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Site 300 B-851 Permit: Radiological Assumptions and Source Term - Air Dispersion Modeling for Radiological Dose Assessment

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May 5th, 2020

Background Information

Lawrence Livermore National Laboratory (LLNL) is a premier research laboratory that is part of the National Nuclear Security Administration (NNSA) within DOE. As a national security laboratory, LLNL is responsible for ensuring that the nation's nuclear weapons remain safe, secure, and reliable. The Laboratory also meets other national security needs, including countering the proliferation of weapons of mass destruction and strengthening homeland security, and conducts major research in atmospheric, earth, and energy sciences; bioscience and biotechnology; and engineering, basic science, and advanced technology. The Laboratory serves as a scientific resource to the U.S. government and a partner to industry and academia.

LLNL consists of two sites—an urban site in Livermore, California, referred to as the "Livermore Site" and a rural experimental test site, referred to as "Site 300," near Tracy, California. Site 300, LLNL's Experimental Test Site, is in the Altamont Hills of the Diablo Range and straddles the San Joaquin and Alameda county line. The site is 12 miles east of the Livermore Site and occupies 10.9 square miles. The city of Tracy, with a population of about 86,000, is approximately 6 miles to the northeast (measured from the northeastern border of Site 300 to Sutter Tracy Community Hospital). Of the 7.1 million people who live within 50 miles of Site 300, 95% are more than 20 miles away in metropolitan areas such as Oakland, San Jose, and Stockton.

B-851 Permit

The following modeling assumptions and source term that is provided in the attachments to this document are meant to serve as a guide to the presentation delivered on April 23rd, 2020, to the San Joaquin Air District Permit Services slides. This analysis is in response to the District's "Project Incompleteness Letter" (Facility Number: N-472 and Project Number: N-1173492)

regarding the potential for depleted uranium (DU) to be resuspended from areas of contaminated soil at Site 300 as a result of high explosive (HE) experiments increased to a requested permitted maximum of 1,000 pound detonations with an annual HE throughput not to exceed 7,500 pounds per year.

LLNL has taken every step in the radiological health risk concerns in the modeling assumptions and final source term to be at a level of maximum conservativeness. As an example, forty soil samples were taken in the B-851 area (LLNL-AR-738708 – 2018) and assayed for uranium-234, uranium-235, and uranium-238 concentrations. The maximum uranium soil concentrations were used in the assumptions (potential for resuspended dust occurring from detonation experiments) and not the use of median uranium soil concentrations – a more realistic outcome. Additionally, these uranium soil concentrations were considered to be at 100% uptake in the vegetation for prescribed burns; vegetation uptake factors were not used as that would lower the final source term. This level of conservativeness was maintained throughout the modeling assumptions.

Attachments

Attachment A: LLNL Site 300 B-851 Permit – Radionuclide Source Term

Attachment B: Radioactive Air Modeling Assumptions

Attachment C: Meteorological Data Key

Attachment D: Site 300 CY12 On-Site Meteorological Data (Wind File)

Attachment E: Independent Verification to Radionuclide Source Term (QA/QC)

Attachment A
LLNL Site 300 B-851 Permit – Radionuclide Source Term

Dust Mass			
Conditions	**Mass (lbs)**	**Particle Size**	**Fall Velocity**
Ground-level skirt soil particle emissions	15	10 µm or less	0.003 m/s
Small particle stem soil particle emissions	9	10 µm or less	0.003 m/s
Small particle fireball soil particle emissions	3	10 µm or less	0.003 m/s
Ground-level soil particle emissions (caused by falling project fragments and very large crater particles)	19	10 µm or less	0.003 m/s

Attachment A, continued

Detonation Source Term from Resuspened Soil							
Nuclide	**pCi/g(*)**	**g/lb**	**lbs/detonation**	**Ci/pCi**	**Ci/detonation**	**Shot/yr**	**Ci/yr**
U-234	3.70	453.592	46	1.00E-12	7.72E-08	8	6.18E-07
U-235	0.63	453.592	46	1.00E-12	1.31E-08	8	1.05E-07
U-238	44.00	453.592	46	1.00E-12	9.18E-07	8	7.34E-06
Calculation		(pCi/g)(g/lb) = pCi/lb of soil	(pCi/g)(g/lb)(lb/shot) = pCi/shot	(pCi/g)(g/lb)(lb/shot)(Ci/pCi) = Ci/shot		(pCi/g)(g/lb)(lb/shot)(Ci/pCi)(shot/yr) = Ci/yr	
Information Source	Soil sampling	Conversion	COMBIC	Conversion	Calculated	Permit Request	Calculated

Prescribed Burn Source Term from Vegetation										
Nuclide	**pCi/g(*)**	**Fraction uptake**	**g/lb**	**lb/acre**	**acre/burn**	**Emission factor (lb particulate released/lb vegetation burned)**	**Ci/pCi**	**Ci/burn**	**Burns/yr**	**Ci/yr**
U-234	3.70	1	453.592	2000	2200	0.008	1.00E-12	5.91E-05	1	5.91E-05
U-235	0.63	1	453.592	2000	2200	0.008	1.00E-12	1.01E-05	1	1.01E-05
U-238	44.00	1	453.592	2000	2200	0.008	1.00E-12	7.03E-04	1	7.03E-04
Calculation		(pCi/g)(fraction uptake) = pCi/g	(pCi/g)(fraction uptake)(g/lb) = pCi/lb	(pCi/g)(fraction uptake)(g/lb)(lb/acre) = pCi/acre	(pCi/g)(fraction uptake)(g/lb)(lb/acre)(acre/burn) = pCi/burn	(pCi/g)(fraction uptake)(g/lb)(lb/acre)(acre/burn)(emission factor) = pCi/burn released to air	(pCi/g)(fraction uptake)(g/lb)(lb/acre)(acre/burn)(emission factor)(Ci/pCi) = Ci/burn released to air		(pCi/g)(fraction uptake)(g/lb)(lb/acre)(acre/burn)(emission factor)(Ci/pCi)(burn/yr) = Ci/yr released to air	
Information Source	Soil sampling	Uptake is modeled at 100%	Conversion	Reporting value to San Joaquin Air District	Historical observation	District approved value	Conversion	Calculated	Prescribed Burn Plan	Calculated

* *LLNL-AR-738708*, Table 9. (2018)

Final Source Term (Ci)		
Nuclide	**Detonation (1000 lb TNT-**	**Burn (Veg only)**
U-234	7.72E-08	5.91E-05
U-235	1.31E-08	1.01E-05
U-238	9.18E-07	7.03E-04

Public Receptor Distances		
Location	**Distance (mi)**	**Distance (m)**
Tracy Hills	4.16	6695
RISI/Teledyne	3.43	5520
Connolly Ranch	3.70	5955
Carnegie - OHV	2.06	3315

Attachment B
Radioactive Air Modeling Assumptions

General Assumptions

- Dust particle emission have the same concentration of contamination as soil
- Maximum project explosive charge (per detonation): 1,000 pounds TNT-equivalent yield
- Up to eight maximum sized detonations per year
- One prescribed burn per year
- Site-specific CY2012 meteorological data at 10 meters height
    - Removed day 366 for converting to HotSpot meteorological file input format
- Modeled using HotSpot Version 3.1.2
- Receptor distances
    - 2.06 miles (Carnegie)
    - 3.43 miles (RISI/Teledyne)
    - 3.70 miles (Connolly Ranch)
    - 4.16 miles (Tracy Hills)
- Receptor height = 5 ft
- Mass of soil resuspended in respirable range (10 micrometers and less)
    - Total = 46 lbs dust per 1000 lb detonation
        - Primary resuspension
            - Ground-level skirt = 15 lbs
            - Small particle stem = 9 lbs
            - Small particle fireball = 3 lbs
        - Secondary resuspension = 19 lbs
- Respirable fraction = 100%
- Deposition velocity of respirable particles = 0.3 cm/sec

- Deposition velocity of non-respirable particles = 0.0 cm/sec
- Radionuclide concentration in soil
    - U-234: 3.70 pCi/gram
    - U-235: 0.63 pCi/gram
    - U-238: 44.00 pCi/gram
- Terrain = Standard/Rural
- Sample time = 10 minutes
- Source geometry = simple
- Holdup time = 0 minutes
- DCF library = FGR 13
- Breathing rate = 4.17 E-04 m^3/sec
- Total Effective Dose Percentile Values
    - Percentile-A = 50th
    - Percentile-B = 90th
    - Percentile-C = 95th
    - Percentile-D = 99th
    - Percentile-E = 99.5^{th}
- Wind direction = 'Wind from'
- Meteorological Wind Speed Usage = 'Each data entry (no wind grouping)'

Attachment C
Meteorological Data Key

Field	Variable Name	Description
A	OSMO	Month
B	OSDY	Day
C	OSYR	Year
D	OSHR	Hour
E	PRES	Station pressure (millibars*10)
F	SLVP	Sea level pressure (millibars*10)
G	PRCP	Precipitation(millimeters*100)
H	PAMT	Precipitation amount (centimeters)
I	INSO	Insolation (watts/square meter)
J	NRAD	Net radiation (watts/square meter)
K	TT01	Temperature °C @ 2-meters
L	TT02	Temperature °C @ 10-meters
M	TT03	Temperature °C @ 23-meters
N	TT04	Temperature °C @ 52-meters
O	DT01	DT01 Temperature difference (10 meter - 2 meter) °C
P	DP01	Dew Point Temperature °C @ 2-meters
Q	DP02	Dew Point Temperature °C @ 10-meters
R	RH01	Relative Humidity (%) @ 2-meters
S	RH02	Relative Humidity (%) @ 10-meters
T	WS02	Wind speed (meters/second) @10-meters
U	WS03	Wind speed (meters/second) @23-meters
V	WS04	Wind speed (meters/second) @52-meters
W	WD02	Wind direction (degrees from north) @10-meters
X	WD03	Wind direction (degrees from north) @23-meters
Y	WD04	Wind direction (degrees from north) @52-meters
Z	SA02	Standard deviation of horizontal wind (degrees) @ 10-meters
AA	SA03	Standard deviation of horizontal wind (degrees) @ 23-meters
AB	SA04	Standard deviation of horizontal wind (degrees) @ 52-meters
AC	SW02	Standard deviation of vertical wind speed (meters/second) @ 10-meters
AD	SW03	Standard deviation of vertical wind speed (meters/second) @ 23-meters
AE	SW04	Standard deviation of vertical wind speed (meters/second) @ 52-meters
AF		Stability

Attachment D
Site 300 CY12 On-Site Meteorological Data (Wind File)

The Site 300 CY12 on-site meteorological data used as input to AERMET and HotSpot modeling is sent separate in a .txt file format.

Attachment E
Independent Verification to Radionuclide Source Term (QA/QC)

B851 Detonation (COMBIC)

Analyte	Table 9 B851 pCi/g[1]	lbs resusupension[2]	grams	pCi	Source term (Ci) One 1000 lb detonation	Source term (Ci) Eight 1,000 lb detonations
U234	3.7	46	20866	7.72E+04	7.72E-08	6.18E-07
U235	0.63	46	20866	1.31E+04	1.31E-08	1.05E-07
U238	44	46	20866	9.18E+05	9.18E-07	7.34E-06

1. LLNL-AR-738708, Table 9, maximum soil concentrations for U-234, U-235, and U-238

2. Pounds of resuspension per one 1,000 lb detonation (Combic) considered to be 100% respirable

Prescribed Burn (Vegetation)

Analyte	lbs/acre	Total Acres/y	Emission Factor[1]	lbs[2]	Table 9 B851 pCi/g[3]	grams	pCi	Source term (Ci) 2200 acres/y
U234	2000	2200	0.008	35200	3.7	15966720	5.91E+07	5.91E-05
U235	2000	2200	0.008	35200	0.63	15966720	1.01E+07	1.01E-05
U238	2000	2200	0.008	35200	44	15966720	7.03E+08	7.03E-04

1. SJVAPDCD Emission Report

2. Pounds of emission considered to be 100% respirable.

3. LLNL-AR-738708, Table 9, maximum soil concentrations for U-234, U-235, and U-238