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Assessment of Aircraft Crash Frequency for the Hanford Site 200 Area Tank Farms

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3/22/03

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RPP-11736
Revision 0

Assessment of Aircraft Crash Frequency for the Hanford Site 200 Area Tank Farms

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

CH2MHILL
Hanford Group, Inc.

Richland, Washington

Contractor for the U.S. Department of Energy
Office of River Protection under Contract DE-AC27-99RL14047

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LIST OF TERMS

BPA	Bonneville Power Administration
DBA	design basis accident
DOE	U.S. Department of Energy
DST	double-shell tank
nmi	nautical mile
smi	statute mile
SST	single-shell tank

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1.0 INTRODUCTION

This study estimates the frequency of an aircraft crash into the 200 Area tank farms. DOE-STD-3014-96, *Accident Analysis For Aircraft Crash Into Hazardous Facilities*, provides a multi-step approach for assessing the significance of an aircraft crash risk to facility safety. It also provides guidelines for determining whether the analysis is sufficient following any of these steps.

The first step of the approach is to determine whether the facility contains materials that are hazardous to the health and safety of the public. The second step of the approach is to assess the potential for an aircraft crash at the facility. DOE-STD-3014-96 provides a methodology for conservatively estimating the annual frequency of an aircraft crash. Using this methodology, an annual frequency of aircraft crash less than 10^{-6}/yr requires no further analysis. A value more than this requires further analysis into the effects of a crash.

The U.S. Department of Energy (DOE) aircraft crash analysis approach combines annual crash frequency from near-airport activities and from non-airport activities. The near-airport activities are primarily takeoffs and landings, based on investigation of the proximity of airports to the facility and flight data from those airports. The non-airport activities are near and over-flight crash frequencies, using data from DOE-STD-3014-96 for the Hanford Site.

The 200 Area tank farms include a series of underground waste storage tanks and other associated structures as well as selected aboveground facilities. Based on their inventories, much of the 200 Area tank farms are designated Hazard Category 2, according to the methodology of DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*. Therefore, they meet the applicability criterion that Section 1.3 of DOE-STD-3014-96 gives for facilities requiring assessment of the aircraft crash risk.

The 200 East Area analysis uses the Hazard Category 2 204-AR Waste Unloading Facility as the representative aboveground facility. Likewise, for the 200 West Area analysis, the facility is the inactive and isolated 242-T Evaporator, which contains a Hazard Category 2 heel in the aboveground evaporator tank. In addition, the analysis uses the tank farms as crash targets because of their overall classification as Hazard Category 2.

2.0 SUMMARY

Two factors, the near-airport crash frequency and the non-airport crash frequency, enter into the estimate of the annual aircraft crash frequency at a facility. The near-airport activities, i.e., takeoffs and landings from any of the airports in a 23-statute-mile (smi) (20-nautical-mile, [nmi]) radius of the facilities, do not significantly contribute to the annual aircraft crash frequency for the 200 Area tank farms. However, using the methods of DOE-STD-3014-96, the total frequency of an aircraft crash for the 200 Area tank farms, all from non-airport operations, is calculated to be 7.10E-6/yr. Thus, DOE-STD-3014-96 requires a consequence analysis for aircraft crash.

This total frequency consists of contributions from general aviation, helicopter activities, commercial air carriers and air taxis, and from large and small military aircraft. The major contribution to this total is from general aviation with a frequency of 6.77E-6/yr. All other types of aircraft have less than 1E-6/yr crash frequencies. The two individual aboveground facilities were in the realm of 1E-7/yr crash frequencies: 204-AR Waste Unloading Facility at 1.56E-7, and 242-T Evaporator at 8.62E-8.

DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*, states that external events, such as aircraft crashes, are referred to as design basis accidents (DBA) and analyzed as such: "if frequency of occurrence is estimated to exceed 10^{-6}/yr conservatively calculated . . ." DOE-STD-3014-96 considers its method for estimating aircraft crash frequency as being conservative. Therefore, DOE-STD-3009-94 requires DBA analysis of an aircraft crash into the 200 Area tank farms. DOE-STD-3009-94 also states that beyond-DBAs are not evaluated for external events. Thus, it requires only a DBA analysis of the effects of an aircraft crash into the 200 Area tank farms.

There are two attributes of an aircraft crash into a Hanford waste storage tank, which produce radiological and toxicological effects: the physical-crash, tank-dome-collapse activity, and the ensuing fire from the broken-up fuel tank(s) of the aircraft. Both of these attributes will produce an aerosol of the tank contents.

3.0 ANALYSIS OF AIRCRAFT CRASH FREQUENCY

3.1 METHODOLOGY

Aircraft crash frequencies are estimated using a "four-factor formula" that considers: (1) the number of operations, (2) the probability that an aircraft will crash, (3) given a crash, the probability that the aircraft crashes into a 1 mi^2 area where the facility is located, and (4) the size of the facility. DOE-STD-3014-96 uses the four-factor formula in two ways, each for the phase of flight:

- For near-airport activities, which consist of takeoffs (i=1) and landings (i=3), the four-factor formula uses a combination of site-specific information, local airport operations data, and specific tables provided in DOE-STD-3014-96, Appendix B.

- For non-airport activities (i=2), DOE-STD-3014-96, Appendix B, provides site-specific values for all aircraft types except helicopters (helicopter data is site-specific), as well as reasonable estimates applicable throughout the continental United States for the expected number of crashes per mi^2/yr in the site vicinity (i.e., the value of $NPf(x,y)$).

The four-factor formula is:

$$F = \Sigma_{i,j,k}\ N_{ijk} \cdot P_{ijk} \cdot f_{ijk}(x,y) \cdot A_{ij} \qquad (1)$$

where:

F	=	estimated annual aircraft crash frequency for the facility of interest (no./yr)
N_{ijk}	=	estimated annual number of site-specific aircraft operations (i.e., takeoffs, landings, and in-flights) for each applicable summation parameter (no./yr)
P_{ijk}	=	aircraft crash rate per takeoff or landing for the near-airport phase of operation, and per flight for the in-flight (non-airport) phase of operation for each applicable summation parameter
$f_{ijk}(x,y)$	=	aircraft crash location conditional probability (per mi^2) given a crash evaluated at the facility location for each applicable summation parameter
A_{ij}	=	site-specific effective area for the facility of interest that includes skid-in and fly-in effective areas (mi^2) for each applicable summation parameter, aircraft category or subcategory, and flight phase for military aviation (DOE-STD-3014-96, Appendix B)
i	=	index for flight phase: i=1, 2, or 3 (respectively, takeoff, in-flight, or landing)
j	=	index for aircraft category or subcategory: j=1, 2,..., 11
k	=	index for flight source: k=1, 2,..., K (there could be more than one runway, and non-airport operations)
Σ	=	$\Sigma_i\ \Sigma_j\ \Sigma_k$
i,j,k	=	site-specific summation over-flight phase, i; aircraft category or subcategory, j; and flight source, k.

The analysis implemented the four-factor formula by combining the value of $NPf(x,y)$ with the facility effective area to assess frequency. The effective area represents the ground surface area surrounding a facility, such that, if an unobstructed aircraft were to crash within the area, it would crash into the facility, either by direct fly-in or by skid-in to the facility. The effective area depends on the length, width, and height of the facility, as well as on the aircraft's wingspan, its flight path angle, its heading angle relative to the heading of the facility, and its length of skid.

The effective area consists of two parts: the fly-in area and the skid-in area. The first represents the area corresponding to a direct fly-in crash and consists of two parts, the footprint area and the shadow area. The footprint is the facility area that an aircraft would hit on its descent even if the facility height were zero. The shadow area is the facility area that an aircraft would hit on its descent, but which it would have missed if the facility height were zero (which is the case with the underground waste storage tanks). The skid-in area is the facility area an aircraft would traverse before coming to a stop. A helicopter has no skid-in process.

The study represents the facility by a bounding rectangle, and the heading of the crashing aircraft with respect to the facility is perpendicular to the diagonal of the bounding rectangle. These assumptions provide a conservative approximation to the true effective area.

The formulas for calculating the effective area (A_{eff}), the fly-in area (A_f), and the skid area (A_s) for an aircraft crashing into a rectangular building are respectively provided in equations 2, 3, and 4. DOE-STD-3014-96, Table B-16, provides typical wingspans for general aviation, helicopters, commercial aircraft, and military aircraft; Table B-17 gives the value for the mean of the cotangent of the crash angle for each aircraft category; and Table B-18 provides the mean skid distance for each aircraft type.

$$A_{eff} = A_f + A_s \tag{2}$$

where:

$$A_f = (WS + R) \cdot H \cdot cot\Phi + \frac{2 \cdot L \cdot W \cdot WS}{R} + L \cdot W \tag{3}$$

and

$$A_s = (WS + R) \cdot S \tag{4}$$

where:

- A_{eff} = total effective target area
- A_f = effective fly-in area
- A_s = effective skid-in area
- WS = aircraft wingspan, from DOE-STD-3014-96, Table B-16
- R = length of the diagonal of the facility = $(L^2 + W^2)^{0.5}$
- H = facility height - facility-specific
- $cot\Phi$ = mean of the cotangent of the aircraft crash angle, from DOE-STD-3014-96, Table B-17 (for in-flight crashes, use the takeoff mean of the cotangent of the crash angle)
- L = length of facility - facility-specific
- W = width of facility - facility-specific
- S = mean value of aircraft skid distance from DOE-STD-3014-96, Table B-18 (for in-flight crashes, use the takeoff skid length, if available).

This analysis calculated the effective area parameters, A_f, A_s, and A_{eff} for the 204-AR Waste Unloading Facility, the 242-T Evaporator, and the 200 Area tank farms. In the first two cases, the analysis modeled the facility as a rectangular slab with footprint dimensions corresponding to the facility plan dimensions with the highest concentrations of hazardous wastes and height corresponding to the maximum facility height. For the 200 Area tank farms, the analysis modeled the right-cylindrical tank footprint for one tank and the tank height as zero, and then adjusted to the number of tanks in the tank farms. For the circular tank, the study used πr^2 to replace the product of the length and the width of a rectangular building ($L \cdot W$).

The 204-AR Waste Unloading Facility in the 200 East Area has overall plan dimensions of 42 ft 4 in. by 77 ft 8 in. and an overall height dimension of 26 ft 10 in. The highest concentration of hazardous waste would be in the southwestern half of the facility. Therefore, the model only used half of the building's width: 21 ft 2 in. This reinforced concrete building sits about 17.5 degrees askew of true north, with its long sides facing northeasterly - southwesterly. This orientation and a number of other factors make the 204-AR Waste Unloading Facility almost secure from an aircraft skid-in from nearly every direction except northeasterly, south-southeasterly, and westerly. The other factors include facilities in the immediate area that provide shielding from the skid-in process. Nonetheless, the analysis did not consider any obstructions to a direct hit.

The dimensions for the 242-T Evaporator in the 200 West Area are 43 ft by 43 ft and 22 ft 11 in. high. This reinforced concrete building sits on a regular north-south, east-west orientation, with the evaporator itself located in the southeastern quadrant. As the hazardous waste is concentrated within one fourth of the building, the analysis model used half of the width and half of the length: 21 ft 6 in. by 21 ft 6 in. The shutdown operations complex of frame and metal buildings completely shields the east side of the 242-T Evaporator building. A hillock some 500 ft south-southwest of the 242-T Evaporator would tend to, depending on the ground speed and mass, stop or redirect any skidding-in aircraft over or into the top of the 242-T Evaporator building from that direction. Again, however, the analysis did not consider any obstructions to a direct hit.

The 200 Areas contain 18 tank farms: 11 in 200 East Area and 7 in 200 West Area. The centers of the two areas are approximately 4 mi apart, with approximately a 2-mi total semi-arid-land separation. The 11 tank farms in the 200 East Area include 66 inactive single-shell tanks (SST) and 25 active double-shell tanks (DST). The 7 tank farms in the 200 West Area include 83 inactive SSTs and 3 active DSTs.

All 177 waste storage tanks are at least 6 ft underground and are typically 75 ft inside diameter with perpendicular centerlines. The SSTs are typically on 102-ft centers in quadrangles, and the DST centerlines are typically separated 107 ft north-south and 135 ft east-west on centers. There are 16 "200 Series" SSTs that are uniquely 20 ft in diameter and correspondingly less separated underground. Four of these tanks are in the 241-B and 241-C tank farms in 200 East Area and four are in the 241-T and 241-U tank farms in 200 West Area. However, the analysis did not treat these tanks uniquely as a conservative approach in the final calculation for the tanks. This conservatism played only a small part, less than 5% total estimated, in the final outcome.

All waste storage tanks in the 200 Areas are reinforced concrete with carbon steel liners. The SSTs contain a single carbon steel liner that covers the bottom "dish" and covers the walls up to the bottom of the semi-domed reinforced concrete top. Through the years of Hanford Site operations, the SSTs increased in total volume capacity by increasing the heights of the walls. The DSTs are basically similar in design, except for a second carbon steel liner inside the first liner, forming an annulus between the two liners and providing a second means of protecting the environment. The second tank steel liner also forms a single liner inside the reinforced concrete tank dome. The steel dome liner is 3/8-in. plate, but a 12-ft-diameter ½-in.-thick plate forms the top of the dome.

3.2 AIRCRAFT CRASH FREQUENCY FOR LOCAL AIRPORTS

According to DOE-STD-3014-96, only airports within 23 smi (20 nmi) of a facility can make a significant contribution to the aircraft crash frequency at the facility. To locate the airports within 23 smi of the 200 Area facilities, the analysis used the AIRNAV Internet Site, http://www.airnav.com/. The latitudinal and longitudinal coordinates for the 200 East Area are, respectively, 46 degrees 33 minutes north and 119 degrees 31 minutes west; those coordinates for the 200 West Area are 46 degrees 33 minutes north and 119 degrees 37 minutes west. These coordinates are not facility specific, but are effectively the centers of the areas. The Hanford Site Cartographer obtained these coordinates from the web site, http://www.topozone.com/.

Nine airports are within 23 smi of the 200 Area tank farms. Reviews of the information from the AIRNAV website determined that all the airports exclusively served general aviation aircraft, except the Richland Airport, where a commercial air taxi operates one flight in and out daily. Several of these airports are small grass strips that serve agricultural aircraft, company aircraft, or personal aircraft. The nearest airport with significant commercial and military air activity is the Tri-Cities Airport located in Pasco, Washington, which is 28 smi southeast of the 200 East Area and 31 smi east-southeast of the 200 West Area. Table 1 lists the airports within 23 smi of the 200 East Area and their distances from and orientations to that facility. Table 2 does the same for the 200 West Area.

Table 1. Airports within 23 Statute Miles of the 200 East Area.

Airport	Distance (smi)	Direction
Green Acres	11.5	ENE
Mattawa	15.4	NW
Dorman	16.1	E
McWhorter	16.6	SSW
C B Wahluke	17.4	NW
Basin City	17.4	E
Richland	19.7	SSE
Desert Aire	21.4	WNW
Slinkard	21.9	E

Table 2. Airports within 23 Statute Miles of the 200 West Area.

Airport	Distance (smi)	Direction
C B Wahluke	13.2	NW
Mattawa	14.0	NNW
McWhorter	15.9	SSW
Green Acres	16.1	ENE
Desert Aire	17.3	WNW
Dorman	20.8	E
Basin City	22.1	E
Richland	22.4	SE
Sunnyside	22.8	SW

Figure 1 provides a map of the Hanford Site showing the locations of the 200 Areas and the local airports. Figure 2 provides a map of the 200 East Area, showing the locations of the tank farms, the burial grounds that apply to this analysis, and the 204-AR Waste Unloading Facility toward the eastern side of the area. Figure 3 provides a map of the 200 West Area showing the tank farms, the burial grounds, and the 242-T Evaporator complex near the center of the area. Table 3 and Table 4 provide the general aviation near-airport activity crash frequency information for the 200 East and 200 West areas, respectively.

Figure 1. Map of the Hanford Site Showing the 200 Areas and the Local Airports.

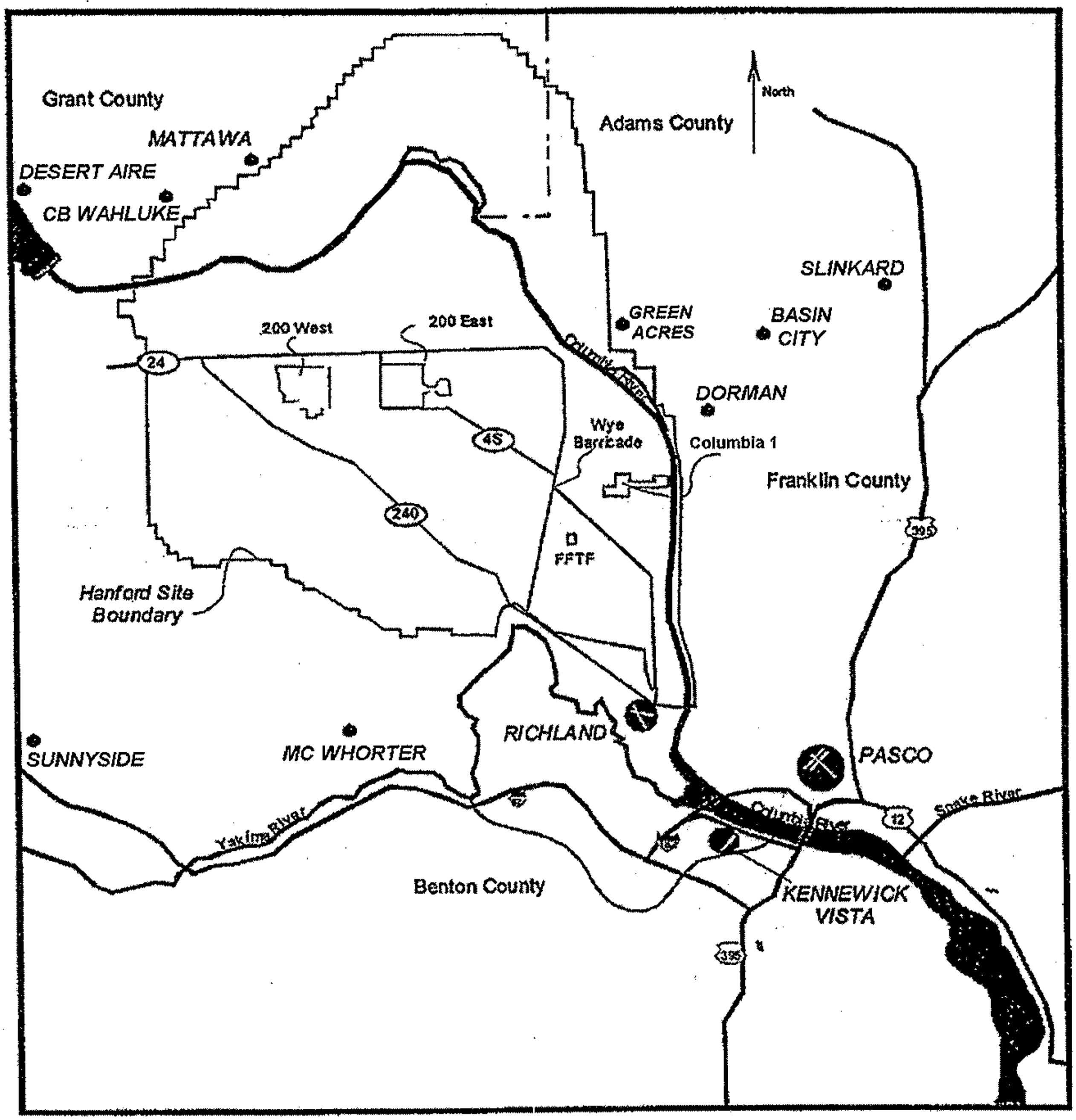

Figure 2. Map of the 200 East Area Showing Locations of Tank Farms, Applicable Burial Grounds, and 204-AR Waste Unloading Facility.

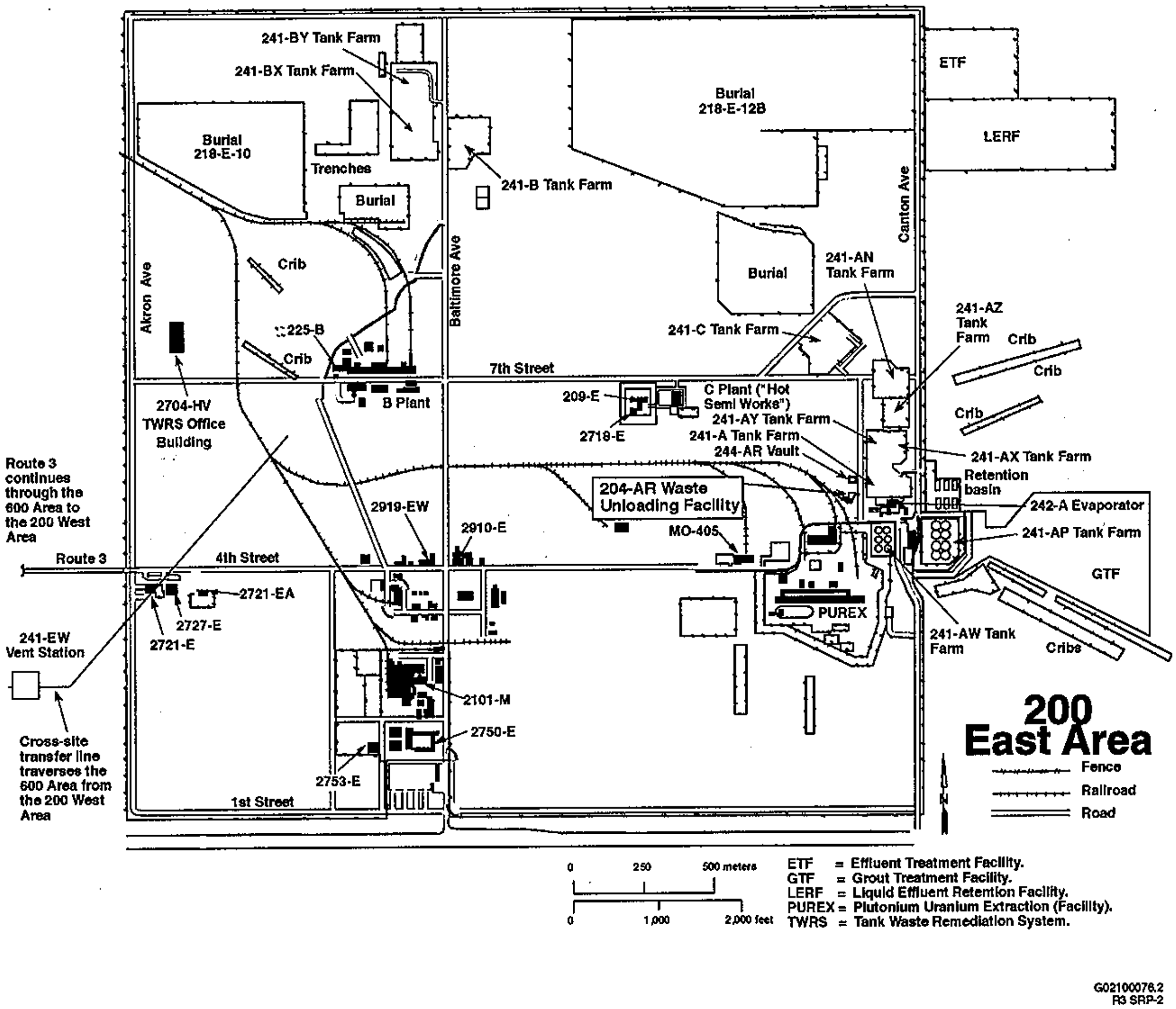

Figure 3. Map of the 200 West Area Showing Locations of Tanks Farms, Applicable Burial Grounds, and 242-T Evaporator.

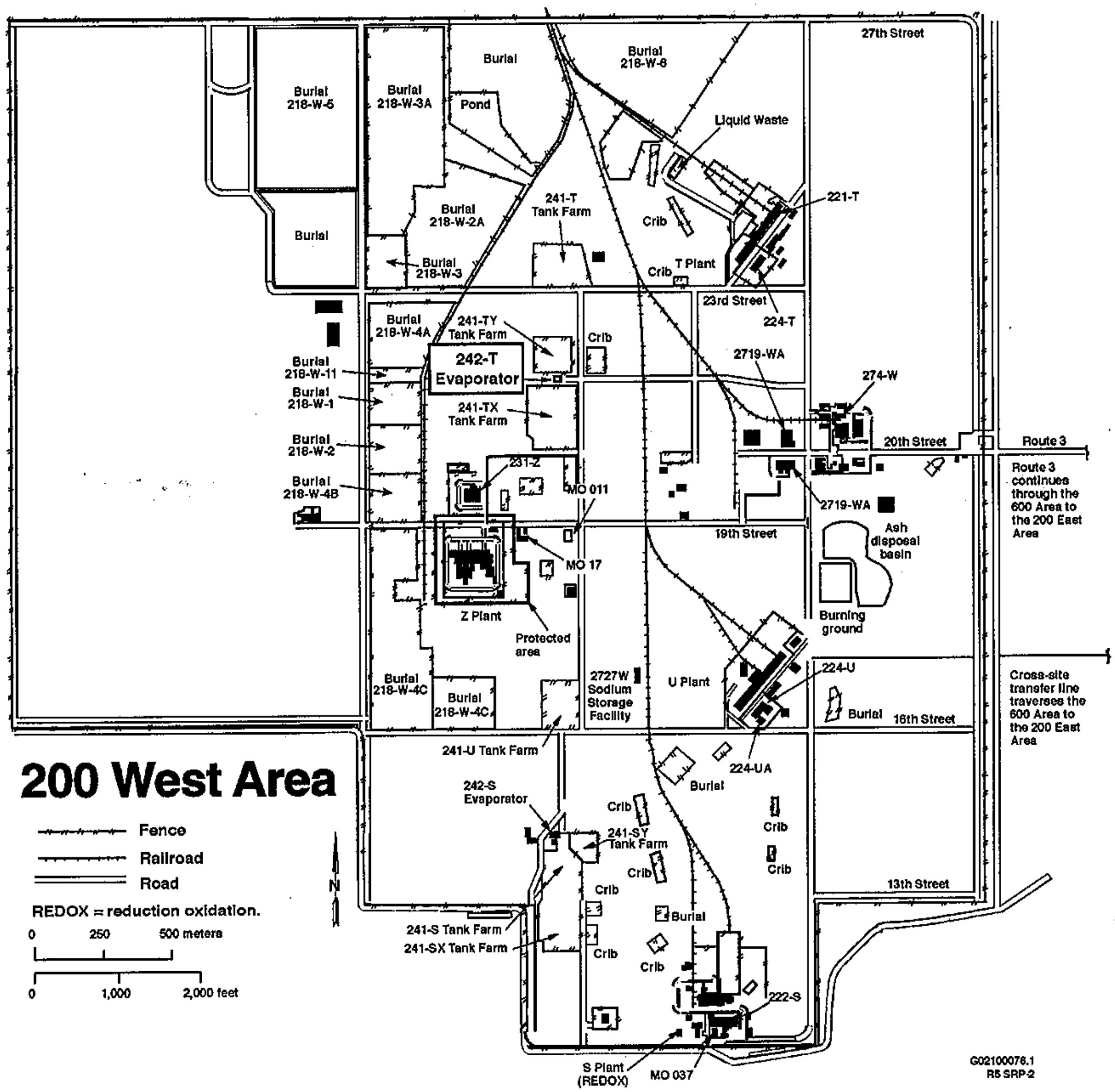

Table 3. 200 East Area General Aviation Near-Airport Activity Crash Frequency.

Airfield	Run-way Mag. Hdg.	Distance (smi)	Theta (θ)	Phi (vs. Mag. N) (Φ)	Theta minus Phi	X	Y	General aviation					Aircraft crash freq.
								Opera-tions	Crash rate	Take-off[1]	Land-ing[2]	Area	
Green Acres	160	11.51	67.5	160	-92.5	0.50	-11.50	N/A	N/A	0	0	N/A	0
	340	11.51	67.5	340	-272.5	-0.50	11.50	N/A	N/A	0	0	N/A	0
Mattawa	180	15.42	315	180	135	10.90	10.90	N/A	N/A	0	0	N/A	0
	360	15.42	315	360	-45	-10.90	-10.90	N/A	N/A	0	0	N/A	0
Dorman	30	16.11	90	30	60	-8.06	13.95	N/A	N/A	0	0	N/A	0
	210	16.11	90	210	-120	8.06	-13.95	N/A	N/A	0	0	N/A	0
McWhorter	50	16.57	202.5	50	152.5	14.70	7.65	N/A	N/A	0	0	N/A	0
	230	16.57	202.5	230	-27.5	-14.70	-7.65	N/A	N/A	0	0	N/A	0
C B Wahluke	70	17.38	315	70	245	7.35	-15.75	N/A	N/A	0	0	N/A	0
	250	17.38	315	250	65	-7.35	15.75	N/A	N/A	0	0	N/A	0
Basin City	40	17.38	90	40	50	-11.17	13.31	N/A	N/A	0	0	N/A	0
	220	17.38	90	220	-130	11.17	-13.31	N/A	N/A	0	0	N/A	0
Richland	7	19.68	157.5	7	150.5	17.13	9.69	N/A	N/A	0	0	N/A	0
	187	19.68	157.5	187	-29.5	-17.13	-9.69	N/A	N/A	0	0	N/A	0
Richland	76	19.68	157.5	76	81.5	-2.91	19.46	N/A	N/A	0	0	N/A	0
	256	19.68	157.5	256	-98.5	2.91	-19.46	N/A	N/A	0	0	N/A	0
Desert Aire	100	21.4	292.5	100	192.5	20.89	-4.63	N/A	N/A	0	0	N/A	0
	280	21.4	292.5	280	12.5	-20.89	4.63	N/A	N/A	0	0	N/A	0
Slinkard	40	21.86	90	40	50	-14.05	16.75	N/A	N/A	0	0	N/A	0
	220	21.86	90	220	-130	14.05	-16.75	N/A	N/A	0	0	N/A	0

Notes:
[1] DOE-STD-3014-96, *Accident Analysis For Aircraft Crash Into Hazardous Facilities,* Table B-4, U.S. Department of Energy, Washington, D.C.
[2] DOE-STD-3014-96, *Accident Analysis For Aircraft Crash Into Hazardous Facilities,* Table B-5, U.S. Department of Energy, Washington, D.C.
N/A = not applicable.

Table 4. 200 West Area General Aviation Near-Airport Activity Crash Frequency.

Airfield	Run-way Mag. Hdg.	Distance (smi)	Theta (θ)	Phi (vs. Mag. N) (Φ)	Theta minus Phi	X	Y	General aviation					Aircraft crash freq.
								Opera-tions	Crash rate	Take-off[1]	Land-ing[2]	Area	
Mattawa	180	13.23	337.5	180	157.5	12.22	5.06	N/A	N/A	0	0	N/A	0
	360	13.23	337.5	360	-22.5	-12.22	-5.06	N/A	N/A	0	0	N/A	0
C B Wahluke	70	14.04	315	70	245	5.93	-12.72	N/A	N/A	0	0	N/A	0
	250	14.04	315	250	65	-5.93	12.72	N/A	N/A	0	0	N/A	0
McWhorter	50	15.88	180	50	130	10.21	12.16	N/A	N/A	0	0	N/A	0
	230	15.88	180	230	-50	-10.21	-12.16	N/A	N/A	0	0	N/A	0
Green Acres	160	16.11	67.5	160	-92.5	0.70	-16.09	N/A	N/A	0	0	N/A	0
	340	16.11	67.5	340	-272.5	-0.70	16.09	N/A	N/A	0	0	N/A	0
Desert Aire	100	17.26	292.5	100	192.5	16.85	-3.74	N/A	N/A	0	0	N/A	0
	280	17.26	292.5	280	12.5	-16.85	3.74	N/A	N/A	0	0	N/A	0
Dorman	30	20.83	90	30	60	-10.42	18.04	N/A	N/A	0	0	N/A	0
	210	20.83	90	210	-120	10.42	-18.04	N/A	N/A	0	0	N/A	0
Basin City	40	22.09	90	40	50	-14.20	16.92	N/A	N/A	0	0	N/A	0
	220	22.09	90	220	-130	14.20	-16.92	N/A	N/A	0	0	N/A	0
Richland	7	22.44	135	7	128	13.82	17.68	N/A	N/A	0	0	N/A	0
	187	22.44	135	187	-52	-13.82	-17.68	N/A	N/A	0	0	N/A	0
Richland	76	22.44	135	76	59	-11.56	19.23	N/A	N/A	0	0	N/A	0
	256	22.44	135	256	-121	11.56	-19.23	N/A	N/A	0	0	N/A	0
Sunnyside	70	22.79	225	70	155	20.65	9.63	N/A	N/A	0	0	N/A	0
	250	22.79	225	250	-25	-20.65	-9.63	N/A	N/A	0	0	N/A	0

Notes:
[1] DOE-STD-3014-96, *Accident Analysis For Aircraft Crash Into Hazardous Facilities,* Table B-4, U.S. Department of Energy, Washington, D.C.
[2] DOE-STD-3014-96, *Accident Analysis For Aircraft Crash Into Hazardous Facilities,* Table B-5, U.S. Department of Energy, Washington, D.C.
N/A = not applicable.

3.3 AIRCRAFT CRASH FREQUENCY FOR NON-AIRPORT OPERATIONS

The analysis uses as its basis for crash frequency of the non-airport operations for all categories of aircraft the same four-factor formula that it used for the airport operations:

$$F_j = N_j P_j f_j(x,y) A_j \tag{5}$$

where:

F = crash frequency of non-airport operations
j = class of solid-wing aircraft
NP = estimated number of in-flight crashes per year
$f(x,y)$ = probability, given a crash, that the crash occurs in a 1 mi^2 area surrounding the 200 Area facility
A = effective area of the facility.

This analysis modeled all waste storage tanks in the 200 Area tank farms as 75 ft in diameter. The analysis will calulate a statistical asymptotical approach to 1.0 using the form $1 - (1 - F)^n$, where F is the calculated one-tank helicopter crash frequency, and n is the total number of tanks.

Among other DOE sites' values, DOE-STD-3014-96, Tables B-14 and B-15, provide Hanford site-specific values for the expected number of crashes per mi^2/yr. This is the product of *NP* and $f(x,y)$. Table 5 is a compilation of these tables from DOE-STD-3014-96 for the Hanford Site. These tables do not have values for helicopters, because each site is different.

Table 5. Maximum, Minimum, and Average CONUS, and Hanford Site-Specific Values for the Expected Number of Crashes per Square Mile per Year, $NPf(x,y)$.

Site	General aviation	Air carrier	Air taxi	Large military	Small military
Maximum CONUS	$3x10^{-3}$	$2x10^{-6}$	$8x10^{-6}$	$7x10^{-7}$	$6x10^{-6}$
Minimum CONUS	$1x10^{-7}$	$7x10^{-8}$	$4x10^{-7}$	$6x10^{-8}$	$4x10^{-8}$
Average CONUS	$2x10^{-4}$	$4x10^{-7}$	$1x10^{-6}$	$2x10^{-7}$	$4x10^{-6}$
Hanford[(a)]	$1x10^{-4}$	$1x10^{-7}$	$1x10^{-6}$	$1x10^{-7}$	$4x10^{-8}$

Notes:
[(a)] DOE-STD-3014-96, *Accident Analysis For Aircraft Crash Into Hazardous Facilities*, Tables B-14 and B-15, U.S. Department of Energy, Washington, D.C.
CONUS = continental United States.

The crash frequency for non-airport operations for a particular class of aircraft is the Hanford site-specific product of the estimated number of crashes per year and the probability, given a crash, that the crash occurs in a 1 mi^2 area surrounding the facility of interest. This is the $NPf(x,y)$ value provided in Table 5, combined with the effective facility area. The unit for effective area is square miles.

The helicopter crash frequency calculation is as follows:

$$F_H = N_H P_H (2/L_H) A_H \tag{6}$$

where:

F_H = helicopter crash frequency
N_H = expected number of local helicopter over flights per year
P_H = probability of a helicopter crash per flight, from Table B-1 in DOE-STD-3014-96: 2.5E-5
L_H = average length of a helicopter flight over or close to the site
A_H = effective area (fly-in accident only; there is no skid-in process for a helicopter), calculated according to Equation 3 for A_f earlier in this document.

As previously noted, helicopter traffic for each DOE site is different. DOE STD-3014-96 requires each site to determine the helicopter activities for that site. Table 6 presents the bounding Hanford Site values for helicopter traffic at the 200 Areas. See Appendix A for the information, sources, explanations, and assumptions that produced Table 6.

Table 6. Bounding Values for Helicopter Traffic Over and Around the 200 Areas.

Type	Frequency	Maximum no./yr	Trip distance (mi.)
BPA Transmission Line Surveillance	16 per year	0	0
Weed Control	Four per year	0	0
Medical Evacuation (Moses Lake, WA)	Two evacuations (to and from) per year	4	37
Radiological Survey	Once every 5 years (with facility subject to impact from 7 passes)	1.4	250
Fire Control	Once every 10 years	0.1	74
		$N_H = 5.5$	$L_H = 92$
Facility	**A_H Effective area (mi.^{2})**		**F_H (χρασηεσ/ψρ)**
One Tank	3.70E-4		1.11E-9
204-AR	2.05E-4		5.98E-10
242-T	1.10E-4		3.29E-10

Note:
BPA = Bonneville Power Administration

Other factors that enter into these calculations, as mentioned previously, are the aircraft wingspans, the mean of the cotangent of the crash angle, and the mean skid distance of representative aircraft in the categories of general aviation, helicopters (no skid), commercial aviation, and military aviation. Tables B-16, B-17, and B-18 of DOE-STD-3014-96 are the sources for this information. Using equations 3 and 4, respectively, for the effective fly-in area, A_f, and the effective skid-in area, A_s, Table 7 gives the results for the 204-AR Waste Unloading Facility, Table 8 for the 242-T Evaporator, and Table 9 for the 200 Area tank farms.

Table 7. Results of Effective Area Calculations for the 200 East Area 204-AR Waste Unloading Facility.

Parameter	General aviation	Helicopter	Commercial aviation		Military aviation		
			Air carrier	Air taxi	Large	Small – High P	Small – Low P
WS, ft	50	50	98	59	223	78	110
R, ft	80.50	80.50	80.50	80.50	80.50	80.50	80.50
H, ft	26.83	26.83	26.83	26.83	26.83	26.83	26.83
$cot\Phi$	8.2.	0.58	10.2	10.2	7.4	8.4	8.4
L, ft	77.67	77.67	77.67	77.67	77.67	77.67	77.67
W, ft	21.17	21.17	21.17	21.17	21.17	21.17	21.17
S, ft	60	0	1440	1440	780	246	246
$A_f + A_s = A_{eff}$, mi^2	1.44E-3	2.05E-4[(a)]	1.12E-2	8.72E-3	1.10E-2	2.85E-3	3.44E-3

Note:

[(a)] For helicopters, this is A_h of Equation 6.

Table 8. Results of Effective Area Calculations for the 200 West Area 242-T Evaporator.

Parameter	General aviation	Helicopter	Commercial aviation		Military aviation		
			Air carrier	Air taxi	Large	Small – High P	Small – Low P
WS, ft	50	50	98	59	223	78	110
R, ft	30.41	30.41	30.41	30.41	30.41	30.41	30.41
H, ft	22.92	22.92	22.92	22.92	22.92	22.92	22.92
$cot\Phi$	8.2	0.58	10.2	10.2	7.4	8.4	8.4
L, ft	21.50	21.50	21.50	21.50	21.50	21.50	21.50
W, ft	21.50	21.50	21.50	21.50	21.50	21.50	21.50
S, ft	60	0	1440	1440	780	246	246
$A_f + A_s = A_{eff}$, mi^2	7.86E-4	1.09E-4[(a)]	7.83E-3	5.45E-3	8.89E-3	1.81E-3	2.35E-3

Note:

[(a)] For helicopters, this is A_h of Equation 6.

Table 9. Results of Effective Area Calculations for One Tank in the 200 Area Tank Farms.

Parameter	General aviation	Helicopter	Commercial aviation		Military aviation		
			Air carrier	Air taxi	Large	Small – High P	Small – Low P
WS, ft	50	50	98	59	223	78	110
R, ft	75	75	75	75	75	75	75
H, ft	0	0	0	0	0	0	0
$cot\Phi$	8.2	0.58	10.2	10.2	7.4	8.4	8.4
Radius, r, ft	37.5	37.5	37.5	37.5	37.5	37.5	37.5
Area, πr^2, ft^2	4.42E-3	4.42E-3	4.42E-3	4.42E-3	4.42E-3	4.42E-3	4.42E-3
S, ft	0	0	0	0	0	0	0
$A_f = A_{eff}$, mi^2	3.70E-4	3.70E-4[(a)]	5.73E-4	4.08E-4	1.10E-3	4.88E-4	6.24E-4

Note:

(a) For helicopters, this is A_h of Equation 6.

Table 10 shows the frequency of non-airport aircraft crashes per year into the 200 Areas by combining the effective area of the 200 Area facilities and the conditional probability of crash, and that the crash occurs in a 1 mi^2 area of the vicinity of the facility, *NPf(x,y)*. Table 5 presented the Hanford site-specific data for *NPf(x,y)* for all categories of aircraft, except helicopter. Table 6 presented the DOE-STD-3014-96 required values for helicopter traffic in and around the 200 Areas.

The non-airport crash frequency for all aircraft into the 200 East Area 204-AR Waste Unloading Facility is 1.56E-7/yr. For the 200 West Area 242-T Evaporator, it is 8.62E-8/yr. However, the same value for the waste storage tanks is 6.86E-6/yr. Therefore, the combined frequency for aircraft crash into any of the stored waste in the 200 Area is 7.10E-6/yr. This value is more than the crash frequency evaluation guideline of 1E-6/yr. Thus, *DOE-STD-3014-96 requires* a consequence analysis, as well as a DBA analysis.

Table 10. Non-Airport Crash Frequencies for the 200 Areas.

Aircraft	Hanford Site $NPf(x,y)$ (from Table 5)	200 East – 204-AR		200 West – 242-T		Tank farms			Combined F_j (crashes/yr)
						One tank		Tanks[a]	
		A_{eff} (mi^2) (from Table 7)	F_j (crashes/yr)	A_{eff} (mi^2) (from Table 8)	F_j (crashes/yr)	A_{eff} (mi^2) (from Table 9)	F_j^1 (crashes/yr)	F_j (crashes/yr)	
General Aviation	1E-4	1.44E-3	**1.44E-7**	7.86E-4	**7.86E-8**	3.70E-4	3.70E-8	**6.55E-6**	**6.77E-6**
Helicopter	--	2.05E-4[b]	**5.98E-10**[c]	1.10E-4[b]	**3.29E-10**[c]	3.70E-4[b]	1.11E-9[c]	**1.96E-7**	**1.97E-7**
Coml. Air Carrier	1E-7	1.12E-2	**1.12E-9**	7.83E-3	**7.83E-10**	5.70E-4	5.70E-11	**1.01E-8**	**1.20E-8**
Coml. Air Taxi	1E-6	8.72E-3	**8.72E-9**	5.45E-3	**5.45E-9**	4.08E-4	4.08E-10	**7.22E-8**	**8.64E-8**
Military - Large	1E-7	1.10E-2	**1.10E-9**	8.89E-3	**8.89E-10**	1.10E-3	1.10E-10	**1.95E-8**	**2.15E-8**
Military Sm. – High P	4E-8	2.85E-3	**1.14E-10**	1.81E-3	**7.24E-11**	4.90E-4	1.96E-11	**3.46E-9**	**3.65E-9**
Military Sm. – Low P	4E-8	3.44E-3	**1.38E-10**	2.35E-3	**9.40E-11**	6.24E-4	2.50E-11	**4.42E-9**	**4.65E-9**
		Totals	**1.56E-7**	--	**8.62E-8**	--	--	**6.86E-6**	**7.10E-6**

Notes:
[a] The statistical asymptotical approach to 1.0, $1 - (1 - F_j^1)^n$, where n is 177 for all aircraft.
[b] For helicopters this is A_H of Equation 6; see footnote (c).
[c] F_H from Table 6.

4.0 REFERENCES

DOE-STD-1027-92, 1997, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, Change Notice No. 1, U.S. Department of Energy, Washington, D.C.

DOE-STD-3009-94, 2002, *Preparation Guide for U. S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses,* Change Notice No. 2, U.S. Department of Energy, Washington, D.C.

DOE-STD-3014-96, 1996, *Accident Analysis For Aircraft Crash Into Hazardous Facilities,* U.S. Department of Energy, Washington, D.C.

http://airnav.com, Air Nav, LLC, Morganville, New Jersey.

http://topozone.com, Maps a la carte, Inc., North Chelmsford, Massachusetts.

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APPENDIX A

AIRCRAFT ACTIVITY DETERMINATIONS FOR THE HANFORD 200 AREAS

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APPENDIX A

AIRCRAFT ACTIVITY DETERMINATIONS FOR THE HANFORD 200 AREAS

This appendix documents the methods of determining helicopter activities over and around the 200 East and 200 West tank farms. It also presents the basis for defining the activities of general aviation aircraft. Accordingly, DOE-STD-3014-96 states that helicopter traffic at a given site is unique, and each site must determine its own values for the number of trips and the average length for each trip. These are then used to determine the frequency of crash for a helicopter at a site. Because the resultant crash frequency is more than 1E-6 crashes per year, the analysis must consider the physical characteristics of the helicopters being used at the time of the analysis and those of the general aviation aircraft.

HELICOPTER

Table A-1 presents the helicopter activities for the 200 Areas and their information discovery contacts. Table A-2 gives the physical characteristics for the helicopters in use over and around the 200 Areas. Some of this information was taken from the web site http://www.janes.com/. All the information that supports the analysis for each of the helicopter activities follows in Table A-2.

Table A-1. Hanford Site 200 Areas Helicopter Activities.

Activity	Schedule	Helicopter type	Contact
Bonneville Power Administration, electrical transmission line surveillance	16 per year	Bell 206 Jet Ranger	Bonneville Power Authority, Walla Walla, WA, Office, William Erickson, 509-527-6238 Gerry Bell, 509-376-0680
Weed control	Up to four times per year per route or location	Bell UH-1 (Huey)	Tri-City Helicopter Service, Richland Airport Bill Svancera, 509-967-5147 Rusty Wayman, 509-531-1257 Gerry Bell, 509-376-0680 Juan Rodriguez, 509-376-5128
Medical evacuation	Two evacuations per year	Eurocopter EC-135	Northwest Med Star, Moses Lake Airport Michael Day, 800-572-3210 X7964
Radiological survey	Up to once every 5 years	Bell 412	Bechtel Nevada Paul Guss, 702-295-8601 Tom McKissack, 702-295-8061 Gerry Bell, 509-376-0680
Fire control	Once every 10 years	Chinook CH-47	U.S. Forest Service Gerry Bell, 509-376-0680

Table A-2. Helicopter Physical Characteristics.

Helicopter	Fuel capacity (gal)	Speed (mi/h)	Weight (lb)
Bell 206 Jet Ranger	91	40 - 60	3,200
Bell UH-1 (Huey)	220	100	9,500
Eurocopter EC-135	180	150	6,237
Bell 412	330	69 – 92 (goes unstable at $\leq$46)	11,400 with equipment *and personnel*
Chinook CH-47[a]	1030	150-196	50,000 maximum gross

Note:

[a] The consequences of a Chinook CH-47 crash were not calculated because frequency of a crash impacting a facility are "beyond extremely unlikely."

Additional information about helicopter flights over the Hanford Site is as follows:

Bonneville Power Administration (BPA) Electrical Transmission Line Surveillance: The BPA offices in Spokane, Washington, and in Redmond, Oregon, perform these aerial surveillances, independently of each other, three times per office each year. They surveil two separate 500 kilovolt-amps transmission lines that parallel each other diagonally northwest of 200 West Area from over the hills on the west side of the overall Hanford Site to the Hanford 100 N Area substation. In any given year, they also perform two special aerial trips over the same route to and from the substation for other purposes. If there were any possibility of these newer design helicopters crashing, the 241-T-Tank Farm would be the nearest to the crash site. However, the over 1-mi distance, even while straying off course in an emergency situation, is adequate to preclude any and all physical interaction.

Weed Control: Table A-3 presents the 200 Area burial grounds that are subject to aerial application of herbicides, and also gives the application swathing directions.

Table A-3. 200 Area Burial Grounds Subject to Aerial Herbicide Application.

Area	Swathing directions	
	East/West	North/South
	Burial Ground	Burial Ground
200 East	218-E-10 218-E-12B	--
200 West	218-W-3A 218-W-5 218-W-6	218-W-1 218-W-2 218-W-2A 218-W-3 218-W-4A 218-W-4B 218-W-4C

In addition, herbicides are aerially applied to all 200 Area perimeter fence lines, except where workers are typically present on the ground (such as along the east border of the 200 East Area), and in the section of the 218-W-4C Burial Ground east of the line of utility poles. These latter areas and all other burial grounds in both 200 East and 200 West areas are sprayed using tank trucks.

Application passes (swaths) are a maximum 60 ft wide (50 ft assumed for overlap conservatism), and are flown at 15 to 30 ft above ground level at a maximum of 80 mi/h. At the end of each swath (except the first and last of each spray run), the helicopter performs a tight, steep, 180 degree turn to prepare for the next swath. The helicopter can spray approximately 50 acres in about 6 minutes before landing to reload herbicide and/or fuel (known as "hot operation mode").

The spraying activity over the 200 East Area burial grounds directly approaches the 241-B, 241-BX, and 241-BY tank farms on at least half the swaths. The spraying activity over the 200 West Area burial grounds does not directly approach any tank farms. There are 1,000 ft between the inner boundaries of each of the two 200 East Area burial grounds and the outer boundaries of the tank farms. Discussions with one local aerial applicator about the turnaround process found that, for fixed-wing aircraft, the flight path would extend as far as 1/4 mi (1,320 ft) beyond the end of application when turning around, especially when fully loaded. However, herbicide application for the 200 Area burial grounds uses the Bell UH-1 (Huey) helicopter that turns in a very short comparative distance, with an assumed maximum of 25% of the fixed-wing aircraft, or 330 ft. Therefore, the helicopter would remain over 650 ft from the tank farm during herbicide application. There will be no direct over flight of the tank farms from aerial applications of herbicide to the burial grounds and the perimeter fence lines of the Hanford Site 200 Area tank farms.

Medical Evacuation: These Northwest Med Star Eurocopter EC-135 helicopter flights originate from the Moses Lake, Washington, Municipal Airport, over 37 mi north-northeast of the 200 Areas. Because any such flight would only be made in the extremes of medical emergencies, the need for speed is paramount. With about 3/4 of its fuel tank full in preparation for speedy service, this helicopter can reach its maximum cruising speed of 150 mi/h very shortly after take off. Therefore, it will reach its destination in about 15 minutes.

The helicopter pad in 200 East Area is about 100 yd east-southeast of the Hanford Patrol Operations Center, and the "pad" for 200 West Area is on the road at the car entrance at the extreme southeastern corner of the area. The Hanford Fire Department is in constant communication with the helicopter pilot on each approach to either area. The oral flight instructions stress that after entering the area between 200 East and 200 West to avoid any high obstructions, approach the 200 East Area pad from the southwest, and approach the 200 West Area landing site from the southeast. There are a number of tall off-gas stacks in both areas, at least one for each generally inactive, large separations facility and others for some smaller facilities.

However, in an extreme emergency such as an urgent life or death situation, flight instructions may be violated. Hence, the analysis assumes these flights as over-flying the 200 East Area or the 200 West Area, both inbound and outbound.

Radiological Survey: These survey flights are performed 60 ft above ground level at 400-ft north-south transects, with turnarounds at the north and south Hanford Site boundaries. Because the over flights transect every 400 feet, and the assumed crash zone for helicopters is 0.25 miles each side of the flight path, a single facility is considered at risk from multiple over flights. With one flight over the facility, the facility is also at risk from the adjacent three over flights to the east and the adjacent three over flights to the west for a total of seven over flights.

The fuel capacity of the Bell 412 used for conducting radiological surveys has a range of 310 miles. Presuming the pilot would land with a 20% reserve, the length of radiological survey flights has been estimated to be 250 miles.

Fire Control: This U.S. Forest Service activity comes as the fourth or fifth responder after and by request of the Hanford Fire Department to and through the Central Washington Interagency Communications Center. This request is made only after it appears that the previous responders will exhaust their resources. The last time this occurred was 1999, and the previous occurrence was in 1984. The helicopter flight is modeled as a round trip from Moses Lake, Washington. At the Hanford Site, plans are under consideration to reduce or eliminate the fuel supply through aggressive control of plants and weeds and/or collection of residue before a possible fire source attacks it. In 1999, the Hanford range fire charred much of the southwestern quarter of the site before being contained. The Forest Service helicopters are generally reserved for and largely provide for hot-spot control.

The analysis assumes a range fire surrounds the 200 Area sites once every 10 years.
The analysis also assumes that the helicopter has the potential to fly over any facility in tank farms.

GENERAL AVIATION AIRCRAFT

The average general aviation traffic to and from the Richland Airport is 75% single-engine aircraft and 25% twin-engine aircraft. The Port of Benton (County), Washington, manager of the airport, Scott Keller at 509-375-3060, provided this information. Although the activity of the twin-engine aircraft is just one-third of the single-engine traffic activity at the Richland Airport, the analysis uses the twin-engine aircraft as bounding in its physical characteristics.

Conversations with Federal Aviation Administration personnel at the Tri-Cities Airport were the bases for the selection of representative aircraft in the general aviation category. They reported an upper limit for weight of general aviation aircraft of 12,500 lb. Therefore, this analysis uses the twin-engine Raytheon Aircraft 2001 King Air B200, formerly the Beechcraft B200, as the bounding general aviation aircraft. The values this analysis uses are the B200's fully loaded weight of 12,500 lb at takeoff and landing and its maximum fuel load of 544 gal. The study uses this fuel load as bounding for the analysis of the fire that follows the crash into a waste tank.

APPENDIX B

PEER REVIEW CHECKLIST

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APPENDIX B

PEER REVIEW CHECKLIST

Document Reviewed: RPP-11736 "Assessment of Aircraft Crash Frequency for the 200 Area Tank Farms"

Scope of Review (e.g., document section or portion of calculation): All

Yes	No	NA*	
[X]	[ ]	[ ]	1. Previous reviews are complete and cover the analysis, up to the scope of this review, with no gaps.
[X]	[ ]	[ ]	2. Problem is completely defined.
~~[X]~~	[ ]	[X]	3. Accident scenarios are developed in a clear and logical manner.
[X]	[ ]	[ ]	4. Analytical and technical approaches and results are reasonable and appropriate. *(ORP QAPP criterion 2.8)*
[X]	[ ]	[ ]	5. Necessary assumptions are reasonable, explicitly stated, and supported. *(ORP QAPP criterion 2.2)*
[ ]	[ ]	[X]	6. Computer codes and data files are documented.
[X]	[ ]	[ ]	7. Data used in calculations are explicitly stated.
[X]	[ ]	[ ]	8. Bases for calculations, including assumptions and data, are consistent with the supported safety basis document (e.g., the Tank Farms Final Safety Analysis Report).
[X]	[ ]	[ ]	9. Data were checked for consistency with original source information as applicable. *(ORP QAPP criterion 2.9)*
[X]	[ ]	[ ]	10. For both qualitative and quantitative data, uncertainties are recognized and discussed, as appropriate. *(ORP QAPP criterion 2.17)*
[ ]	[ ]	[X]	11. Mathematical derivations were checked including dimensional consistency of results. *(ORP QAPP criterion 2.16)*
[ ]	[ ]	[X]	12. Models are appropriate and were used within their established range of validity or adequate justification was provided for use outside their established range of validity.
[X]	[ ]	[ ]	13. Spreadsheet results and all hand calculations were verified.
[X]	[ ]	[ ]	14. Calculations are sufficiently detailed such that a technically qualified person can understand the analysis without requiring outside information. *(ORP QAPP criterion 2.5)*
[ ]	[ ]	[X]	15. Software input is correct and consistent with the document reviewed.
[ ]	[ ]	[X]	16. Software output is consistent with the input and with the results reported in the document reviewed.
[ ]	[ ]	[X]	17. Software verification and validation are addressed adequately. *(ORP QAPP criterion 2.6)*
[X]	[ ]	[ ]	18. Limits/criteria/guidelines applied to the analysis results are appropriate and referenced. Limits/criteria/guidelines were checked against references. *(ORP QAPP criterion 2.9)*
[X]	[ ]	[ ]	19. Safety margins are consistent with good engineering practices.
[X]	[ ]	[ ]	20. Conclusions are consistent with analytical results and applicable limits.

[X] [ ] [ ] 21. Results and conclusions address all points in the purpose. *(ORP QAPP criterion 2.3)*

[X] [ ] [ ] 22. All references cited in the text, figures, and tables are contained in the reference list.

[X] [ ] [ ] 23. Reference citations (e.g., title and number) are consistent between the text callout and the reference list.

[X] [ ] [ ] 24. Only released (i.e., not draft) references are cited. *(ORP QAPP criterion 2.1)*

[X] [ ] [ ] 25. Referenced documents are retrievable or otherwise available.

[X] [ ] [ ] 26. The most recent version of each reference is cited, as appropriate. *(ORP QAPP criterion 2.1)*

[X] [ ] [ ] 27. There are no duplicate citations in the reference list.

[X] [ ] [ ] 28. Referenced documents are spelled out (title and number) the first time they are cited.

[X] [ ] [ ] 29. All acronyms are spelled out the first time they are used.

[X] [ ] [ ] 30. The Table of Contents is correct.

[X] [ ] [ ] 31. All figure, table, and section callouts are correct.

[X] [ ] [ ] 32. Unit conversions are correct and consistent.

[X] [ ] [ ] 33. The number of significant digits is appropriate and consistent.

[ ] [ ] [X] 34. Chemical reactions are correct and balanced.

[X] [ ] [ ] 35. All tables are formatted consistently and are free of blank cells.

[X] [ ] [ ] 36. The document is complete (pages, attachments, and appendices) and in the proper order.

[X] [ ] [ ] 37. The document is free of typographical errors.

[X] [ ] [ ] 38. The tables are internally consistent.

[X] [ ] [ ] 39. The document was prepared in accordance with HNF-2353, Section 4.3, Attachment B, "Calculation Note Format and Preparation Instructions".

[X] [ ] [ ] **Concurrence**

D.M. Carson [signature] 31 Dec 02

Reviewer (Printed Name and Signature) Date

* If No or NA is chosen, provide an explanation on this form.

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed:

Scope of Review (e.g., document section or portion of calculation):

Yes	No	NA*	
[ ]	[ ]	[X]	1. Previous reviews are complete and cover the analysis, up to the scope of this review, with no gaps.
[ ]	[ ]	[X]	2. Problem is completely defined.
[ ]	[ ]	[X]	3. Accident scenarios are developed in a clear and logical manner.
[ ]	[ ]	[X]	4. Analytical and technical approaches and results are reasonable and appropriate. *(ORP QAPP criterion 2.8)*
[ ]	[ ]	[X]	5. Necessary assumptions are reasonable, explicitly stated, and supported. *(ORP QAPP criterion 2.2)*
[ ]	[ ]	[X]	6. Computer codes and data files are documented.
[ ]	[ ]	[X]	7. Data used in calculations are explicitly stated.
[ ]	[ ]	[X]	8. Bases for calculations, including assumptions and data, are consistent with the supported safety basis document (e.g., the Tank Farms Final Safety Analysis Report).
[ ]	[ ]	[X]	9. Data were checked for consistency with original source information as applicable. *(ORP QAPP criterion 2.9)*
[ ]	[ ]	[X]	10. For both qualitative and quantitative data, uncertainties are recognized and discussed, as appropriate. *(ORP QAPP criterion 2.17)*
[ ]	[ ]	[X]	11. Mathematical derivations were checked including dimensional consistency of results. *(ORP QAPP criterion 2.16)*
[ ]	[ ]	[X]	12. Models are appropriate and were used within their established range of validity or adequate justification was provided for use outside their established range of validity.
[ ]	[ ]	[X]	13. Spreadsheet results and all hand calculations were verified.
[ ]	[ ]	[X]	14. Calculations are sufficiently detailed such that a technically qualified person can understand the analysis without requiring outside information. *(ORP QAPP criterion 2.5)*
[ ]	[ ]	[X]	15. Software input is correct and consistent with the document reviewed.
[ ]	[ ]	[X]	16. Software output is consistent with the input and with the results reported in the document reviewed.
[ ]	[ ]	[X]	17. Software verification and validation are addressed adequately. *(ORP QAPP criterion 2.6)*
[ ]	[ ]	[X]	18. Limits/criteria/guidelines applied to the analysis results are appropriate and referenced. Limits/criteria/guidelines were checked against references. *(ORP QAPP criterion 2.9)*
[ ]	[ ]	[X]	19. Safety margins are consistent with good engineering practices.
[ ]	[ ]	[X]	20. Conclusions are consistent with analytical results and applicable limits.

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	Effective Date	**12/17/02**

[] [] [] 21. Results and conclusions address all points in the purpose. *(ORP QAPP criterion 2.3)*

[X] [] [] 22. All references cited in the text, figures, and tables are contained in the reference list.

[X] [] [] 23. Reference citations (e.g., title and number) are consistent between the text callout and the reference list.

[X] [] [] 24. Only released (i.e., not draft) references are cited. *(ORP QAPP criterion 2.1)*

[X] [] [] 25. Referenced documents are retrievable or otherwise available.

[X] [] [] 26. The most recent version of each reference is cited, as appropriate. *(ORP QAPP criterion 2.1)*

[X] [] [] 27. There are no duplicate citations in the reference list.

[X] [] [] 28. Referenced documents are spelled out (title and number) the first time they are cited.

[X] [] [] 29. All acronyms are spelled out the first time they are used.

[X] [] [] 30. The Table of Contents is correct.

[X] [] [] 31. All figure, table, and section callouts are correct.

[] [] [X] 32. Unit conversions are correct and consistent.

[] [] [X] 33. The number of significant digits is appropriate and consistent.

[] [] [X] 34. Chemical reactions are correct and balanced.

[X] [] [] 35. All tables are formatted consistently and are free of blank cells.

[X] [] [] 36. The document is complete (pages, attachments, and appendices) and in the proper order.

[X] [] [] 37. The document is free of typographical errors.

[X] [] [] 38. The tables are internally consistent.

[] [] [X] 39. The document was prepared in accordance with HNF-2353, Section 4.3, Attachment B, "Calculation Note Format and Preparation Instructions".

[] [] [] **Concurrence**

NA check for those items not responsibility of tech editor.

Laurie L. Kraemer / Laurie L Kraemer 3/17/03
Reviewer (Printed Name and Signature) Date

RPP-11736

* If No or NA is chosen, provide an explanation on this form.