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Soil Screening Concentrations for Airborne Exposure to Radionuclides Released from Wildland Fires and Fugitive Dust Sources

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Title: Soil Screening Concentrations for Airborne Exposure to Radionuclides Released from Wildland Fires and Fugitive Dust Sources

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1. Index Codes
   Building/Type: NA SSC ID: NA Site Area: NA
2. Quality Level and Determination No.: NA
3. Objective/Purpose: Calculate soil screening concentrations for two release scenarios: 1) radionuclides suspended in fugitive dust, and 2) radionuclides on plant surfaces and in plant tissue that are released during a wildland fire on INL Site lands. Soil screening concentrations are based on a dose of 10 mrem effective dose (ED) to a firefighter, INL Site worker, or member of the public.
4. Conclusions/Recommendations: Soil screening concentrations that would result in an effective dose of 10 mrem to an individual (firefighter, INL Site worker, or member of the public) exposed to releases from a wildland fire or fugitive dust emissions were calculated for key radionuclides at the INL. These concentrations are intended to be compared with radionuclide soil measurements to determine whether soil contamination may need to be monitored for or remediated.

5. Review (R) and Approval (A) and Acceptance (Ac)[1]:

		Typed Name/Organization	Signature or eCR No. [2]
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Nuclear Safety[3]	Ac	NA	
Software Quality Assurance[4]	R	NA	

1. Review and approval are required. See LWP-10200 for definitions and responsibilities.
2. Electronic Change Request (eCR) numbers in lieu of signatures on this page indicate electronic final review, approval and acceptance by the listed individuals.
3. If required, per LWP-10200.
4. Required if the ECAR contains safety software validation.

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SCOPE AND BRIEF DESCRIPTION

The objective of this calculation is to provide screening concentrations in soil and biota for two release scenarios: 1) A wildland fire burns across INL lands and radionuclides on and in the tissue of plants are released to the air, and 2) radionuclides in soil that are suspended into the air via wind erosion processes. Radionuclides in biota are the result of root uptake and resuspension of radionuclide in soil. The soil or plant concentration that would result in a dose of 10 mrem effective dose (ED) to an individual exposed to either a fire or soil suspension event was calculated. The ED limit of 10-mrem was selected because 1) it is the dose limit for airborne release as stated in 40 CFR Part 61 Subpart H (NESHAPS), and 2) it is 1/10th the 100 mrem/yr dose limit as stated in DOE Order 458.1. The assessment is generic and is not specific to an actual contaminated site on the INL. The assessment is similar to that provided in Engineering Design File 1873 (EDF-1873, 2001). However, EDF-1873 was a forward calculation where the measured concentrations in soil and biota for contaminated sites on the INL were used as input to the model, and the dose to various individuals were calculated. This assessment is a backwards calculation in that the soil and biota concentrations that result in a dose of 10 mrem ED are calculated. This ECAR uses data from EDF-1873 such as fire burn rates and receptor breathing rates in the calculation.

DESIGN OR TECHNICAL PARAMETER INPUT AND SOURCES

Wildland Fire Emission Model

The wildland fire emission model assumes that when the biomass is burned, all radionuclides both within the plant tissue and on the plant surface are released. This model differs from what was used in EDF-1873 because radionuclides on the plant surface were not accounted for in the model used for EDF-1873. The radionuclide concentration on the plants is thus composed of radionuclides incorporated into the plant tissue via root uptake and radionuclides on the surface of the plants. The model for radionuclides on the surface of the plant is based on the PATHWAY (Whicker and Kirchner, 1987) and COMIDA (Abbott and Rood, 1993) model. The soil-plant conceptual model for radionuclides on the surface of the plant is illustrated in Figure 1.

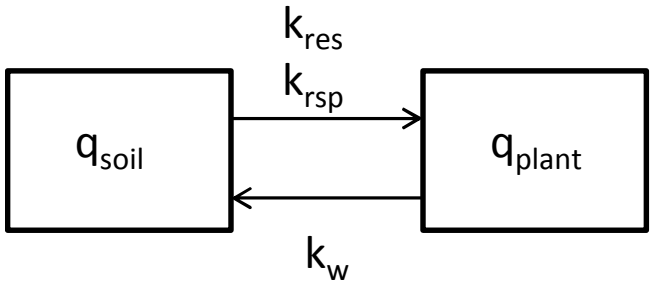

Figure 1. Conceptual model for soil-plant model for radionuclides on the plant surface.

The differential equations describing the soil-plant conceptual model are given below.

$$\frac{dq_{soil}}{dt} = k_w q_{plant} - \left(k_{res} + k_{rsp}\right) q_{soil}$$
$$\frac{dq_{plant}}{dt} = \left(k_{res} + k_{rsp}\right) q_{soil} - k_w q_{plant} \quad (1)$$

where

q_{plant} = radionuclide inventory on plant (pCi/m^2),

q_{soil} = radionuclide inventory susceptible to resuspension on soil surface (pCi/m^2),

k_w = weathering rate constant (1/d),

k_{res} = resuspension rate constant (1/d),

k_{rsp} = rainsplash rate constant (1/d).

The solution to the plant compartment Equation 1 at equilibrium is given in Equation 2.

$$q_{plant} = \frac{q_{soil}\left(k_{res} + k_{rsp}\right)}{k_w} \tag{2}$$

The radionuclide inventory on the plant is converted to concentration (C_{plant}) by dividing by the plant biomass (B, kg/m^2, dry weight). The soil inventory is calculated by the product of the soil concentration (C_{soil}, pCi/kg) and the areal soil density (ρ_A, kg/m^2). The areal soil density is calculated by the product of the soil bulk density (kg/m^3) and the thickness of the layer that is susceptible to resuspension (m).

Added to the radionuclides on the plant surfaces are the radionuclides incorporated in the plant tissue. Radionuclides in the plant tissue are calculated using the radionuclide-specific soil-to-plant transfer factor.

$$C_{plant} = B_{iv}\, C_{soil} \tag{3}$$

where

B_{iv} = soil-to-plant transfer factor, dry weight (kg_{soil}/kg_{plant}),

C_{plant} = radionuclide concentration in plant (pCi/kg_{plant}),

C_{soil} = radionuclide concentration in soil (pCi/kg_{soil}).

Thus the total concentration of radionuclides on and in the plant in terms of the soil concentration is given by Equation 4

$$C_{plant} = \frac{C_{soil}\,\rho_A \dfrac{k_{res} + k_{rsp}}{k_w}}{B} + B_{iv}\, C_{soil} \tag{4}$$

The release rate of radionuclides during a burn is given by

$$Q_{fire} = \left(\frac{C_{soil}\,\rho_A \dfrac{k_{res} + k_{rsp}}{k_w}}{B} + B_{iv}\, C_{soil} \right) \frac{B}{t_{burn}} \tag{5}$$

where

Q_{fire} = radionuclide release rate from a fire (pCi/m^2-s),

t_{burn} = burn time (seconds).

The burn time is given by the quotient of the length of the source parallel to the direction of the burn (L_{fire}, m) and burn rate (R_{fire}, m/s). The soil concentration that would result in a dose limit being met is given by

$$C_{soil} = \frac{D_{\lim}}{DF\left(\frac{C_{soil}\,\rho_A\,\frac{k_{res}+k_{rsp}}{k_w}}{B} + B_{iv}\,C_{soil}\right)\frac{B}{t_{burn}}\,AT\,BR\,DC} \quad (6)$$

where

DF = air dispersion factor for the area of the source and averaging time (s/m),

AT = averaging time (hr),

BR = breathing rate (m^3/hr),

DC = dose coefficient (mrem/pCi),

D_{lim} = dose limit (mrem),

The air dispersion factor was calculated for different areas and and averaging times using the AERMOD model. Application of AERMOD is discussed in a subsequent section of this document. Model parameter values are summarized in Table 1.

Table 1. Summary of parameter values for wildland fire emission model.

Parameter	Units	Value	Comments
Resuspension rate constant, k_{res}	1/day	0.0017	Whicker and Kirchner, 1987
Rain splash rate constant, k_{rsp}	1/day	8.6E-04	Whicker and Kirchner, 1987
Weathering rate constant, k_w	1/day	0.0495	Whicker and Kirchner, 1987
Biomass density (dry), B	g/m^2	1230	EDF-1873, page 6
Soil bulk density, ρ_b	kg/m^3	1500	DOE 1993, Table 12
Resuspension layer thickness	m	0.001	Whicker and Rood, 2008, pg 301
Soil areal density, ρ_A	kg/m^2	1.5	Calculated
Burn rate, R_{fire}	m/hr	201	EDF-1873, page 9, based on 660 ft/hr
Breathing rate BR	m^3/hr	1.6	EDF-1873, page 18
Averaging time AT	hrs	1, 8, 24	Value used depends on burn time
Dose limit	mrem	10	1/10th 100 mrem/yr dose limit

Fugitive Dust Emission Model

The fugitive dust emission model is based on soil suspension models described by Cowherd et al. (1985) and is applied to short-term releases and annual releases. The mass emission rate of soil particles less than 10 μm (PM10) for short-term releases is calculated using

$$E_{10h} = 0.036(1 - V)u_{6h}^3 \quad (7)$$

where

V = fraction of soil that is vegetated (conservatively assumed to be zero),

u_{6h} = maximum 6-hr mean wind speed at 7 m (m/s),

E_{10h} = PM10 emission rate (g/m^2-hr)

0.036 = empirical proportionality constant (g/m^2-hr).

The maximum 6-hr mean wind speed was 14.5 m/s and was determined for the period of May 1st to October 31st as provided in EDF-1873. The exponent of 3 was the recommended value by Cowherd et al. (1985). Using these parameters, the E_{10h} value was 109.8 g/m^2-hr (0.0305 g/m^2-s).

The annual average PM10 emission rate from soil is given by

$$E_{10a} = 0.036(1 - V)(u/u_t)^3 F(x) \quad (8)$$

where

u = mean annual wind speed at 7 m height (m/s),

u_t = equivalent threshold wind speed extrapolated to 7 m height (m/s),

$F(x)$ = function plotted in Figure 4-3 in Cowherd et al. (1985),

x = $0.886(u_t/u_m)$

The mean wind speed of 3.57 m/s was provided EDF-1873 and derived from Clawson et al., 1989. The value of u_t is determined by equation 4-3 in Cowherd et al. (1985)[1].

$$u_t = \frac{u_t^*}{0.4}\ln\left(\frac{z_a}{z_0}\right) \quad (9)$$

where

u^*_t = threshold friction velocity (m/s),

z_a = extrapolation height (7 m),

z_0 = roughness height for vegetation-free surface (0.004 m from Abbott, 1999).

[1] There is a mistake in this equation in EDF-1873. The value is multiplied by a factor of 2 and results in an underestimation of the annual average emission factor.

The threshold friction velocity is estimated by the aggregate particle size mode of the soil. Figure 3-4 in Cowherd et al. (1985) provides a plot of the threshold friction velocity as a function of the aggregate particle size mode ranging from 0.1 to 100 mm. Whicker and Rood (2008) provides an equation to estimate the threshold friction velocity.

$$u_t^* = 65.5315 p^{0.417673} \quad (10)$$

where p = aggregate particle size mode (mm). Thus for p= 0.1 mm, u^*_t = 0.25 m/s. Using Equation 9, u_t was calculated to be 2.447 m/s and x was calculated to be 0.593. The function F(x) can be determined using Figure 4-3 in Cowherd et al. (1985) or calculated using Equation 6.47 in Whicker and Rood (2008). Using Equation 6.47 in Whicker and Rood, F(x) was calculated to be 1.877. Assuming no vegetative cover, the annual average soil particulate emission factor is then

$$E_{10a} = 0.036 \text{ g/m}^2\text{ - hr}(1-0)\left(\frac{3.57 \text{ m/s}}{2.447 \text{ m/s}}\right)^3 1.877 = 0.21 \text{ g/m}^2\text{ - hr}$$

or 5.83E-5 g/m^2-s.

The soil concentration that would result in a given dose via the soil suspension pathway is given by

$$C_{soil} = \frac{D_{\lim}}{DF\ E_{10} AT\ BR\ DC} \quad (11)$$

where E_{10} is either E_{10h} or E_{10a} and DF is the dispersion factor for a given area and averaging time that is consistent with with either a short-term or annual emission rate. C_{soil} values were evaluated for averaging times of 1-, 8-, and 24-hr, and annual average. For the 1-, 8-, and 24-hr averaging times, the E_{10h} emission rate was used. For the annual averaging time (8760 hrs), the E_{10a} value was used. The minimum C_{soil} value for these averaging times was reported as the screening value. Model parameter values for the soil suspension model are summarized in Table 2.

Table 2. Summary of parameter values for soil suspension calculations

Parameter	Units	Value	Comments
Maximum 6-hr mean wind speed, u_{6h}	m/s	14.5	EDF-1873, page 10
Mean annual wind speed, u	m/s	3.57	EDF-1873, page 11
Fraction of vegetation, V	---	0	EDF-1873, page 10
Aggregate particle size mode	mm	0.1	Conservatively assumed
Averaging times	hrs	1, 8, 24, 8760	Averaging times in AERMOD
Breathing rate	m^3/hr	1.6	EDF-1873, page 18
Dose limit (effective dose)	mrem	10	1/10th 100 mrem/yr dose limit in DOE Order 458.1 and the dose limit under 40 CFR Part 61 Subpart H

For most of the radionuclide considered, radioactive decay was not significant during the release time. However, for annual releases decay might be important for some radionuclides with half-lives less than

about 20 years. In these cases, a decay correction was applied. The decay correction factor is divided into C_{soil} to provide a C_{soil} value corrected for radioactive decay during annual emissions. The decay factor is derived from the integrated decay equation and is given by

$$DF = \frac{(1 - \exp[-\lambda t])}{\lambda t} \quad (12)$$

where

λ = decay rate constant (ln(2)/half-life) (1/yr),

t = averaging time (1 year).

AERMOD Modeling

AERMOD (EPA 2004a, EPA 2004b) (version 12345) was used to calculate dispersion factors (or X/Q values) for different source sizes and averaging times. Five-years of meteorological data (2000-2004) from the Grid 3 meteorological tower were processed through AERMET (version 12345) as described in Rood (2013). The AERMET simulation was rerun from Rood (2013) using Idaho Falls surface data downloaded from National Climatic Data Center (NCDC) in the TD-3505 ISH data format (http://www1.ncdc.noaa.gov/pub/data/noaa). This format is required for AERMET version 12345 and later. A windrose for the Grid 3 meteorological tower is illustrated in Figure 2

Rectangular area sources were modeled and in all cases, the length of the source parallel to the predominant wind direction was a factor of two greater than its width. This source configuration is realistic for wildland fires because the fire will burn in an area that will elongate parallel to the wind direction. It also provides a conservative dispersion estimate of fugitive dust sources. The predominant wind direction is from the southwest (azimuth 225 degrees), thus the source needed to be rotated 45 degrees. Four receptors were situated around the source along the principle axes of the rectangle. The receptor was located 100 m from the edge of the source (Figure 3). This distance was chosen because conventional dispersion coefficients for steady-state atmospheric transport models have a minimum distance of 100 m. Although AERMOD does not use conventional dispersion coefficients, the distance was retained as a reasonable minimum distance that accounts for not only the accuracy of the dispersion estimates, but a practical limit on where a person might be during a fire. That is, if a person is closer that 100-m or engulfed in burning brush, it is likely other hazards (i.e., smoke inhalation and being severely burned) may overwhelm their radiation dose. The source is centered on the Grid 3 meteorological tower located near the center of the INL (north of the INTEC facility) at UTM Coordinates 343398 E 4828132 N. Source and receptor coordinates are presented in Appendix B.

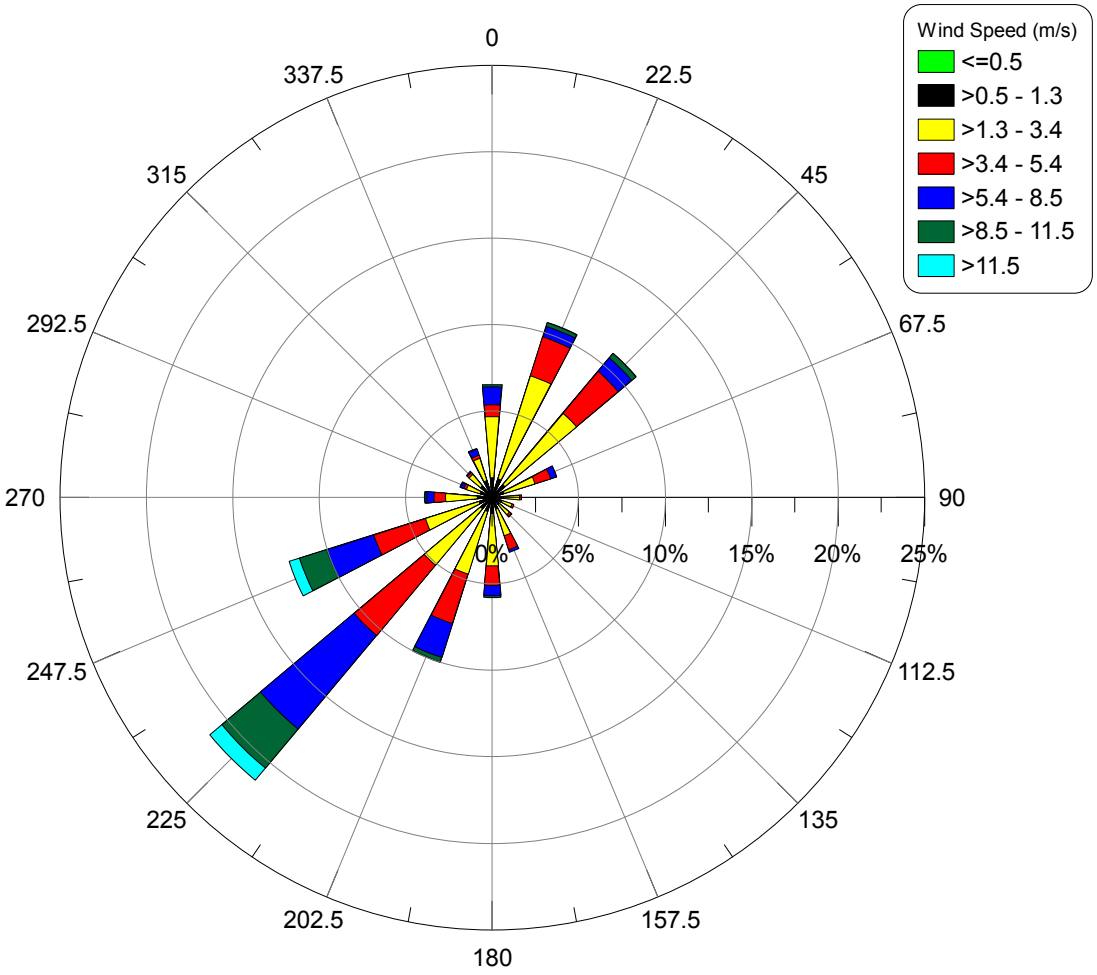

Figure 2. Windrose for the Grid 3 meteorological tower.

The coordinate transformation for the rotated source is given by the equations below.

$$x' = x_o + (x - x_o)\cos\theta + (y - y_o)\sin\theta$$
$$y' = y_o + (x - x_o)\sin\theta + (y - y_o)\cos\theta \quad (13)$$

where

x', y' = transformed x and y coordinates (m),

x_o, y_o = x and y coordinates of origin of rectangular (m),

x, y = x and y coordinates of non-rotated point (m),

θ = rotation angle (degrees azimuth).

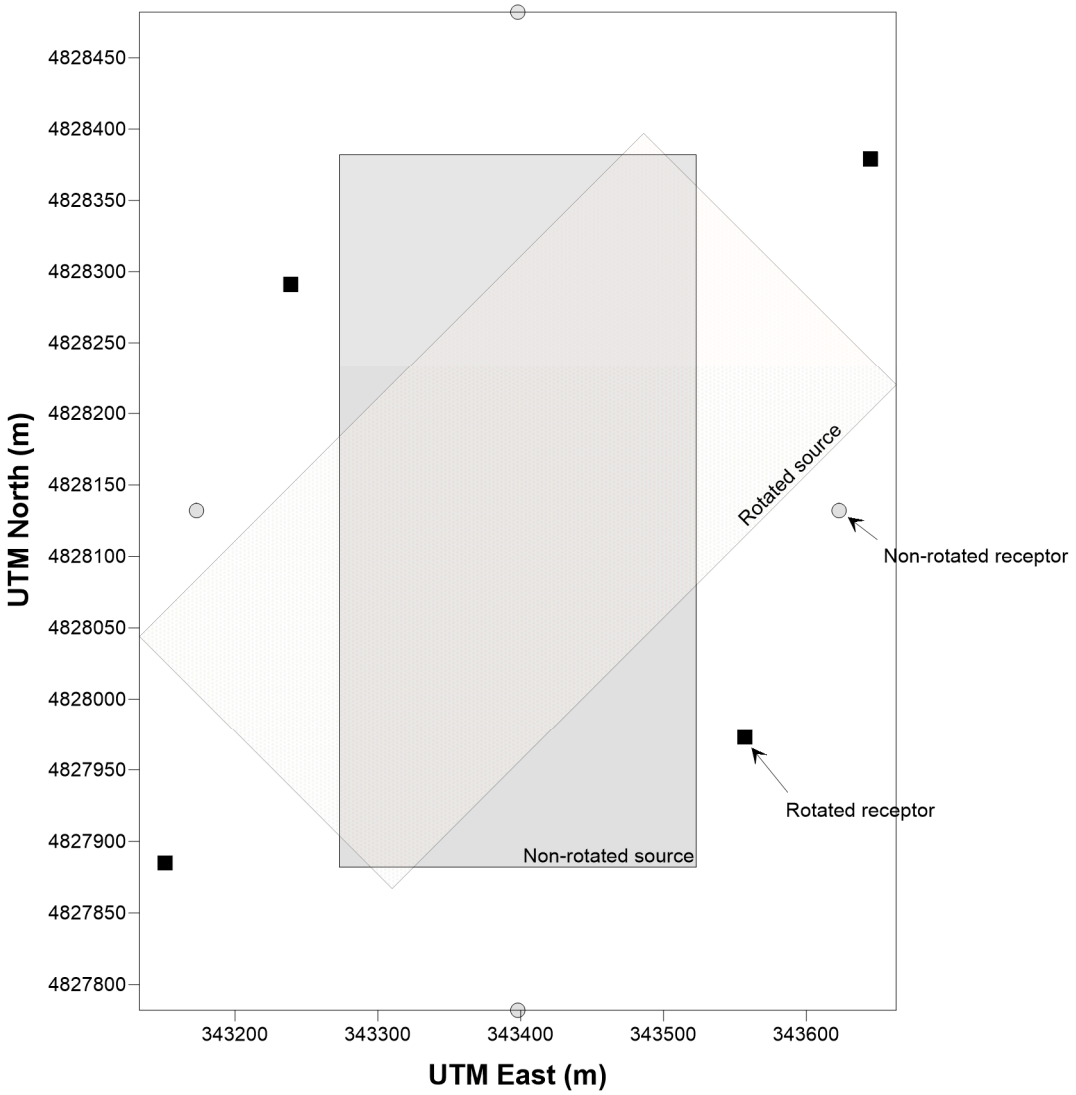

Figure 3. Source and receptor configuration for a rotated and non-rotated source.

The 5-year AERMOD simulation was run to determine maximum 1-hr, 8-hr, and 24-hr dispersion factors at the receptors. For soil suspension sources, annual average dispersion factors at the receptors were also calculated. The dispersion factor (sometimes referred to as the X/Q value) is the average concentration for the averaging time (g/m^3) divided by the source release rate (g/m^2-s) yielding units of s/m. A unit source term (1 g/m^2-s) was used in each of these simulations. Emission scaling factors were used to modify the source term according to the time of year and the wind speed. Maximum concentrations typically occur during winter months under low wind-speed and stable atmospheric conditions, resulting in minimum dispersion conditions. For fire emissions, it is not likely that a wildland fire would occur during the late fall, winter, and early spring months because of cool wet weather and snow cover are not conducive to wildland fires. Thus, the emission rate was set to zero for the months November, December, January, February, March, and April. For all other months, the emission scaling factor was set to 1.0. For the fire releases, three source areas were considered that equate to the time necessary to burn the region in approximately 1-hr, 8-hr, and 24-hr periods. The

source areas, burn times, averaging times, and dispersion factors are summarized in Table 3 for the fire emissions.

Table 3. Source areas, burn times, averaging times, and dispersion factors for fire sources

Dimension of source	Area (km^2)	Burn time (hours)	Averaging time (hours)	Dispersion factor (s/m)
200 m × 100 m	0.02	0.995	1	291.6
1500 m × 750 m	1.125	7.46	8	81.94
5000 m × 2500 m	12.5	24.9	24	29.29

For the soil suspension sources, wind-speed dependent emission factors were established. Like the wildland fire scenario, wind-driven soil suspension is less likely when the soil is wet and snow covered. Additionally, during low wind speeds, soil suspension decreases dramatically. To account for these processes, monthly emission scaling factors were applied to the annual average dispersion factors. For the short-term dispersion factors, emission scaling factors were applied based on wind speed. The monthly emission scaling factors were 1.0 for May through October, 0.5 for April and November, and 0.1 for December, January, and February. The wind-speed dependent emission factors are summarized in Table 4. These factors used Equation 7 and AERMOD wind-speed bins to compute an emission rate. The emission scaling factor is the ratio of the emission rate for a given wind speed divided by the maximum emission rate (based on 14.5 m/s wind speed).

Table 4. Wind speed dependent emission scaling factors

Wind speed (m/s)	Peak suspension flux (g/m^2-s)	Emission scaling factor
1.54	3.65E-05	0.0012
3.09	2.95E-04	0.0097
5.14	1.36E-03	0.0445
8.23	5.57E-03	0.1829
10.8	1.26E-02	0.4132
>10.8	3.05E-02	1.0000

Dispersion factors for soil suspension sources by area and averaging time are presented in Table 5. Note that the short-term dispersion factors are substantially less than the short-term dispersion factors for fire sources. This is because when soil suspension is highest, dispersion conditions are also highest resulting in lower concentrations. For the fire sources, the same emission rate is applied regardless of wind speed.

Table 5. Dispersion factors for fugitive dust sources

Length of source parallel to wind direction (m)	Dispersion factors for different averaging times (s/m)			
	1-hr	8-hr	24-hr	Annual
100	7.43E-01	3.61E-01	3.05E-01	5.88E-01
200	1.53E+00	8.16E-01	6.74E-01	1.66E+00
300	2.11E+00	1.15E+00	9.37E-01	2.81E+00
400	2.59E+00	1.41E+00	1.14E+00	3.97E+00
500	3.02E+00	1.61E+00	1.30E+00	5.09E+00
750	3.90E+00	2.01E+00	1.61E+00	7.63E+00
1,000	4.68E+00	2.31E+00	1.83E+00	9.88E+00
1,250	5.35E+00	2.55E+00	2.02E+00	1.19E+01
1,500	5.92E+00	2.77E+00	2.18E+00	1.38E+01
2,000	6.99E+00	3.13E+00	2.44E+00	1.72E+01
2,500	7.85E+00	3.42E+00	2.64E+00	2.01E+01
3,000	8.62E+00	3.67E+00	2.82E+00	2.28E+01
4,000	9.90E+00	4.08E+00	3.11E+00	2.73E+01
5,000	1.11E+01	4.44E+00	3.35E+00	3.13E+01

Radionuclide-Specific Parameters

Radionuclides that have been observed in INL soils from past releases, and radionuclides that were determined to be the primary dose contributors based on the NESHAPs annual report and that accumulate in soils were included in the calculations (Table 6). Radionuclides reported in INL soils were derived from EDF-1873. Activity concentrations were reported for Th-234 in EDF-1873. However, this isotope of thorium is short-lived, and would not be present without its parent, U-238. For that reason, U-238 and its other natural uranium isotopes (U-234, and U-235) were included in the assessment. Decay corrections were applied to Co-60 (half-life 5.27 years) and Cs-134 (half-life 2.065 years). Tritium (H-3) was an important dose contributor but does not accumulate in soil, and for this reasons it was not included in the assessment.

Inhalation dose coefficients for effective dose were obtained from DOE Standard 1196 (DOE 2011) for the reference individual. Three inhalation solubility classes (F= fast, M= medium, S= slow) were presented in DOE (2011). Because these calculations are screening in nature, the solubility class that yields the highest dose coefficient was used. As was done in EDF-1873, soil-to-plant transfer factors were obtained from IAEA (1994). Transfer factors for grasses were used, and where available, for grasses grown in higher pH soils such as occur on the INL. Because of their shallower rooting depths, grasses are known to have higher uptake of radionuclides in surface soils than sagebrush and rabbitbrush. Most areas on the INL contain a mixture of grasses, sagebrush, and rabbitbrush; therefore, the uptake calculated here is conservative.

Table 6. Inhalation dose coefficients for effective dose and soil-to-plant transfer factors.

Radionuclide	Inhalation dose coefficient (mrem/pCi)	Concentration ratio, B_{iv} (pCi/g plant/pCi/g soil, dry weight)	Comments
Ag-108m	1.49E-04	1.50E-01[a]	Reported in EDF-1873
Am-241	3.63E-01	1.20E-03[a]	Reported in EDF-1873 and important dose contributor
Co-60	1.22E-04	5.40E-02	Reported in EDF-1873
Cs-134	8.21E-05	1.10E-01	Reported in EDF-1873
Cs-137	1.54E-04	1.10E-01	Reported in EDF-1873 and important dose contributor
Pu-238	4.07E-01	3.40E-04	Important dose contributor
Pu-239	4.48E-01	3.40E-04	Important dose contributor
Ra-226	3.81E-02	8.00E-02	Reported in EDF-1873
Sr-90	6.07E-04	1.10E+00	Reported in EDF-1873 and important dose contributor
Th-232	4.26E-01	1.10E-02	Reported in EDF-1873
U-234	3.74E-02	2.30E-02	Reported in EDF-1873
U-235	3.38E-02	2.30E-02	Reported in EDF-1873
U-238	3.21E-02	2.30E-02	Reported in EDF-1873

a. The B_{iv} value reported in EDF-1873 was incorrectly transcribed from IAEA 1994.

COMPUTER CODE VALIDATION

All computer code modeling and spreadsheet calculations in this report were performed on a MacPro® Workstation (2 Intel® Quad Core Xeon® @ 2.4 GHz) running OS 10.7.5 and Windows 7 operating on a Parallels Version 10.1.4 virtual machine. The computer input files and copies of the spreadsheet worksheets are provided in the appendices. The computer output files are not provided in the appendices due to their size, but are provided on electronic media. All electronic files, including code input, output, executable files, and the spreadsheet files are provided under “Click here for additional information” (select Supporting Information) in the INL Electronic Document Management System.

AERMOD Calculations

AERMOD and AERMET (version 12345) were used in these calculations. The Window’s executable distributed by EPA was used in these simulations. AERMOD input files are presented in Appendix A.

Microsoft Excel Calculations

Microsoft® Office Excel® 2011 Version 14.4.8 (150116) was used for several supporting calculations.. To validate the calculations performed with Excel, the formulas in all calculation cells were checked for accuracy and a sample of the calculations were checked by hand. Source and receptor coordinates were calculated in the Excel spreadsheet are are presented in Appendix B.

RESULTS/DISCUSSION

The minimum radionuclide concentrations in soil that will result in a dose of 10 mrem ED via inhalation to the receptor are referred to as soil screening concentrations. Soil screening concentrations are presented first for the fire scenario followed by the fugitive dust scenario. A comparison of values determined for the two scenarios are presented at the end of this section

Wildland Fire Scenario

Soil screening concentrations for the fire scenario are presented in Table 7. The concentrations represent the average across the burn area, and should not be applied to single measurements within the area. Plant concentrations that correspond to the soil concentrations that would yield a dose of 10 mrem ED are presented in Table 8. The plant concentrations are presented so that radionuclide measurements in plants can be compared to these limits. In all cases, the soil concentrations for the 8-hr burn time were the lowest. In general, larger source areas result in lower limiting soil concentrations. However, in the fire scenario larger areas also equate to longer averaging times. Greater dispersion of the radionuclides released to air occurs for longer averaging times.

Table 7. Radionuclide soil screening concentrations for the fire scenario and burn times of 1-hr, 8-hr, and 24-hr and burn areas of 0.02 km^2, 1.125 km^2, and 12.5 km^2 respectively.

Radionuclide	Soil screening concentration for 1-hr burn time (pCi/g)	Soil screening concentration for 8-hr burn time (pCi/g)	Soil screening concentration for 24-hr burn time (pCi/g)	Minimum soil screening concentration (pCi/g)
Ag-108m	1.97E+03	9.10E+02	1.27E+03	9.10E+02
Am-241	2.68E+00	1.24E+00	1.72E+00	1.24E+00
Co-60	4.37E+03	2.02E+03	2.82E+03	2.02E+03
Cs-134	4.39E+03	2.03E+03	2.83E+03	2.03E+03
Cs-137	2.34E+03	1.08E+03	1.51E+03	1.08E+03
Pu-238	2.42E+00	1.12E+00	1.56E+00	1.12E+00
Pu-239	2.20E+00	1.02E+00	1.42E+00	1.02E+00
Ra-226	1.15E+01	5.30E+00	7.38E+00	5.30E+00
Sr-90	8.84E+01	4.09E+01	5.70E+01	4.09E+01
Th-232	1.98E+00	9.16E-01	1.27E+00	9.16E-01
U-234	1.94E+01	8.98E+00	1.25E+01	8.98E+00
U-235	2.15E+01	9.93E+00	1.38E+01	9.93E+00
U-238	2.26E+01	1.05E+01	1.46E+01	1.05E+01

Table 8. Radionuclide screening concentrations in plants for the fire scenario and burn times of 1-hr, 8-hr, and 24-hr and burn areas of 0.02 km^2, 1.125 km^2, and 12.5 km^2 respectively.

Radionuclide	Plant screening concentration for 1-hr burn time (pCi/g)	Plant screening concentration for 8-hr burn time (pCi/g)	Plant screening concentration for 24-hr burn time (pCi/g)	Minimum plant screening concentration (pCi/g)
Ag-108m	4.19E+02	1.94E+02	2.70E+02	1.94E+02
Am-241	1.72E-01	7.96E-02	1.11E-01	7.96E-02
Co-60	5.12E+02	2.37E+02	3.30E+02	2.37E+02
Cs-134	7.60E+02	3.52E+02	4.90E+02	3.52E+02
Cs-137	4.05E+02	1.88E+02	2.61E+02	1.88E+02
Pu-238	1.53E-01	7.10E-02	9.88E-02	7.10E-02
Pu-239	1.39E-01	6.45E-02	8.98E-02	6.45E-02
Ra-226	1.64E+00	7.59E-01	1.06E+00	7.59E-01
Sr-90	1.03E+02	4.76E+01	6.63E+01	4.76E+01
Th-232	1.47E-01	6.78E-02	9.44E-02	6.78E-02
U-234	1.67E+00	7.73E-01	1.08E+00	7.73E-01
U-235	1.85E+00	8.55E-01	1.19E+00	8.55E-01
U-238	1.94E+00	9.00E-01	1.25E+00	9.00E-01

Fugitive Dust Scenario

Radionuclide soil screening concentrations in soil for the fugitive dust emission model are presented in Table 9 for fourteen area sources and 1-hr, 8-hr, 24-hr and annual averaging times. In all cases, the annual averaging time results in the lowest soil screening concentrations. This result is consistent with what is expected based on the wind-speed dependent suspension model and dispersion conditions that that increase with the increasing wind speed. However, it is not credible that a person would spend 24 hours per day, 365 days per year at a location onsite. Thus, the shorter averaging times are more appropriate for periodic field workers and firefighters. However, if a person is assumed to be present for several release events, then the soil screening concentration would need to be divided by the number of events the person was exposed to. Thus, the annual values may not always provide a bounding estimate of limiting soil concentrations if for example, a person is assumed to be present multiple times a year during high-wind events that would maximum releases. As with the fire scenario, soil concentrations represent the average over the source area and should not be applied to a single soil measurement.

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Table 9. Limiting soil concentrations for the fugitive dust emission scenario (pCi/g).

Length (m)	Averaging time	Ag-108	Am-241	Co-60	Cs-134	Cs-137	Pu-238	Pu-239	Ra-226	Sr-90	Th-232	U-234	U-235	U-238
100	1-hr	1.85E+06	7.60E+02	2.26E+06	3.36E+06	1.79E+06	6.78E+02	6.16E+02	7.24E+03	4.55E+05	6.48E+02	7.38E+03	8.16E+03	8.60E+03
	8-hr	4.76E+05	1.95E+02	5.82E+05	8.64E+05	4.61E+05	1.74E+02	1.58E+02	1.86E+03	1.17E+05	1.67E+02	1.90E+03	2.10E+03	2.21E+03
	24-hr	1.87E+05	7.69E+01	2.29E+05	3.40E+05	1.81E+05	6.86E+01	6.23E+01	7.32E+02	4.60E+04	6.55E+01	7.46E+02	8.25E+02	8.69E+02
	Annual	1.39E+05	5.69E+01	1.81E+05	2.96E+05	1.34E+05	5.08E+01	4.61E+01	5.42E+02	3.40E+04	4.85E+01	5.52E+02	6.11E+02	6.43E+02
	Minimum	1.39E+05	5.69E+01	1.81E+05	2.96E+05	1.34E+05	5.08E+01	4.61E+01	5.42E+02	3.40E+04	4.85E+01	5.52E+02	6.11E+02	6.43E+02
200	1-hr	8.97E+05	3.68E+02	1.10E+06	1.63E+06	8.68E+05	3.29E+02	2.98E+02	3.51E+03	2.20E+05	3.14E+02	3.58E+03	3.96E+03	4.17E+03
	8-hr	2.05E+05	8.40E+01	2.50E+05	3.71E+05	1.98E+05	7.49E+01	6.80E+01	8.00E+02	5.02E+04	7.16E+01	8.15E+02	9.02E+02	9.50E+02
	24-hr	8.46E+04	3.47E+01	1.03E+05	1.54E+05	8.18E+04	3.10E+01	2.81E+01	3.31E+02	2.08E+04	2.96E+01	3.37E+02	3.73E+02	3.93E+02
	Annual	4.90E+04	2.01E+01	6.39E+04	1.05E+05	4.75E+04	1.80E+01	1.63E+01	1.92E+02	1.20E+04	1.72E+01	1.95E+02	2.16E+02	2.28E+02
	Minimum	4.90E+04	2.01E+01	6.39E+04	1.05E+05	4.75E+04	1.80E+01	1.63E+01	1.92E+02	1.20E+04	1.72E+01	1.95E+02	2.16E+02	2.28E+02
300	1-hr	6.53E+05	2.68E+02	7.98E+05	1.19E+06	6.32E+05	2.39E+02	2.17E+02	2.55E+03	1.60E+05	2.28E+02	2.60E+03	2.88E+03	3.03E+03
	8-hr	1.43E+05	5.88E+01	1.75E+05	2.60E+05	1.39E+05	5.24E+01	4.76E+01	5.60E+02	3.52E+04	5.01E+01	5.71E+02	6.32E+02	6.65E+02
	24-hr	6.08E+04	2.50E+01	7.43E+04	1.10E+05	5.89E+04	2.23E+01	2.02E+01	2.38E+02	1.49E+04	2.13E+01	2.42E+02	2.68E+02	2.82E+02
	Annual	2.91E+04	1.19E+01	3.79E+04	6.21E+04	2.81E+04	1.06E+01	9.67E+00	1.14E+02	7.13E+03	1.02E+01	1.16E+02	1.28E+02	1.35E+02
	Minimum	2.91E+04	1.19E+01	3.79E+04	6.21E+04	2.81E+04	1.06E+01	9.67E+00	1.14E+02	7.13E+03	1.02E+01	1.16E+02	1.28E+02	1.35E+02
400	1-hr	5.32E+05	2.18E+02	6.49E+05	9.65E+05	5.14E+05	1.95E+02	1.77E+02	2.08E+03	1.31E+05	1.86E+02	2.12E+03	2.34E+03	2.47E+03
	8-hr	1.16E+05	4.77E+01	1.42E+05	2.11E+05	1.13E+05	4.26E+01	3.87E+01	4.55E+02	2.86E+04	4.07E+01	4.63E+02	5.13E+02	5.40E+02
	24-hr	4.99E+04	2.05E+01	6.09E+04	9.05E+04	4.83E+04	1.83E+01	1.66E+01	1.95E+02	1.22E+04	1.75E+01	1.99E+02	2.20E+02	2.32E+02
	Annual	2.06E+04	8.44E+00	2.68E+04	4.39E+04	1.99E+04	7.53E+00	6.84E+00	8.04E+01	5.05E+03	7.19E+00	8.19E+01	9.06E+01	9.54E+01
	Minimum	2.06E+04	8.44E+00	2.68E+04	4.39E+04	1.99E+04	7.53E+00	6.84E+00	8.04E+01	5.05E+03	7.19E+00	8.19E+01	9.06E+01	9.54E+01
500	1-hr	4.56E+05	1.87E+02	5.57E+05	8.27E+05	4.41E+05	1.67E+02	1.52E+02	1.78E+03	1.12E+05	1.59E+02	1.82E+03	2.01E+03	2.12E+03
	8-hr	1.00E+05	4.12E+01	1.22E+05	1.82E+05	9.70E+04	3.67E+01	3.34E+01	3.92E+02	2.46E+04	3.51E+01	4.00E+02	4.42E+02	4.66E+02
	24-hr	4.37E+04	1.79E+01	5.34E+04	7.94E+04	4.23E+04	1.60E+01	1.45E+01	1.71E+02	1.07E+04	1.53E+01	1.74E+02	1.93E+02	2.03E+02
	Annual	1.60E+04	6.57E+00	2.09E+04	3.42E+04	1.55E+04	5.86E+00	5.33E+00	6.26E+01	3.93E+03	5.60E+00	6.38E+01	7.06E+01	7.43E+01
	Minimum	1.60E+04	6.57E+00	2.09E+04	3.42E+04	1.55E+04	5.86E+00	5.33E+00	6.26E+01	3.93E+03	5.60E+00	6.38E+01	7.06E+01	7.43E+01

Title: Soil Screening Concentrations for Airborne Exposure to Radionuclides Released from Wildland Fires and Fugitive Dust Sources

ECAR No.: 2850 ECAR Rev. No.: 0 Project File No.: NA Date:

Length (m)	Averaging time	Ag-108	Am-241	Co-60	Cs-134	Cs-137	Pu-238	Pu-239	Ra-226	Sr-90	Th-232	U-234	U-235	U-238
750	1-hr	3.53E+05	1.45E+02	4.31E+05	6.41E+05	3.42E+05	1.29E+02	1.17E+02	1.38E+03	8.67E+04	1.23E+02	1.41E+03	1.56E+03	1.64E+03
	8-hr	8.02E+04	3.29E+01	9.80E+04	1.46E+05	7.76E+04	2.94E+01	2.67E+01	3.14E+02	1.97E+04	2.81E+01	3.20E+02	3.54E+02	3.72E+02
	24-hr	3.54E+04	1.45E+01	4.32E+04	6.42E+04	3.42E+04	1.30E+01	1.18E+01	1.38E+02	8.69E+03	1.24E+01	1.41E+02	1.56E+02	1.64E+02
	Annual	1.07E+04	4.39E+00	1.39E+04	2.28E+04	1.03E+04	3.91E+00	3.55E+00	4.18E+01	2.62E+03	3.74E+00	4.26E+01	4.71E+01	4.96E+01
	Minimum	1.07E+04	4.39E+00	1.39E+04	2.28E+04	1.03E+04	3.91E+00	3.55E+00	4.18E+01	2.62E+03	3.74E+00	4.26E+01	4.71E+01	4.96E+01
1000	1-hr	2.94E+05	1.21E+02	3.59E+05	5.33E+05	2.84E+05	1.08E+02	9.77E+01	1.15E+03	7.21E+04	1.03E+02	1.17E+03	1.30E+03	1.36E+03
	8-hr	6.95E+04	2.85E+01	8.49E+04	1.26E+05	6.73E+04	2.54E+01	2.31E+01	2.72E+02	1.71E+04	2.43E+01	2.77E+02	3.06E+02	3.23E+02
	24-hr	3.10E+04	1.27E+01	3.78E+04	5.62E+04	3.00E+04	1.13E+01	1.03E+01	1.21E+02	7.61E+03	1.08E+01	1.23E+02	1.37E+02	1.44E+02
	Annual	8.26E+03	3.39E+00	1.08E+04	1.76E+04	7.99E+03	3.02E+00	2.75E+00	3.23E+01	2.03E+03	2.89E+00	3.29E+01	3.64E+01	3.83E+01
	Minimum	8.26E+03	3.39E+00	1.08E+04	1.76E+04	7.99E+03	3.02E+00	2.75E+00	3.23E+01	2.03E+03	2.89E+00	3.29E+01	3.64E+01	3.83E+01
1250	1-hr	2.57E+05	1.06E+02	3.14E+05	4.67E+05	2.49E+05	9.42E+01	8.56E+01	1.01E+03	6.32E+04	9.00E+01	1.03E+03	1.13E+03	1.19E+03
	8-hr	6.29E+04	2.58E+01	7.68E+04	1.14E+05	6.09E+04	2.30E+01	2.09E+01	2.46E+02	1.54E+04	2.20E+01	2.51E+02	2.77E+02	2.92E+02
	24-hr	2.81E+04	1.15E+01	3.43E+04	5.10E+04	2.72E+04	1.03E+01	9.35E+00	1.10E+02	6.90E+03	9.84E+00	1.12E+02	1.24E+02	1.31E+02
	Annual	6.85E+03	2.81E+00	8.93E+03	1.46E+04	6.63E+03	2.51E+00	2.28E+00	2.68E+01	1.68E+03	2.40E+00	2.73E+01	3.02E+01	3.18E+01
	Minimum	6.85E+03	2.81E+00	8.93E+03	1.46E+04	6.63E+03	2.51E+00	2.28E+00	2.68E+01	1.68E+03	2.40E+00	2.73E+01	3.02E+01	3.18E+01
1500	1-hr	2.32E+05	9.54E+01	2.84E+05	4.22E+05	2.25E+05	8.50E+01	7.73E+01	9.09E+02	5.70E+04	8.13E+01	9.26E+02	1.02E+03	1.08E+03
	8-hr	6.21E+04	2.55E+01	7.58E+04	1.13E+05	6.01E+04	2.27E+01	2.07E+01	2.43E+02	1.52E+04	2.17E+01	2.47E+02	2.74E+02	2.88E+02
	24-hr	2.63E+04	1.08E+01	3.21E+04	4.77E+04	2.54E+04	9.62E+00	8.74E+00	1.03E+02	6.45E+03	9.19E+00	1.05E+02	1.16E+02	1.22E+02
	Annual	5.96E+03	2.45E+00	7.77E+03	1.27E+04	5.76E+03	2.18E+00	1.98E+00	2.33E+01	1.46E+03	2.08E+00	2.37E+01	2.63E+01	2.77E+01
	Minimum	5.96E+03	2.45E+00	7.77E+03	1.27E+04	5.76E+03	2.18E+00	1.98E+00	2.33E+01	1.46E+03	2.08E+00	2.37E+01	2.63E+01	2.77E+01
2000	1-hr	1.97E+05	8.08E+01	2.40E+05	3.57E+05	1.90E+05	7.21E+01	6.55E+01	7.70E+02	4.83E+04	6.89E+01	7.84E+02	8.68E+02	9.14E+02
	8-hr	5.11E+04	2.10E+01	6.24E+04	9.27E+04	4.94E+04	1.87E+01	1.70E+01	2.00E+02	1.25E+04	1.79E+01	2.04E+02	2.25E+02	2.37E+02
	24-hr	2.32E+04	9.53E+00	2.84E+04	4.21E+04	2.25E+04	8.50E+00	7.72E+00	9.08E+01	5.70E+03	8.12E+00	9.25E+01	1.02E+02	1.08E+02
	Annual	4.74E+03	1.95E+00	6.18E+03	1.01E+04	4.59E+03	1.74E+00	1.58E+00	1.86E+01	1.16E+03	1.66E+00	1.89E+01	2.09E+01	2.20E+01
	Minimum	4.74E+03	1.95E+00	6.18E+03	1.01E+04	4.59E+03	1.74E+00	1.58E+00	1.86E+01	1.16E+03	1.66E+00	1.89E+01	2.09E+01	2.20E+01
2500	1-hr	1.75E+05	7.20E+01	2.14E+05	3.18E+05	1.70E+05	6.42E+01	5.83E+01	6.86E+02	4.30E+04	6.13E+01	6.98E+02	7.73E+02	8.14E+02

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ECAR No.: 2850 ECAR Rev. No.: 0 Project File No.: NA Date:

Length (m)	Averaging time	Ag-108	Am-241	Co-60	Cs-134	Cs-137	Pu-238	Pu-239	Ra-226	Sr-90	Th-232	U-234	U-235	U-238
	8-hr	4.68E+04	1.92E+01	5.71E+04	8.49E+04	4.52E+04	1.71E+01	1.56E+01	1.83E+02	1.15E+04	1.64E+01	1.86E+02	2.06E+02	2.17E+02
	24-hr	2.14E+04	8.79E+00	2.62E+04	3.89E+04	2.07E+04	7.84E+00	7.12E+00	8.37E+01	5.26E+03	7.49E+00	8.53E+01	9.44E+01	9.94E+01
	Annual	4.06E+03	1.67E+00	5.29E+03	8.67E+03	3.93E+03	1.49E+00	1.35E+00	1.59E+01	9.96E+02	1.42E+00	1.62E+01	1.79E+01	1.88E+01
	Minimum	4.06E+03	1.67E+00	5.29E+03	8.67E+03	3.93E+03	1.49E+00	1.35E+00	1.59E+01	9.96E+02	1.42E+00	1.62E+01	1.79E+01	1.88E+01
3000	1-hr	1.75E+05	6.55E+01	1.95E+05	2.90E+05	1.54E+05	5.84E+01	5.31E+01	6.24E+02	3.92E+04	5.58E+01	6.36E+02	7.03E+02	7.41E+02
	8-hr	4.68E+04	1.79E+01	5.31E+04	7.89E+04	4.21E+04	1.59E+01	1.45E+01	1.70E+02	1.07E+04	1.52E+01	1.73E+02	1.92E+02	2.02E+02
	24-hr	2.14E+04	8.21E+00	2.44E+04	3.63E+04	1.94E+04	7.33E+00	6.66E+00	7.83E+01	4.91E+03	7.00E+00	7.97E+01	8.82E+01	9.29E+01
	Annual	4.06E+03	1.47E+00	4.67E+03	7.66E+03	3.47E+03	1.31E+00	1.19E+00	1.40E+01	8.80E+02	1.25E+00	1.43E+01	1.58E+01	1.66E+01
	Minimum	4.06E+03	1.47E+00	4.67E+03	7.66E+03	3.47E+03	1.31E+00	1.19E+00	1.40E+01	8.80E+02	1.25E+00	1.43E+01	1.58E+01	1.66E+01
4000	1-hr	1.39E+05	5.70E+01	1.70E+05	2.52E+05	1.34E+05	5.09E+01	4.62E+01	5.43E+02	3.41E+04	4.86E+01	5.54E+02	6.13E+02	6.45E+02
	8-hr	3.91E+04	1.61E+01	4.78E+04	7.10E+04	3.78E+04	1.43E+01	1.30E+01	1.53E+02	9.60E+03	1.37E+01	1.56E+02	1.72E+02	1.82E+02
	24-hr	1.82E+04	7.46E+00	2.22E+04	3.30E+04	1.76E+04	6.65E+00	6.04E+00	7.11E+01	4.46E+03	6.36E+00	7.24E+01	8.01E+01	8.44E+01
	Annual	2.99E+03	1.23E+00	3.90E+03	6.40E+03	2.90E+03	1.10E+00	9.96E-01	1.17E+01	7.35E+02	1.05E+00	1.19E+01	1.32E+01	1.39E+01
	Minimum	2.99E+03	1.23E+00	3.90E+03	6.40E+03	2.90E+03	1.10E+00	9.96E-01	1.17E+01	7.35E+02	1.05E+00	1.19E+01	1.32E+01	1.39E+01
5000	1-hr	1.24E+05	5.09E+01	1.51E+05	2.25E+05	1.20E+05	4.54E+01	4.12E+01	4.85E+02	3.04E+04	4.34E+01	4.94E+02	5.46E+02	5.75E+02
	8-hr	3.59E+04	1.47E+01	4.39E+04	6.52E+04	3.48E+04	1.31E+01	1.19E+01	1.40E+02	8.82E+03	1.26E+01	1.43E+02	1.58E+02	1.67E+02
	24-hr	1.68E+04	6.91E+00	2.06E+04	3.06E+04	1.63E+04	6.16E+00	5.60E+00	6.58E+01	4.13E+03	5.89E+00	6.71E+01	7.42E+01	7.82E+01
	Annual	2.61E+03	1.07E+00	3.41E+03	5.58E+03	2.53E+03	9.57E-01	8.69E-01	1.02E+01	6.41E+02	9.14E-01	1.04E+01	1.15E+01	1.21E+01
	Minimum	2.61E+03	1.07E+00	3.41E+03	5.58E+03	2.53E+03	9.57E-01	8.69E-01	1.02E+01	6.41E+02	9.14E-01	1.04E+01	1.15E+01	1.21E+01

Comparison for the Wildland Fire and Fugitive Dust Scenarios

A comparison of the minimum soil screening concentration regardless of averaging time or size of source is presented in Table 10. In general, radionuclides that have low soil-to-plant transfer factors have almost the same limiting soil concentration for the fire and fugitive dust scenarios. High soil-to-plant transfer factors result in the plant accumulating more radionuclides, that when burned, results in higher activity released. Consequently, the fire scenario has the lowest soil screening concentrations. The minimum of the fire and fugitive dust scenarios (column 4) are suggested for use as an initial screening value. For a mixture of radionuclides, the sum-of ratios (*SOR*) value should be less than or equal to 1.0 to assure that the 10 mrem ED dose constraint is not exceeded. The sum-of-ratios is given by

$$SOR = \sum_{i=1}^{n} \frac{C_i}{CL} \tag{14}$$

where C_i = the measured soil concentration (pCi/g), and CL_i = the limiting soil concentration (pCi/g)

Table 10. Comparison of the minimum radionuclide soil screening concentrations for the fire and fugitive dust scenarios. The minimum is taken across all source areas and averaging times.

Radionuclide	Fire scenario (pCi/g)	Fugitive dust scenario (pCi/g)	Minimum soil concentration (pCi/g)	Soil-to plant transfer factor
Ag-108	9.10E+02	2.61E+03	9.10E+02	1.50E-01
Am-241	1.24E+00	1.07E+00	1.08E+00	1.20E-03
Co-60	2.02E+03	3.41E+03	2.02E+03	5.40E-02
Cs-134	2.03E+03	5.58E+03	2.03E+03	1.10E-01
Cs-137	1.08E+03	2.53E+03	1.08E+03	1.10E-01
Pu-238	1.12E+00	9.57E-01	9.61E-01	3.40E-04
Pu-239	1.02E+00	8.69E-01	8.73E-01	3.40E-04
Ra-226	5.30E+00	1.02E+01	5.30E+00	8.00E-02
Sr-90	4.09E+01	6.41E+02	4.09E+01	1.10E+00
Th-232	9.16E-01	9.14E-01	9.16E-01	1.10E-02
U-234	8.98E+00	1.04E+01	8.98E+00	2.30E-02
U-235	9.93E+00	1.15E+01	9.93E+00	2.30E-02
U-238	1.05E+01	1.21E+01	1.05E+01	2.30E-02

CONCLUSIONS

Soil screening concentrations that results in a 10 mrem ED dose to an individual are presented in Table 7 for the fire scenario and Table 9 for the fugitive dust scenario. The soil screening concentration represents an average concentration across the source area. The values for the fire scenario are presented for different burn times and the values for the fugitive dust scenario are presented for different source area sizes. The minimum soil screening concentrations regardless of source area or release scenario are presented in Table 10. The values in Table 10 are suggested for use as an initial

screening value for the radionuclides presented. For mixtures of radionuclides, a sum-of ratios approach may be used to assure that the combined impacts from all radionuclides does not result in the 10 mrem ED dose constraint not being exceeded.

PROJECT ENGINEER STAMP

NA

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Appendix A: AERMOD Input Files

Fire Scenario Files

```
** Unit release factors for an area source centered on GRI3 met stattion (2000-2004) receptors are situated at the
corners
** and 100 m beyond the edge
**
**
**

CO STARTING
   TITLEONE  Unit release factors for area source for screening evaluation of activity released from fires
   TITLETWO  using GRI3 Met data from 2000-2004.
   MODELOPT  ELEV CONC FASTALL
   AVERTIME  1 8 24
   POLLUTID  TRACER
   RUNORNOT  RUN
   ERRORFIL  AERMOD.ERR
CO FINISHED

SO STARTING
   ELEVUNIT  METERS
** Location is the center of source, rotate 45 degress to align with wind direction
   LOCATION  SOIL  AREAPOLY  343433  4828238   1498

** Area Source       QS      HS     NVERT  iSigZ
**               (g/m^2 s)  (m)           (m)
** Parameters:       ----    ----   ----  ----
   SRCPARAM  SOIL  1.0E-6  1.00     4     0.465
   AREAVERT  SOIL  343433  4828238 343504  4828167 343363  4828026 343292  4828097

** Emission Factors for SOIL
**  Assume potential for resuspension and files minimual during winter months,50% probabaility during late fall and
early spring
** Month                   Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct    Nov    Dec
SO EMISFACT  SOIL  MONTH   0.0    0.0    0.0    0.0    1.0    1.0    1.0    1.0    1.0    1.0    0.0    0.0

   SRCGROUP  ALL
** Set new units using EMISUNIT
** Defaults values are
** 1.0E6 for conc (ug/m3)
** Label for emission unit (grams/sec)
** Lable for conc (micrograms/m3)
** EMISUNIT 1.0E6 grams/s  micrograms/m3
SO FINISHED

RE STARTING
   ELEVUNIT  METERS
   DISCCART  343539  4828273    1498  1498
   DISCCART  343504  4828026    1498  1498
   DISCCART  343257  4827991    1498  1498
   DISCCART  343292  4828238    1498  1498

RE FINISHED

ME STARTING
   SURFFILE  ..\aermet\grd35yr.sfc
   PROFFILE  ..\aermet\grd35yr.pfl
   UAIRDATA  24131  00  BOISE  0  0
   SITEDATA  99999  00  INL    0  0
   SURFDATA  24145  00  IDA    0  0
   PROFBASE  1478    METERS
   STARTEND 2000 01 01 2004 12 31
ME FINISHED

OU STARTING
   FILEFORM EXP
   RECTABLE  ALLAVE  1ST
   PLOTFILE 1  ALL  1ST  TRACER_1HR.DAT
   PLOTFILE 8  ALL  1ST  TRACER_8HR.DAT
   PLOTFILE 24 ALL  1ST  TRACER_24HR.DAT
OU FINISHED
```

```
** Unit release factors for an area source centered on GRI3 met stattion (2000-2004) receptors are situated at the
corners
** and 100 m beyond the edge
**
**
**

CO STARTING
   TITLEONE  Unit release factors for  area source for screening evaluation of fire emissions
   TITLETWO  using GRI3 Met data from 2000-2004.
   MODELOPT  ELEV CONC FASTALL
   AVERTIME  1 8 24
   POLLUTID  TRACER
   RUNORNOT  RUN
   ERRORFIL  AERMOD.ERR
CO FINISHED

SO STARTING
   ELEVUNIT  METERS
** Location is the center of source, rotate 45 degress to align with wind direction
   LOCATION  SOIL  AREAPOLY   343663  4828927  1498

** Area Source       QS      HS     NVERT  iSigZ
**               (g/m^2 s)  (m)           (m)
** Parameters:       ----    ----   ----  ----
   SRCPARAM  SOIL  1.0E-6  1.00     4     0.465
   AREAVERT  SOIL  343663  4828927 344193  4828397 343133  4827337 342603  4827867

** Emission Factors for SOIL
**  Assume potential for resuspension and filres minimual during winter months,50% probabaility during late fall and
early spring
** Month                  Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct    Nov    Dec
SO EMISFACT  SOIL  MONTH   0.0    0.0    0.0    0.0    1.0    1.0    1.0    1.0    1.0    1.0    0.0    0.0

   SRCGROUP  ALL
** Set new units using EMISUNIT
** Defaults values are
** 1.0E6 for conc (ug/m3)
** Label for emission unit (grams/sec)
** Lable for conc (micrograms/m3)
** EMISUNIT 1.0E6 grams/s  micrograms/m3
SO FINISHED

RE STARTING
   ELEVUNIT  METERS
   DISCCART  343999  4828733    1498  1498
   DISCCART  343734  4827796    1498  1498
   DISCCART  342797  4827531    1498  1498
   DISCCART  343062  4828468    1498  1498

RE FINISHED

ME STARTING
   SURFFILE  ..\aermet\grd35yr.sfc
   PROFFILE  ..\aermet\grd35yr.pfl
   UAIRDATA  24131  00  BOISE  0  0
   SITEDATA  99999  00  INL    0  0
   SURFDATA  24145  00  IDA    0  0
   PROFBASE  1478    METERS
   STARTEND 2000 01 01 2004 12 31
ME FINISHED

OU STARTING
   FILEFORM EXP
   RECTABLE  ALLAVE  1ST
   PLOTFILE 1  ALL  1ST  TRACER_1HR.DAT
   PLOTFILE 8  ALL  1ST  TRACER_8HR.DAT
   PLOTFILE 24 ALL  1ST  TRACER_24HR.DAT
OU FINISHED

** Unit release factors for an area source centered on GRI3 met stattion (2000-2004) receptors are situated at the
corners
** and 100 m beyond the edge
**
**
**
```

```
CO STARTING
   TITLEONE  Unit release factors for  area source for screening evaluation of fire emissions
   TITLETWO  using GRI3 Met data from 2000-2004.
   MODELOPT  ELEV CONC FASTALL
   AVERTIME  1 8 24
   POLLUTID  TRACER
   RUNORNOT  RUN
   ERRORFIL  AERMOD.ERR
CO FINISHED

SO STARTING
   ELEVUNIT  METERS
** Location is the center of source, rotate 45 degress to align with wind direction
   LOCATION  SOIL  AREAPOLY   344282  4830784  1498

** Area Source       QS      HS     NVERT  iSigZ
**                (g/m^2 s)  (m)           (m)
** Parameters:       ----    ----   ----  ----
   SRCPARAM  SOIL  1.0E-6  1.00     4     0.465
   AREAVERT  SOIL  344282  4830784 346050  4829016 342514  4825480 340746  4827248

** Emission Factors for SOIL
**  Assume potential for resuspension and filres minimual during winter months,50% probabaility during late fall and
early spring
** Month                   Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct    Nov    Dec
SO EMISFACT  SOIL  MONTH   0.0    0.0    0.0    0.0    1.0    1.0    1.0    1.0    1.0    1.0    0.0    0.0

   SRCGROUP  ALL
** Set new units using EMISUNIT
** Defaults values are
** 1.0E6 for conc (ug/m3)
** Label for emission unit (grams/sec)
** Lable for conc (micrograms/m3)
** EMISUNIT 1.0E6 grams/s  micrograms/m3
SO FINISHED

RE STARTING
   ELEVUNIT  METERS
   DISCCART  345236  4829970    1498  1498
   DISCCART  344353  4827177    1498  1498
   DISCCART  341560  4826294    1498  1498
   DISCCART  342443  4829087    1498  1498

RE FINISHED

ME STARTING
   SURFFILE  ..\aermet\grd35yr.sfc
   PROFFILE  ..\aermet\grd35yr.pfl
   UAIRDATA  24131  00  BOISE  0  0
   SITEDATA  99999  00  INL    0  0
   SURFDATA  24145  00  IDA    0  0
   PROFBASE  1478    METERS
   STARTEND 2000 01 01 2004 12 31
ME FINISHED

OU STARTING
   FILEFORM EXP
   RECTABLE  ALLAVE  1ST
   PLOTFILE 1  ALL  1ST  TRACER_1HR.DAT
   PLOTFILE 8  ALL  1ST  TRACER_8HR.DAT
   PLOTFILE 24 ALL  1ST  TRACER_24HR.DAT
OU FINISHED
```

Sample AERMOD File for Fugitive Dust emissions from a 200 m x 100 m source

```
** Unit release factors for an area source centered on GRI3 met stattion (2000-2004) receptors are situated at the
corners
** and 100 m beyond the edge
**
**
**
CO STARTING
   TITLEONE  Unit release factors for  area source for screening evaluation of soil contamination
   TITLETWO  using GRI3 Met data from 2000-2004.
   MODELOPT  ELEV CONC FASTALL
```

```
   AVERTIME  1 8 24 PERIOD
   POLLUTID  TRACER
   RUNORNOT  RUN
   ERRORFIL  AERMOD.ERR
CO FINISHED

SO STARTING
   ELEVUNIT  METERS
** Location is the center of source, rotate 45 degress to align with wind direction
** SOIL1 is for short-term resuspension (STSOIL group)
** SOIL2 is for annual average resuspension (ANSOIL group)
   LOCATION  SOIL1  AREAPOLY  343433  4828238   1498
   LOCATION  SOIL2  AREAPOLY   343433  4828238   1498

** Area Source       QS      HS     NVERT  iSigZ
**                (g/m^2 s)  (m)            (m)
** Parameters:       ----    ----   ----  ----
   SRCPARAM  SOIL1  1.0E-6  1.00     4     0.465
   AREAVERT  SOIL1  343433  4828238 343504  4828167 343363  4828026 343292  4828097

   SRCPARAM  SOIL2  1.0E-6  1.00     4     0.465
   AREAVERT  SOIL2  343433  4828238 343504  4828167 343363  4828026 343292  4828097

** Emission Factors for SOIL
** Assume potential for resuspension and filres minimual during winter months,50% probabaility during late fall and
early spring
** Month                  Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct    Nov    Dec
SO EMISFACT  SOIL2  MONTH   0.1    0.1    0.5    1.0    1.0    1.0    1.0    1.0    1.0    1.0    0.5    0.1
SO EMISFACT  SOIL1  WSPEED  0.0012 0.0101 0.0464 0.1906 0.4308 1.0000
   SRCGROUP  STSOIL  SOIL1
   SRCGROUP  ANSOIL  SOIL2


** Set new units using EMISUNIT
** Defaults values are
** 1.0E6 for conc (ug/m3)
** Label for emission unit (grams/sec)
** Lable for conc (micrograms/m3)
** EMISUNIT 1.0E6 grams/s  micrograms/m3
SO FINISHED

RE STARTING
   ELEVUNIT  METERS

   DISCCART  343539  4828273    1498  1498
   DISCCART  343504  4828026    1498  1498
   DISCCART  343257  4827991    1498  1498
   DISCCART  343292  4828238    1498  1498

RE FINISHED

ME STARTING
   SURFFILE  ..\aermet\grd35yr.sfc
   PROFFILE  ..\aermet\grd35yr.pfl
   UAIRDATA  24131  00  BOISE  0  0
   SITEDATA  99999  00  INL    0  0
   SURFDATA  24145  00  IDA    0  0
   PROFBASE  1478    METERS
   STARTEND 2000 01 01 2004 12 31
ME FINISHED

OU STARTING
   FILEFORM EXP
   RECTABLE  ALLAVE  1ST
   PLOTFILE 1  STSOIL  1ST  RESUS_1HR.DAT
   PLOTFILE 8  STSOIL  1ST  RESUS_8HR.DAT
   PLOTFILE 24 STSOIL  1ST  RESUS_24HR.DAT
   PLOTFILE PERIOD ANSOIL  RESUS_AA.DAT
OU FINISHED
```

Appendix B: Source Area and Receptor Coordinates

Table_B-1. Coordinates of rectangular area sources.

	NW Corner	NE Corner	SE Corner	SW Corner

Area ID	Length	UTME (m)	UTMN (m)	UTME (m)	UTMN (m)	UTME (m)	UTMN (m)	UTME (m)	UTMN (m)
A1	100	343416	4828185	343451	4828150	343380	4828079	343345	4828114
A2	200	343433	4828238	343504	4828167	343363	4828026	343292	4828097
A3	300	343451	4828291	343557	4828185	343345	4827973	343239	4828079
A4	400	343469	4828344	343610	4828203	343327	4827920	343186	4828061
A5	500	343486	4828397	343663	4828220	343310	4827867	343133	4828044
A6	750	343531	4828530	343796	4828265	343265	4827734	343000	4827999
A7	1000	343575	4828662	343928	4828309	343221	4827602	342868	4827955
A8	1250	343619	4828795	344061	4828353	343177	4827469	342735	4827911
A9	1500	343663	4828927	344193	4828397	343133	4827337	342603	4827867
A10	2000	343752	4829193	344459	4828486	343044	4827071	342337	4827778
A11	2500	343840	4829458	344724	4828574	342956	4826806	342072	4827690
A12	3000	343928	4829723	344989	4828662	342868	4826541	341807	4827602
A13	4000	344105	4830253	345519	4828839	342691	4826011	341277	4827425
A14	5000	344282	4830784	346050	4829016	342514	4825480	340746	4827248

Table_B-2. Coordinates of receptors.

		North		East		South		West	
Area ID	Length	UTME (m)	UTMN (m)	UTME (m)	UTMN (m)	UTME (m)	UTMN (m)	UTME (m)	UTMN (m)
A1	100	343504	4828238	343486	4828044	343292	4828026	343310	4828220
A2	200	343539	4828273	343504	4828026	343257	4827991	343292	4828238
A3	300	343575	4828309	343522	4828008	343221	4827955	343274	4828256
A4	400	343610	4828344	343539	4827991	343186	4827920	343257	4828273
A5	500	343645	4828379	343557	4827973	343151	4827885	343239	4828291
A6	750	343734	4828468	343601	4827929	343062	4827796	343195	4828335
A7	1000	343822	4828556	343645	4827885	342974	4827708	343151	4828379
A8	1250	343911	4828645	343690	4827840	342885	4827619	343106	4828424
A9	1500	343999	4828733	343734	4827796	342797	4827531	343062	4828468
A10	2000	344176	4828910	343822	4827708	342620	4827354	342974	4828556
A11	2500	344353	4829087	343911	4827619	342443	4827177	342885	4828645
A12	3000	344529	4829263	343999	4827531	342267	4827001	342797	4828733
A13	4000	344883	4829617	344176	4827354	341913	4826647	342620	4828910
A14	5000	345236	4829970	344353	4827177	341560	4826294	342443	4829087