 (image date May 2015) relative to PFP. Ten-year meteorology (2004-2013) from 200-West meteorological Station 7 was used in CAP88-PC. The population distribution data used for average regional food ingestion was based on 2010 census data (Hamilton and Snyder 2011).

RESULTS

CAP88-PC dose results are listed in Table G-1. The Onsite receptor at LIGO would potentially incur the greatest dose from the radioactive emissions. The doses to all receptors evaluated are well below the EPA air pathway dose standard of 10 mrem (10 CFR 61, Subpart H, 2009 and WAC 246-247).

Figure G-1. Hanford Site Offsite and Onsite Receptors Evaluated.

Table G-1. CAP88-PC V4 Dose Results

Receptor	Pu-239Annual Release from PFP	Location relative to PFP	Dose (mrem TED)
Offsite MEI	2.58E+08 Bq (6.98E-03 Ci)	24,000 m SE	0.013
Onsite MEI at LIGO	2.58E+08 Bq (6.98E-03 Ci)	20,230 m ESE	0.020
Onsite Receptor at B Reactor	2.58E+08 Bq (6.98E-03 Ci)	8,910 m N	0.012

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