Chapter 18: Screening-Level Evaluation of Airborne Plutonium Releases from DP West Site

Because airborne plutonium releases from DP West Site were documented to have been significantly higher than has been officially reported and residential areas were located quite close to the site, a screening assessment using the methodology of National Council on Radiation Protection and Measurements (NCRP) Report No. 123 (NCRP 1996) was performed for releases from DP West Site Building 12 stacks during 1949, the apparent year of peak emissions. The NCRP methodology uses three levels of screening calculations for atmospheric transport pathways. Level I screening uses the simplest approach and incorporates a high degree of conservatism to avoid underestimating doses to people. Level II screening accounts for dispersion in the atmosphere and combines all significant pathways into a single screening factor. Level III screening includes more definitive pathways analysis for inhalation, external exposure, and ingestion of terrestrial food products in the form of vegetables and/or animal food products.

The documented release of 86.6 g of ^{239}Pu from the DP West Building 12 stacks during calendar year 1949 [see Fig. 18-1; (Hyatt 1956)] was converted to a ^{239}Pu release rate using a specific activity value of 0.063 Ci g^{-1} (ANL/EVS 2005). This is the approximate value that the LASL investigators used in 1956 to convert from measured total alpha activity to the total activity released values, in grams, that were reported in the 1956 memorandum. Multiplicative sample line loss and filter burial correction factors of 5 and 2.33, respectively, were applied based on evaluations conducted by LANL staff (Fuehne 2008). The average ^{239}Pu release rate for 1949 was calculated as follows:

$$86.6\ \text{g} \times 5.0 \times 2.33 \times 0.063\ \text{Ci g}^{-1} \times 3.7\text{x}10^{10}\ \text{Bq Ci}^{-1} \div 3.2\text{x}10^{7}\ \text{s y}^{-1} = 7.35\text{x}10^{4}\ \text{Bq s}^{-1}\ {}^{239}\text{Pu}$$

The annual exhaust volume of $1.88\text{x}10^{9}$ m^3 y^{-1} for the Building 12 stack [see Fig. 18-2; (Andrews ca. 1973)] was converted to 58.8 m^3 s^{-1} to support calculation of the average concentration of plutonium in the stacks.

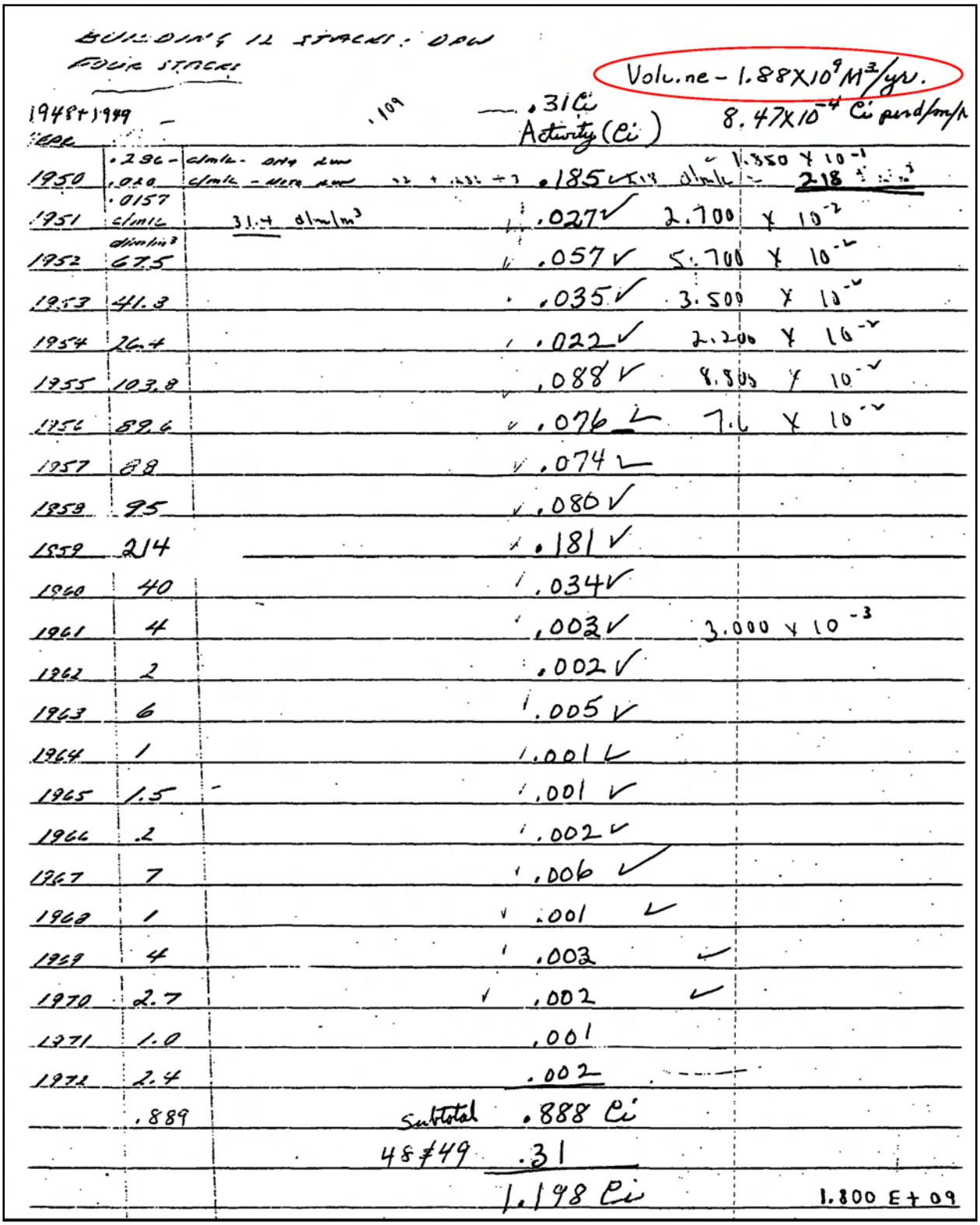
For the screening-level evaluation of releases from the DP West Building 12 stacks in 1949, the closest potentially exposed members of the public were residents at the trailer park located 1 km west of the stacks (see Fig. 18-3). Based on the Level I screening method's assumption that the wind blew toward the closest potentially exposed individual 25% of the time, concentrations at that point were estimated as one-quarter of the average stack concentration. The exposure point concentration (Bq m^{-3}) was multiplied by the all-pathways screening factor (Sv per Bq m^{-3}) from Table 1.1 of NCRP Report No. 123 to yield a screening value that was compared to a limiting value.

DP WEST, BLDG. 12 STACK SAMPLING.

Total activity released from all Stacks in Grams/Month.

	1948	1949	1950	1951	1952	1953	1954	1955
January	0.44	2.40	12.21	1.37	0.33	2.06	0.09	0.26
February	0.28	1.27	8.19	0.27	0.55	0.56	0.08	0.43
March	1.47	3.77	13.17	0.37	0.15	1.71	0.19	1.21
April	1.42	1.34	15.75	0.29	0.66	0.66	0.45	1.67
May	1.21	1.58	2.73	0.69	1.59	0.63	0.24	1.87
June	0.99	2.88	1.25	0.88	2.43	0.71	0.64	3.37
July	1.27	5.34	1.18	4.59	2.81	0.46	0.41	0.82
August	1.56	9.65	1.26	0.45	0.61	0.39	0.33	1.30
September	2.31	16.19	1.04	0.27	2.53	0.48	0.39	1.98
October	2.99	15.13	2.62	0.79	3.02	0.30	1.45	4.62
November	2.44	12.78	1.31	0.25	1.07	0.26	0.98	1.82
December	1.53	14.27	1.03	0.21	0.96	0.19	0.36	0.45
Total Per Year	17.91	86.60	61.74	10.43	16.71	8.41	5.01	19.82

Fig. 18-1. Table of corrected annual releases from DP West Building 12 stacks for 1948 through 1955 per Hyatt (1956)



BUILDING 12 STACKS: DPW
FOUR STACKS

Volume - 1.88X10^9 M^3/yr.

1948+1949 — .109 — .31 Ci
Activity (Ci) 8.47X10^-4 Ci per d/m/m

Year			Activity (Ci)	
1950	.286 - c/mlc - DNA run .020 c/mlc - Note run		.185	1.850 X 10^-1 d/mlc = 218
1951	.0157 c/mlc	31.4 d/m/m^3	.027	2.700 X 10^-2
1952	d/m/m^3 67.5		.057	5.700 X 10^-2
1953	41.3		.035	3.500 X 10^-2
1954	26.4		.022	2.200 X 10^-2
1955	103.8		.088	8.800 X 10^-2
1956	89.6		.076	7.6 X 10^-2
1957	88		.074	
1958	95		.080	
1959	214		.181	
1960	40		.034	
1961	4		.003	3.000 X 10^-3
1962	2		.002	
1963	6		.005	
1964	1		.001	
1965	1.5		.001	
1966	.2		.002	
1967	7		.006	
1968	1		.001	
1969	4		.003	
1970	2.7		.002	
1971	1.0		.001	
1972	2.4		.002	
	.889	Subtotal	.888 Ci	
		48 & 49	.31	
			1.198 Ci	1.800 E+09

Fig. 18-2. Sheet showing exhaust flow volume and (uncorrected) annual releases from DP West Building 12 Stacks for 1948-1972 (Andrews ca 1973). This handwritten sheet is the most basic documentation found of the 1.2-Ci release total that LASL reported in 1979 for operations before 1973.

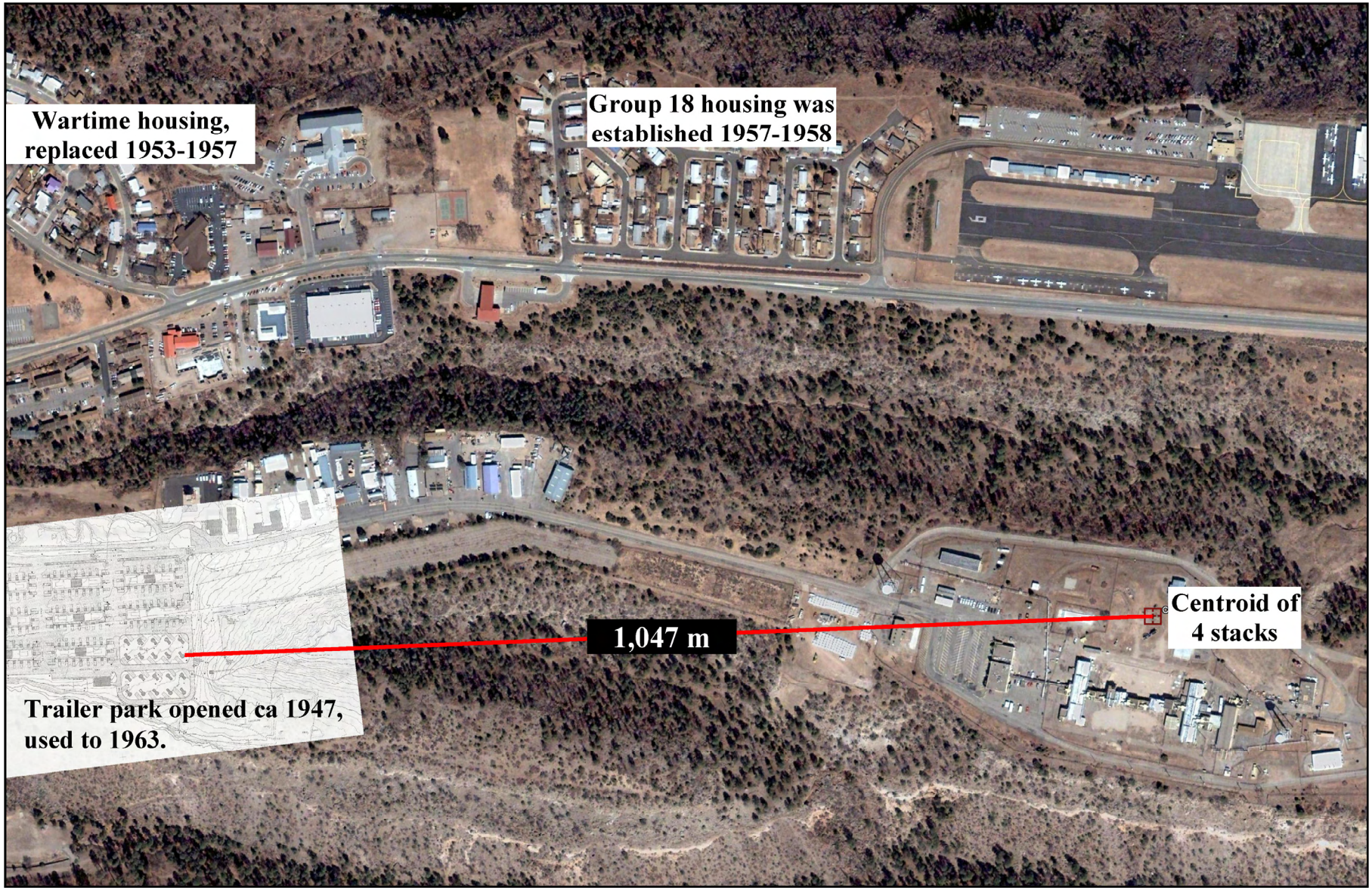


Fig. 18-3. Annotated modern aerial photograph showing former locations of DP West Site Building 12 stacks and nearby residential areas. Trailer park drawing is excerpted from USAEC Drawing LA FM 125 (Sheets L7-SW-1 and L6-SE-1).

For this screening assessment, the limiting value selected was 1.67×10^{-4} Sv y^{-1}, which is based on 1 in 100,000 added risk of fatal or non-fatal cancer using a risk factor of 6.0×10^{-2} Sv^{-1} (ICRP 1990).

It is important to emphasize that the results of the screening calculations are strictly for comparison with an environmental standard (limiting value), to determine if compliance with that standard is assured or further investigation is warranted. The screening values are not intended to represent estimates of actual doses to individuals.

For Level II screening, the release height was determined to be 58.6 ft above ground level based on LASL Drawing 12T35397A2 (See Fig. 18-4). The dimensions of the portion of Building 12 that housed the filters and precipitators and faced west was estimated to have been 14.3 m high by 27.9 m wide (see Fig. 18-5) based on analysis of Photograph 2284 and a report documenting demolition of the building (Christensen et al. 1975).

The atmospheric concentration at the exposure point was estimated using Equation 1 with $f = 0.25$, $Q = 7.35\times10^{4}$ Bq s^{-1}, and u equal to the suggested default value of 2 m s^{-1}.

$$C = \frac{f\ Q\ B}{u} \qquad (1)$$

Where:

C = average atmospheric concentration at exposure point, µCi m^{-3}

f = fraction of time that the wind blew toward the receptor of interest

Q = release rate (µCi s^{-1})

B = the Gaussian plume model diffusion factor modified for building wake effects (from Fig. 1.5 of NCRP Report No. 123)

u = mean wind speed, m s^{-1}

The resulting concentration was multiplied by the atmospheric screening factor from Table 1.1 of NCRP Report No. 123 to obtain the Level II screening value. In accordance with NCRP recommendations, that screening value was compared to 10% of the limiting value in recognition of uncertainties inherent within the calculations and associated assumptions.

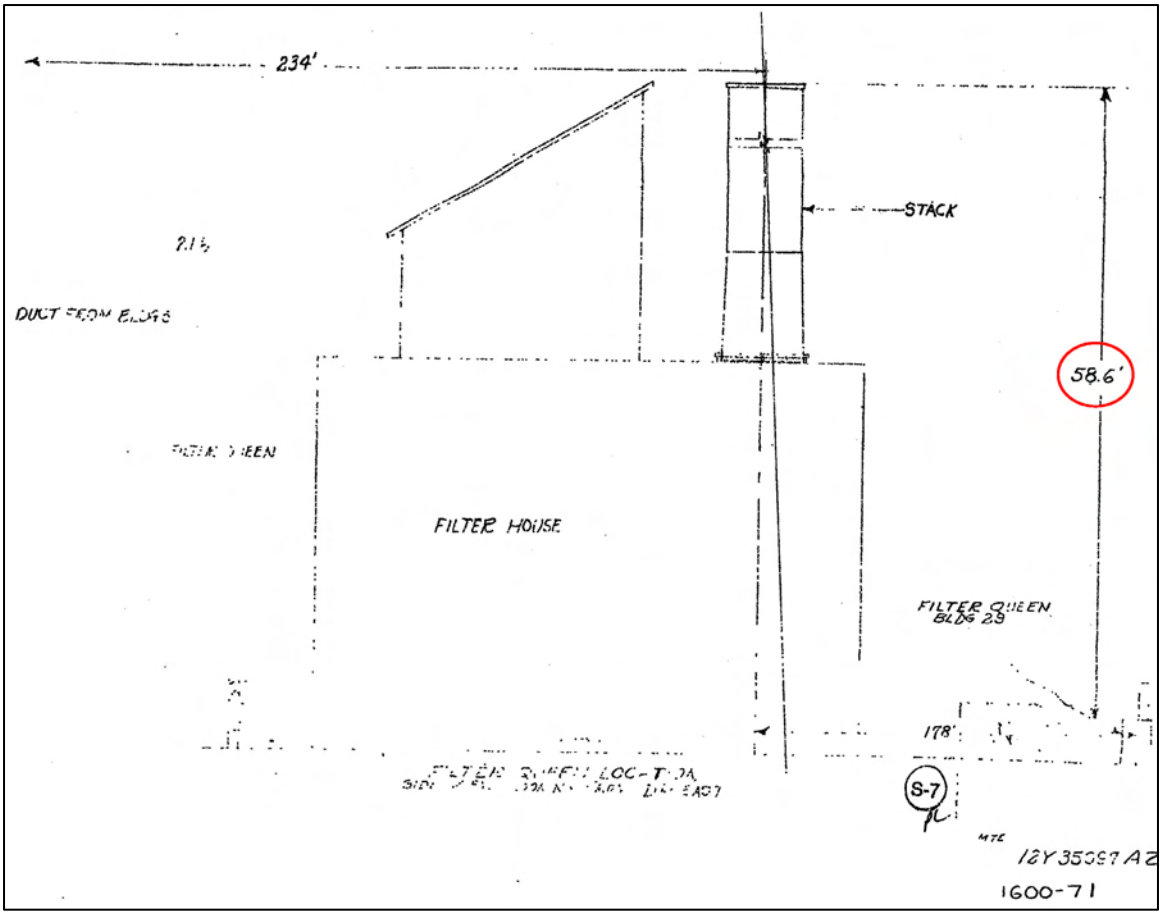


Fig. 18-4. Drawing of DP West Site Building 12 filter house and stacks

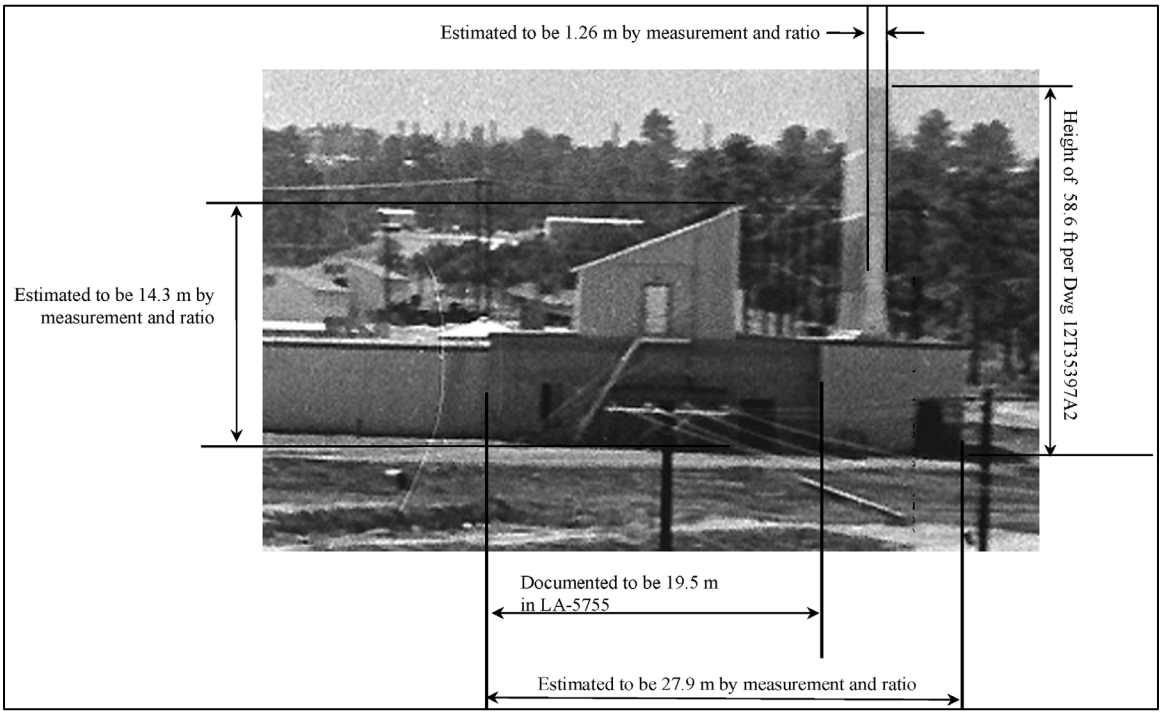


Fig. 18-5. Annotated section of Photograph 2284 showing Building 12 from the east

Historical documents and interviews with residents of Los Alamos indicate that residents were allowed to maintain vegetable gardens after World War II, including at the trailer park west of DP Site, but no evidence has been found of production of animal food products within the townsite. The two screening values were summed and compared to the screening limit (i.e., the limiting value divided by ten as in Level II) to determine whether further evaluation of historical exposures is warranted. In Level III screening, the exposure point air concentration from Level II screening was multiplied by a screening factor for inhalation and external sources/submersion from Table 1.1 of NCRP Report No. 123 and by a second screening factor for vegetable consumption from the same table to obtain screening values for inhalation and external exposure as well as for consumption of home grown vegetables.

Screening Worksheets

The final 18 pages of this chapter present copies of the applicable worksheet pages by which the NCRP Report No. 123 screening method was applied to the DP West Building 12 stack releases.

Results of the Screening

The results of preliminary screening of airborne ^{239}Pu releases from DP West site Building 12 stacks during 1949 are presented in Table 18-1. In Level I and Level II screening, the screening value exceeded the limiting value by at least four orders of magnitude, prompting application of the screening methodology at the next highest level.

The results of the screening calculations are strictly for comparison with an environmental standard (limiting value), to determine if compliance with that standard is assured or further investigation is warranted. The screening values are not intended to represent estimates of actual doses to individuals.

The results of Level III screening, which again exceeded the limiting value by over four orders of magnitude, indicate that airborne ^{239}Pu releases from Building 12 stacks– as represented by estimated releases during 1949– warrant further evaluation by experts in environmental radiological assessment.

Table 18-1. Summary of the preliminary screening of airborne ^{239}Pu releases from DP West Site Building 12 stacks during 1949 using the methodology of NCRP Report No. 123

Level of Screening	Features of Screening Methodology	Screening Value (Sv y^{-1})	Screening Limit exceeded?	NCRP Guidance
I	Vent air, all pathways, concentration at exposure point set equal to 25% of stack concentration.	310	Yes	Proceed to Level II
II	Vent air, all pathways, Gaussian plume modeling to exposure point outside near-wake region, wind blows toward exposure point 25% of the time.	0.37	Yes	Proceed to Level III
III	Vent air, specific pathways (inhalation, external exposure, consumption of vegetables), same dispersion assumptions as Level II.	0.37	Yes	"Seek assistance from experts in environmental radiological assessment"

References

Andrews LL. Los Alamos National Laboratory site releases up to 1972. Los Alamos Scientific Laboratory. ca. 1973. Repos. Nos. 1733, 1734.

ANL/EVS. EVS human health fact sheet, summary radioactive properties for selected radionuclides. Lemont, IL: Argonne National Laboratory, Environmental Science Division; 2005.

Christensen E, Garde R, Valentine A. Demolition of Building 12, an old plutonium filter facility. Los Alamos, NM: Los Alamos National Laboratory; LA-5755; 1975. Repos. No. 2349.

Fuehne DP. Personal communication with David P. Fuehne of LANL Meteorology & Air Quality Group, 2008. Electronic correspondence summarized by LANL staff. 2008. Repos. No. 7875.

Hyatt EC. Total alpha activity released from DP West stacks, Bldg. 12 from 1948 through 1955 (memorandum to Dean D. Meyer). Los Alamos Scientific Laboratory. 1956. Repos. No. 6601.

ICRP. 1990 Recommendations of the International Commission on Radiological Protection. New York; ICRP Publication 60; 1990.

NCRP. Screening Models for Release of Radionuclides to Atmosphere, Surface Water, and Ground. Bethesda, MD: National Council on Radiation Protection and Measurements; NCRP Report No. 123; 1996.

1.1 Atmosphere Screening Level I: Vent Air

Note: Use a separate sheet for each radionuclide until all radionuclides are summed.

I-A-1: Specify the radionuclide released by chemical symbol and atomic mass number (for example, ^{131}I).

I-A-2: Specify the release rate, Q, of the radionuclide entered in I-A-1. This release rate is obtained by estimating the amount released continuously or intermittently in 1 y (Bq y^{-1}) and dividing by the number of seconds in a year (3.2×10^7 s y^{-1}).

I-A-3: Enter the volumetric flow rate of the exhaust vent, V. If the volumetric flow rate of the exhaust vent is unknown, assume a value of 0.3 m^3 s^{-1}.

I-A-4: Calculate the air concentration in the exhaust vent, C_e, for the radionuclide by dividing the release rate (I-A-2) by the volumetric flow rate (I-A-3).

I-A-5: Assume that the wind blows only 25 percent of the time toward the potentially exposed individual. Multiply the values in I-A-4 by 0.25 to calculate the atmospheric concentration, C.

I-A-6: Select from Table 1.1 the all paths screening factor, SF, for the radionuclide entered in I-A-1. The value of SF includes the combined effects of all significant potential pathways of exposure.

I-A-7: Calculate the screening value, SV, by multiplying the atmospheric concentration (calculated in I-A-5) by the SF (I-A-6).

I-A-8: Sum the results in I-A-7 for all radionuclides for all sheets.

I-A-9: Enter the appropriate limiting value. This limiting value may be equivalent to a regulatory dose limit.

I-A-10: If the screening value of the dose estimate in I-A-8 is less than the limiting value entered in I-A-9, **compliance with the limiting value is assured.** If the value in I-A-8 is greater than the limiting value, **proceed to the next level of screening (Section 1.2).**

1-A-1:	Radionuclide	Pu-239	
I-A-2:	Release rate, Q	7.4×10^{4}	Bq s^{-1}
I-A-3:	Volumetric flow rate, *V*	58.8	m^3 s^{-1}
I-A-4:	Exhaust concentration: $C_e = Q V^{-1}$ (I-A-2)(I-A-3)$^{-1}$	1,300	Bq m^{-3}
I-A-5:	Atmospheric concentration: $C = 0.25\ C_e$ 0.25 (I-A-4)	310	Bq m^{-3}
I-A-6:	Enter Table 1.1 *SF* values for the radionuclide	1.0×10^{0}	Sv per Bq m^{-3}
I-A-7:	Screening value: $SV = C \times SF$ (I-A-5) (I-A-6)	310	Sv y^{-1}
I-A-8:	Sum results for all radionuclides in I-A-7	310	Sv y^{-1}
I-A-9:	Limiting value	1.67×10^{-4}	Sv y^{-1}
I-A-10:	Is I-A-8 less than I-A-9?	No	

Yes– STOP
No– Proceed to Section 1.2

1.2 Atmosphere Screening Level II: All Pathways

II-bi: Basic Information, bi, Required for Completing Screening Levels II and III

(for description of parameters see Figure 1.3)

Note: Use a separate sheet for each radionuclide until all radionuclides are summed.

II-bi-1: Enter radionuclide from I-A-1 by chemical symbol and atomic mass number.

II-bi-2: Enter for the radionuclide the air concentration in the exhaust vent, C_e, as calculated in I-A-4.

II-bi-3: Determine the height above ground, H, at which the release will occur. This determination should exclude the effect of plume rise. If the release occurs in a narrow valley, use $H = 0$.

II-bi-4: Determine the height, h_b, and width, h_w, of the building most influencing the dispersion process. This should be the building on which the release point is located unless there is a much larger building in the immediate vicinity, in which case the latter building should be used for this purpose.

II-bi-5: For the building most influencing flow, determine the surface area, A_G, of the side of the building nearest the location of potential human exposure. Multiply the height of the building, h_b, by the width of the building side nearest the potential receptor, h_w.

II-bi-6: Determine the diameter of the stack or vent from which the radionuclide is being released. If the vent is other than circular, determine its equivalent circular diameter, d, by multiplying the area of the vent by 1.3 and taking the square root of the product.

II-bi-7: Determine the wind speed, u, at the release point. If data are not readily available, assume a value of 2 m s^{-1}.

II-bi-8: Determine the distance, x, between the release point and the nearest point routinely occupied by humans. **Proceed to II-A-1.**

II-bi-1:	Radionuclide from I-A-1	Pu-239	
II-bi-2:	Enter from I-A-4 the calculated concentration in the exhaust vent, C_e	1,300	Bq m^{-3}
II-bi-3:	Release height, H	17.9	m
II-bi-4:	Building height, h_b	14.3	m
	and building width, h_w	27.9	m
II-bi-5:	Building surface area: $A_G = h_b h_w$	399	m^2
II-bi-6:	Diameter of stack or vent, d	1.3	m
II-bi-7:	Wind speed, u	2	m s^{-1}
II-bi-8:	Distance from release point to point of exposure, x	1047	m

Proceed to II-A-1

II-A: Initial Decisions

II-A-1: If the release point and the exposure point are both located (a) on the roof, or (b) on the same side of the building, or (c) in the same building, or confinement of the plume is important, **proceed to Section II-B**.
If none of these conditions apply, **proceed to II-A-2**.

II-A-2: Multiply the building height, h_b, in II-bi-4 by 2.5. The result will be used to determine the effect of the building on the atmospheric dispersion of the released radionuclide(s). Enter the release height, H. Compare the result of the multiplication with H.
If H in II-bi-3 is greater than 2.5 times h_b, **proceed to Section II-C.** This condition represents the case where the building will not affect atmospheric dispersion. In this case proceed to II-C.
If H is less than or equal to 2.5 times h_b, **proceed to II-A-3**. This condition represents the case where the building will affect atmospheric dispersion.

II-A-3: To determine which type of atmospheric dispersion model should be used for situations in which building wakes are formed, take the square root of the building surface area, A_G, (II-bi-5) and multiply the result by 2.5.
If the distance, x, between the point of release and the nearest point of exposure (II-bi-8) is equal to or less than 2.5 times the square root of A_G, or is equal to or less than 100 m **proceed to Section II-D.** This condition represents the case where the receptor is in the near-wake region of the building.
If the distance, x, between the point of release and the nearest point of exposure (II-bi-8) is greater than 2.5 times the square root of A_G, and greater than 100 m **proceed to Section II-E.** This condition represents the case where the receptor is outside the near-wake region of the building.

II-A-1: Are the point of release and the potentially exposed individual located as described on the preceding page? No

Yes– Proceed to Section II-B
No– Proceed to Section II-A-2

II-A-2	h_b (II-bi-4)	14.3	m
	$2.5\ h_b$ =	36	m
	H (II-bi-3)	17.9	m

Is H greater than $2.5\ h_b$? No

Yes– Proceed to Section II-C
(no building wakes)
No– Proceed to Section II-A-3
(building wakes)

II-A-3:	A_G (II-bi-5)	399	m^2
	$2.5\ A_G^{1/2}$ =	50	m
	x (II-bi-8)	1047	m

Is x equal to or less than $2.5\ A_G^{1/2}$ or equal to or less than 100 m? No

Yes– Proceed to Section II-D
(near wake region)
No– Proceed to Section II-E
(outside near-wake region)

II-E: Receptor Outside the Near-Wake Region of Building

Condition: Distance to exposure point is greater than 2.5 times the square root of the building surface area, A_G, and greater then 100 m.

II-E-1: If the downwind distance to the nearest point of potential human exposure, x, is less than 2 km from the point of release, use Figure 1.5 to determine the value of the building wake dispersion factor, B, corresponding to the building surface area, A_G, given in II-bi-5 and x in II-bi-8.
If the downwind distance, x, to the nearest point of potential human exposure is greater than 2 km from the point of release, use Figure 1.4, assuming a release height at ground level, or 0 m. Substitute the value P from Figure 1.4 for the building wake dispersion factor.

II-E-2: Enter radionuclide, release rate, Q, and wind speed, u. To calculate the downwind atmospheric concentration for each radionuclide for the potentially exposed individual, assume that the wind blows 25 percent of the time toward the potentially exposed individual. Multiply the release rate from I-A-2 by the dispersion factor, B or P, in II-E-1 and by 0.25; then divide by the wind speed, u, given in II-bi-7. However, if $u > 5\ \mathrm{ms}^{-1}$, use $u = 5\ \mathrm{ms}^{-1}$ in this calculation.

Enter the calculated atmospheric concentration, and **proceed to Section II-F**.

II-E-1:	Dispersion factor B from Fig. 1.5 or P from Fig. 1.4 [see Exhibits G and H]	4×10^{-5}	m^{-2}

II-E-2:	Radionuclide (II-bi-1)	Pu-239	
	Release rate, Q (I-A-2)	7.35×10^{4}	$Bq\ s^{-1}$
	Wind speed, u (II-bi-7)	2	$m\ s^{-1}$
	Atmospheric concentration: $C = 0.25\ Q\ (B \text{ or } P)\ u^{-1}$ [0.25 (I-A-2) (II-E-1)] (II-bi-7)$^{-1}$	0.37	$Bq\ m^{-3}$

Proceed to Section II-F

II-F: Comparison of Screening Value Using Screening Limiting Dose

II-F-1: Enter the radionuclide from II-bi-1. Enter the atmospheric concentration calculated for the radionuclide from Section II-B-1, II-B-2, II-C-2, II-D-1, or II-E-2, depending on atmospheric concentration model used.

II-F-2:. Enter from Table 1.1 the all paths screening factor, *SF*, for the radionuclide.

II-F-3: Multiply the atmospheric concentration entered in II-F-1 by the atmospheric screening factor entered in II-F-2 to obtain the screening value, *SV*.

II-F-4: Sum the results in II-F-3 for all sheets and all radionuclides.

II-F-5: Take the limiting value from I-A-9, divide by 10, and enter. (Note: There are uncertainties inherent within the calculations and assumptions made in this Section. Dividing this limiting value by a factor of 10 reduces the possibility of exceeding the limiting value because of these uncertainties.)

II-F-6: If II-F-5 is greater than II-F-4, **compliance with the limiting value is assured.**
If the value in II-F-5 is equal to or less than II-F-4, **proceed to Screening Level III.**

II-F-1:	Radionuclide from II-bi-1	Pu-239	
	Atmospheric concentration, *C*, from II-B-1, II-B-2, II-C-2, or II-E-2	0.37	Bq m^{-3}
II-F-2:	Atmospheric screening factor, *SF* , from Table 1.1 for each radionuclide	1×10^{0}	Sv per Bq m^{-3}
II-F-3:	Calculate screening value: *SV = C SF* (II-F-1) (II-F-2)	0.37	Sv y^{-1}
II-F-4:	Sum the results in II-F-3 for all sheets and radionuclides	0.37	Sv y^{-1}
II-F-5:	(I-A-9) × 0.1	1.67×10^{-5}	Sv y^{-1}
II-F-6:	Is II-F-5 greater than II-F-4?	No	

Yes– STOP
No– Proceed to Screening Level III

1.3 Atmosphere Screening Level III: Specific Pathways

III-A: Calculation of Inhalation and External Exposure

Condition: It is assumed that inhalation and external exposure pathways always exist at the location corresponding to distance, x, given in II-bi-8.

Note: Use a separate sheet for each radionuclide until all radionuclides are summed.

III-A-1: Enter the radionuclide and the calculated atmospheric concentration from Section II-F-1 for the downwind distance, x.

III-A-2: For each radionuclide, enter the screening factor given in Table 1.1. These factors include the combined effects of internal exposure through inhalation and external exposure to the contaminated plume and ground surface.

III-A-3: Estimate the screening dose from inhalation and external sources of exposure. Multiply the atmospheric concentration entered in III-A-1 by the screening factor entered in III-A-2.

Sum the results for the screening dose.

III-A-1:	Radionuclide from II-F-1	Pu-239	
	Atmospheric concentration, *C*, from II-F-1	0.37	Bq m^{-3}
III-A-2:	Screening factor, *SF* , from Table 1.1	0.55	Sv per Bq m^{-3}
III-A-3:	Screening value for inhalation and external exposure for each radionuclide: *SV = C SF* (II-A-1) (II-A-2)	0.20	Sv y^{-1}
	Sum of results for all radionuclides and for all sheets	0.20	Sv y^{-1}

III-B: Exposure *via* the Ingestion of Terrestrial Food Products

Note: Use a separate sheet for each radionuclide until all radionuclides are summed.

III-B-1: Enter radionuclide from III-A-1.

III-B-2: For conditions where pasture and/or vegetable gardens exist at the receptor location (distance x) given in II-bi-8, enter the atmospheric concentration from III-A-1 for the food categories that may be produced at this location. Enter zero for the food categories that are not likely to be produced at this location. If all the values entered are greater than zero, skip III-B-3 and **proceed to III-B-4.**
If some of the values entered are zero, go to next step.

III-B-3: For food categories that are not produced at the location (distance x) given in II-bi-8: (a) Determine the straight-line distance between the nearest potential production location of each food category and the point of release. (b) Return to the beginning of Section II. (c) Specify new values of x in II-bi-8 for the nearest potential production locations of each food category. (d) Recalculate the atmospheric concentration in either II-C, II-D or II-E for each food category. (e) Enter the recalculated atmospheric concentration for each food category. (Note: The atmospheric concentration will be used to calculate the concentration of radionuclide in terrestrial food products at the nearest specified sites of potential food production.)

III-B-1: Radionuclide from II-A-1 Pu-239

III-B-2: Can vegetable gardens and/or pastures occur at location *x* (II-A-1)?

`

Yes– For each food category potentially produced at location x, enter the atmospheric concentration from III-A-1 in blanks below.

No– Enter zero in blanks below for the atmospheric concentration for the food categories not produced at location x and go to next step.

Vegetables 0.37 Bq m^{-3}

Animal food products 0 Bq m^{-3}

If all the above values are greater than zero– **Proceed to III-B-4**

III-B-3:
(a) Determine distance to the point of nearest production for each food category
(b) Return to Section II.
(c) Specify *x* in II-bi-8 for each food category.
(d) Recalculate atmospheric concentrations for each food category.
(e) Enter recalculated atmospheric concentration from either II-C, II-D, or II-E for each radionuclide and food category in the blanks below.

Vegetables _____ Bq m^{-3}

Animal food products _____ Bq m^{-3}

III-B-4: Calculate the concentration of the radionuclide in terrestrial food products.

Enter value for the concentration of the radionuclide in the atmosphere at the nearest potential sites of vegetable production, and milk and meat production. These values should be obtained from either III-B-2 or III-B-3.

III-B-5: Estimate the screening value from the ingestion of terrestrial foods.

(a) For each radionuclide and food product, enter appropriate screening factor from Table 1.1.

(b) Multiply the atmospheric concentration of the radionuclide (estimated in III-B-4) by the radionuclide-specific screening factors.

(c) Sum the results to obtain the total ingestion screening value. **Proceed to III-C.**

III-B-4:	Enter radionuclide from III-B-1	Pu-239	
	Enter atmospheric concentration, *C*, from either III-B-2 or III-B-3		
	Vegetables	0.37	Bq m^{-3}
	Animal food products	0	Bq m^{-3}
III-B-5:	(a) Enter appropriate screening factor, *SF* , from Table 1.1		
	Vegetables	0.45	Sv per Bq m^{-3}
	Animal food products	0	Sv per Bq m^{-3}
	(b) Screening value: $SV = C \times SF$ (II-B-4) (III-B-5)		
	Vegetables	0.17	Sv
	Animal food products	0	Sv
	(c) Sum the results to obtain the total screening value from ingestion of radionuclide	0.17	Sv

Proceed to III-C

III-C: Receptor Exposed to Pathways from Multiple Locations

Condition: The hypothetical individual residing at the location (distance x) in III-A-1 is assumed to have access to contaminated foods at the potential sites of production nearest the point of release.

III-C-1: Calculate the screening value from all pathways.

(a) Enter from III-A-3 the total screening value calculated for inhalation and external sources of exposure.

(b) Enter the total screening value calculated in III-B-5 for ingestion of contaminated food.

(c) Add the inhalation and external screening values entered in III-C-1(a) to the ingestion doses in III-C-1(b) to calculate the total screening value from all pathways of exposure.

III-C-2: Enter the screening limiting value from II-F-5.

III-C-3: If the total screening value from all pathways in III-C-1(c) is less than the screening limit in III-C-2, **compliance with the limiting value is assured.**

If III-C-1(c) is equal to or greater than III-C-2 , **seek assistance from experts in environmental radiological assessment.**

III-C-1:	(a) Enter III-A-3: external and inhalation screening value	0.20	Sv
	(b) Enter III-B-5: screening value from ingestion	0.17	Sv
	(c) Sum external, inhalation, ingestion screening values: [III-C-1(a)] + [III-C-1(b)]	0.37	Sv
III-C-2:	Enter II-F-5: screening limit	1.67×10^{-5}	Sv
III-C-3:	Is III-C-1(c) less than III-C-2?	No	

Yes– STOP
No– Seek expert assistance

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