INL/CON-22-70161-Revision-0

INL Soil Contamination Areas - Wildland Fire Radiological Hazards

April 2023

Changing the World's Energy Future

Lawrence L Burke

Idaho National Laboratory

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INL/CON-22-70161

2023 | EMI SIG
ANNUAL MEETING

EVOLVING WITH THE HAZARDS:
CLIMATE, VULNERABILITY, RESILIENCY AND SUSTAINABILITY
DENVER, COLORADO
APRIL 25 - 27

INL Soil Contamination Areas
Wildland Fire Radiological Hazards

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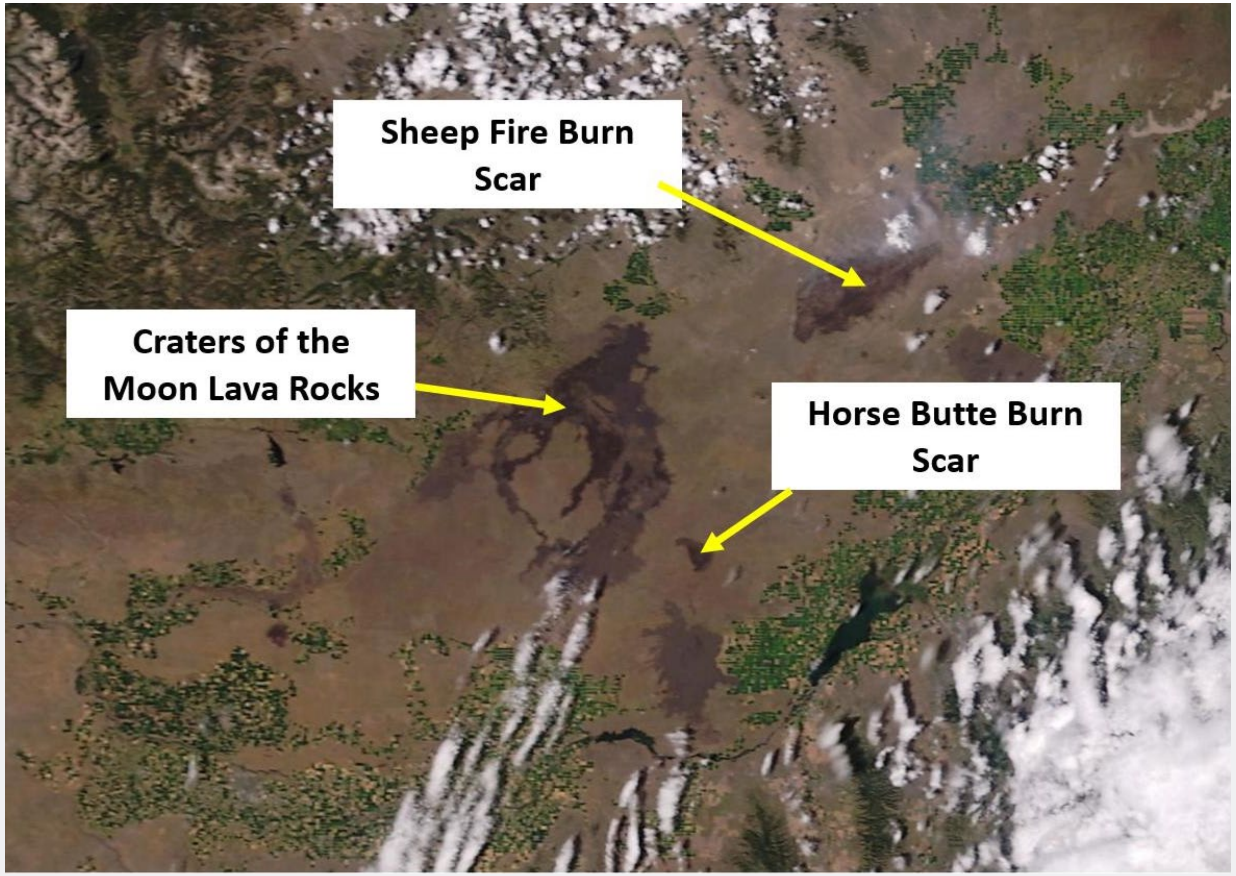
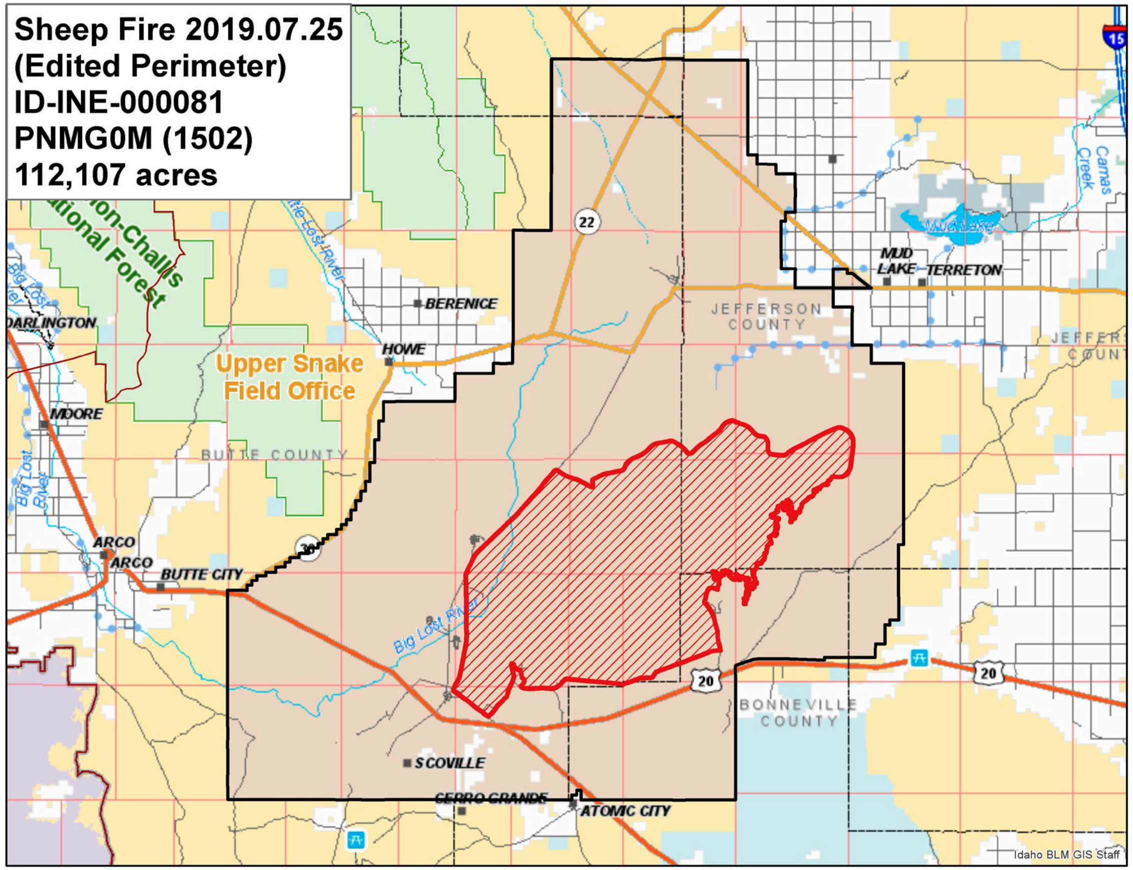
National Nuclear Security Administration

Sheep Fire Fallout

- The Sheep Fire was ignited by a lightening strike around 6:30 p.m. on Monday, July 22, 2019, and the fire eventually burned 112,107 acres in four days.
- There was no personnel injury or damage to the facilities of the INL.
- The INL Site Monitoring team obtained several downwind air samples and the sixteen high-volume air monitors located at NOAA telemetry stations were operated during the event. The results of the sampling were negative with respect to radiological hazard from the fire.
- Radiological Control and Emergency Management initiated a re-evaluation of the wildfire hazards from INL soil contamination areas.

Sheep Fire – July 22-26, 2019





Previous Evaluation

- In 2001 an evaluation of the known soil contamination areas at the INL (35) and the CERCLA sites (18) determined that 6 soil contamination areas and 1 CERCLA site provided a potential for personnel dose in a wildland fire incident that burned through the areas. See EDF-1873, Rev 0.
- After the Sheep Fire, Radiological Control, Environmental Monitoring and Emergency Management revisited the 7 areas and determined that 1 soil contamination areas had been remediated since 2001.
- Five of the remaining soil contamination areas were mapped for radiation intensity and the dose potential of the areas were re-evaluated based upon decay of the radiological constituents. See EDF-1873, Rev 1.

EDF-1873 Original List

- CFA-08: A drain field near the CFA gantry.
- CFA Ditch and Pit: A drainage ditch for hot laundry washings near the CFA gantry.
- EBR-15: A small SCA inside of the EBR-I fence.
- ARA-12: An SCA across from the former site of ARA-III.
- ARA-23: A large SCA incorporating the former SL-1 site, ARA-I and the SL-1 burial ground.
- TSF-07: A remnant of an evaporation pond near the fire station at TAN.
- CPP-95: The very large SCA incorporating the windblown contamination area from INTEC.

Eliminated Sites

- CFA-08: Site has been remediated and is now an URMA.
- EBR-15: Contamination is incorporated into a lava rock outcropping and is not a fire risk.
- CPP-95: The area of contamination is too large (8,068,858 m^2) to be feasibly covered with the time and resources available. As well, the areas which have been mapped and shown to have the highest levels of contamination are located inside the INTEC fence and are not considered a fire risk.

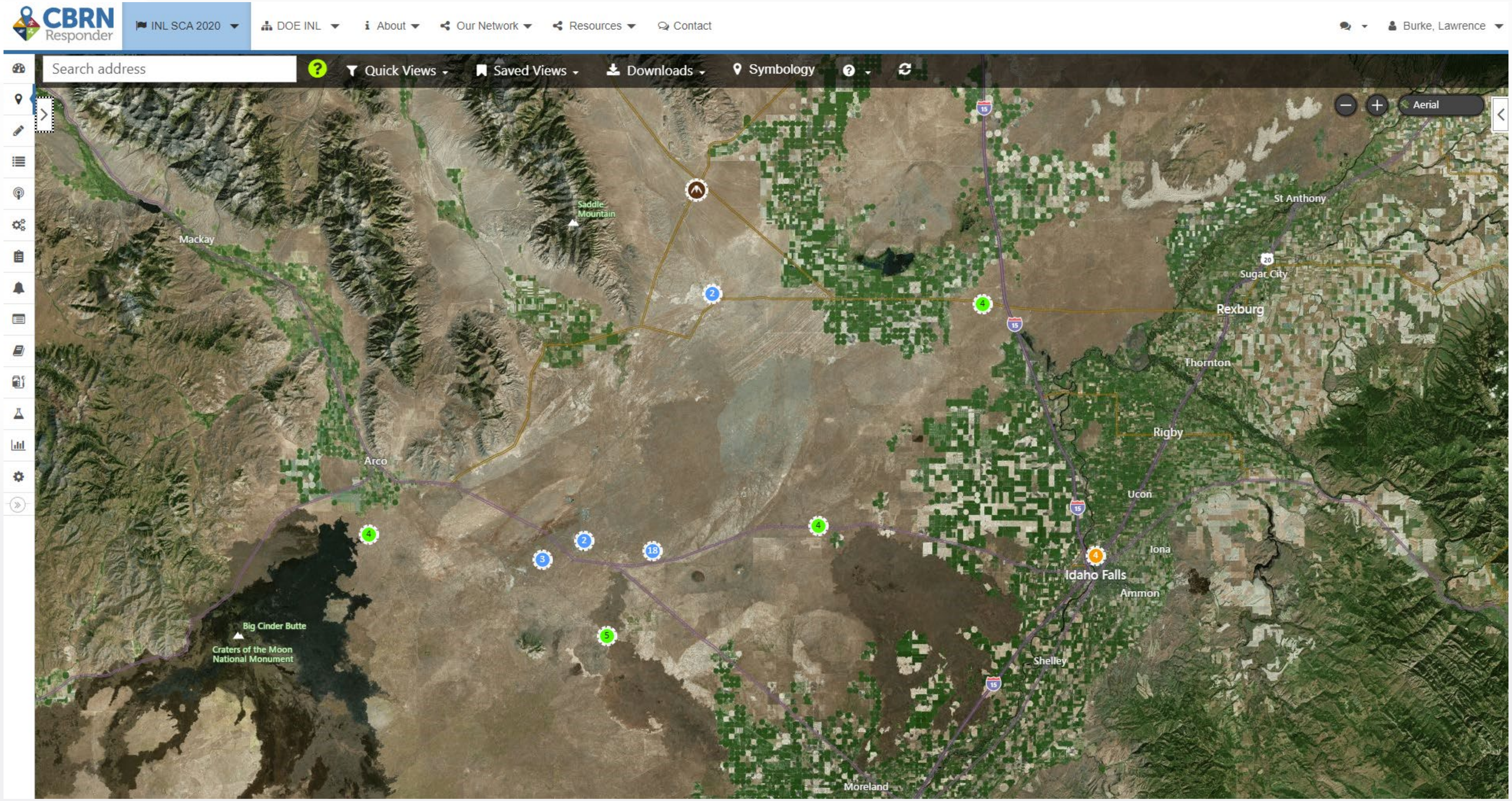
Site Mapping

- It was decided that in order to gain the most accurate understanding of the contamination variability, radiation intensity maps would be generated for each of the sites.
- Radiation intensity maps were generated via manual walkthroughs of each of the sites with backpack mounted 8” NaI detectors.
  - CFA ditch and EBR-I were mapped with dual Jeep-mounted 16” NaI detectors due to availability of the system.
- Identified hot spots were used for measurement of maximum potential soil contamination via in-situ gamma spectroscopy (ORTEC Detective EX-100) and direct soil sampling.

Radiation Intensity Mapping Operations

Gemini Backpack Detector System

High Purity Germanium Detector


CBRN Responder
INL SCA 2020
DOE INL
About
Our Network
Resources
Contact
Burke, Lawrence
Search address
Quick Views
Saved Views
Downloads
Symbology
Aerial
Saddle Mountain
Mackay
St Anthony
Sugar City
Rexburg
Thornton
Rigby
Ucon
Arco
Iona
Idaho Falls
Ammon
Big Cinder Butte
Craters of the Moon National Monument
Shelley
Moreland

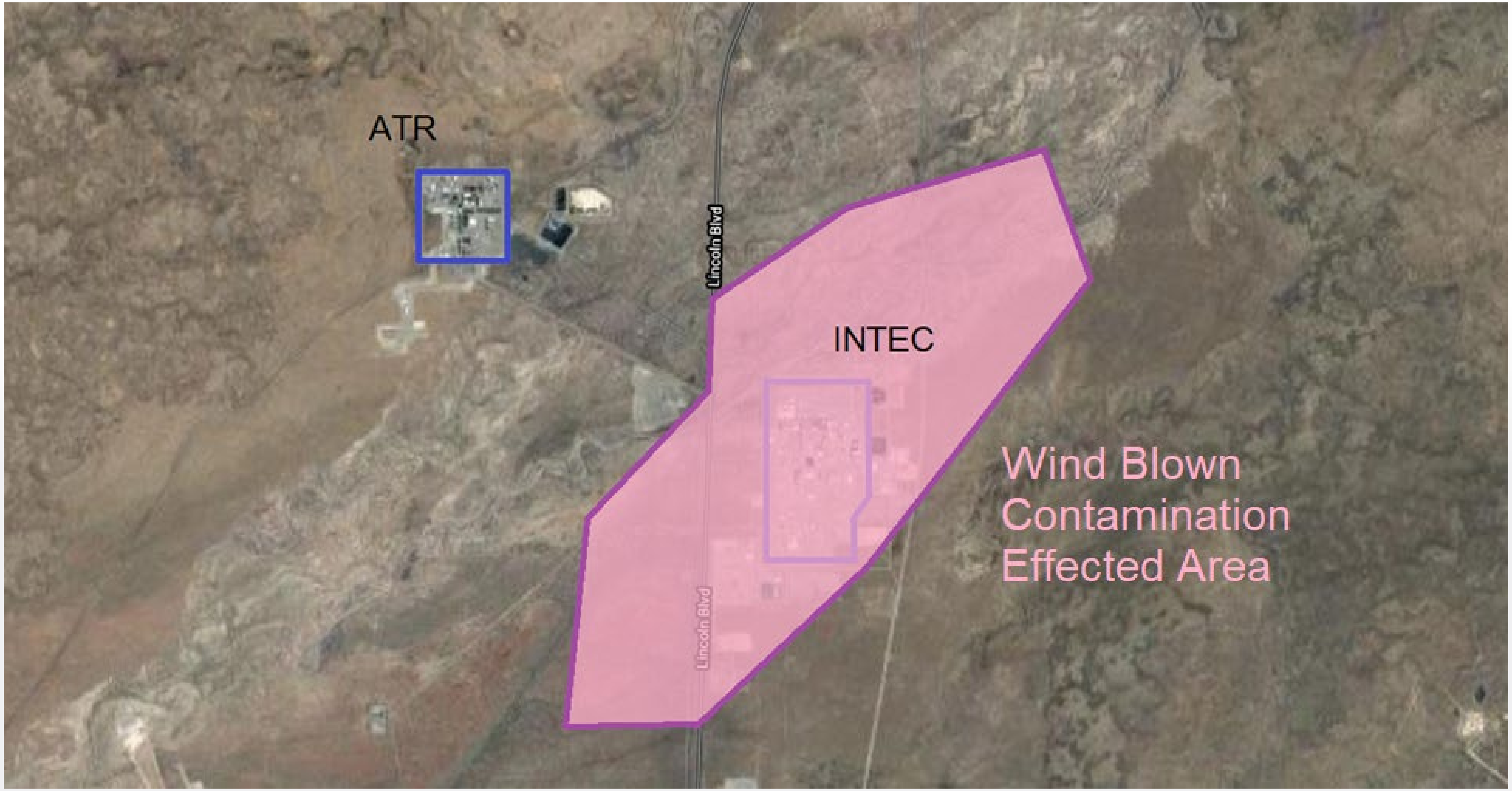
RSI Mobile Detector System

Sampling Review

- In addition to obtaining new surveys of the soil contamination areas, we reviewed the soil sampling data that had been generated since the previous evaluation in 2001.

- We determined there was no new soil sampling of the soil contamination areas except for the largest area that is located around the Idaho Nuclear Technology and Engineering Center (INTEC).

CPP-95 CERCLA Site - Idaho Nuclear Technology and Engineering Center (INTEC)



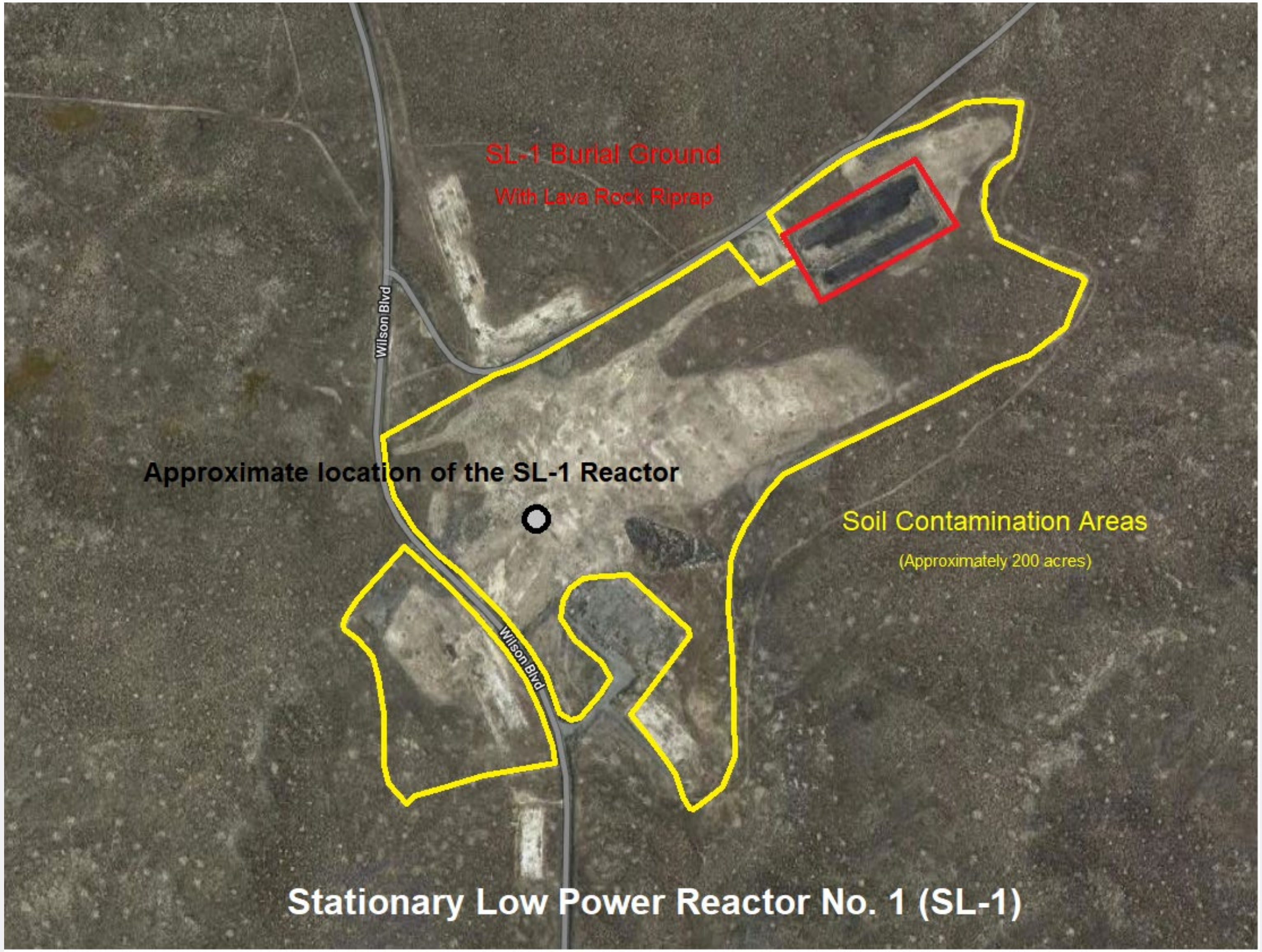
In-Situ Gamma Scan of the Soil Cs-137 Levels (pCi/g) INTEC (2006)

Cs-137 Soil Concentrations Around INTEC Reported in the INL Annual Environmental Reports

Year	2006	2007	2010	2011	2012	2013	2014
No. of Samples	95	96	86	64	14	6	14
Mean (pCi/g)	0.882	1.88	1.16	3.45	1.57	2.09	1.29
Median (pCi/g)	0.0545	1.02	0.935	2.78	1.605	2.32	0.815
Minimum (pCi/g)	0.000284	0.020	0.02	0.18	0.53	0.27	0.44
Maximum (pCi/g)	8.79	49.0	3.92	12.68	2.72	3.72	3.54
Standard Deviation	1.14	4.99	0.803	2.51	0.699	1.19	1.01
Variance	1.31	24.9	0.645	6.32	0.489	1.42	1.03

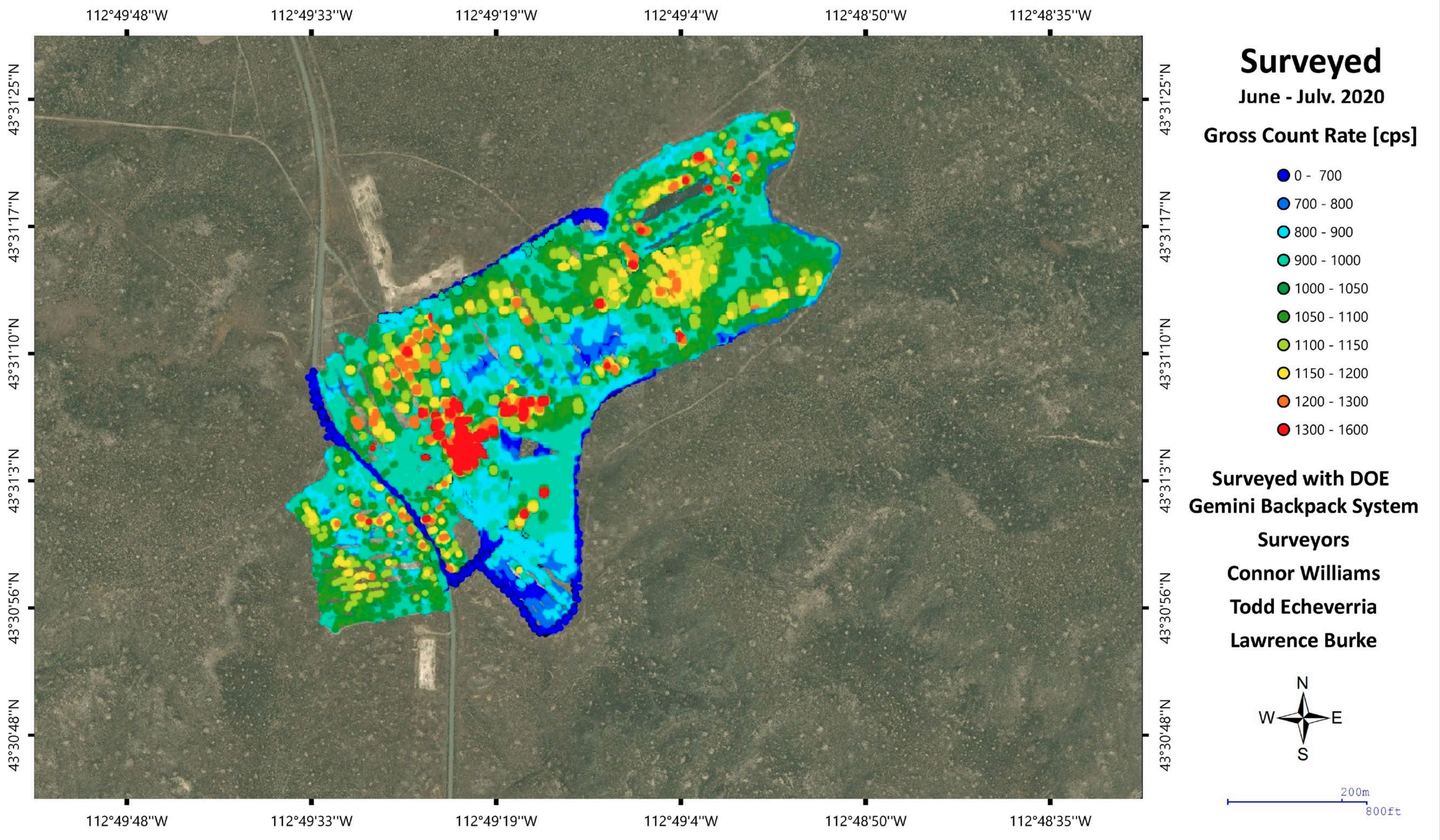
Stationary Low-Power Reactor No. 1 (SL-1)

Soil Contamination Area Postings

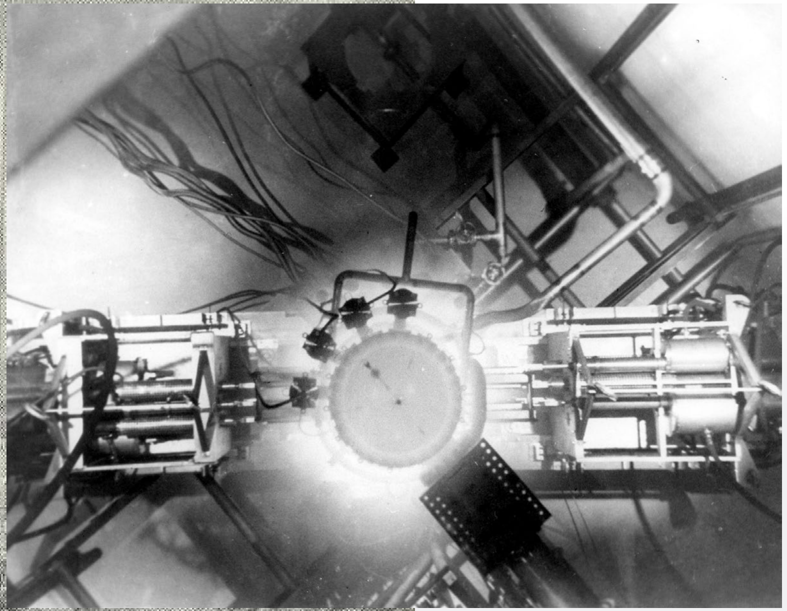

SL-1 Burial Ground
With Lava Rock Riprap
Wilson Blvd
Approximate location of the SL-1 Reactor
Soil Contamination Areas
(Approximately 200 acres)
Wilson Blvd
Stationary Low Power Reactor No. 1 (SL-1)


CAUTION
CAUTION

Stationary Low Power Reactor (SL-1) Soil Contamination Area



Auxiliary Reactor Area No. 3 (Previously Army Reactor Area)
Army Gas Cooled Reactor Experiment (GCRE)



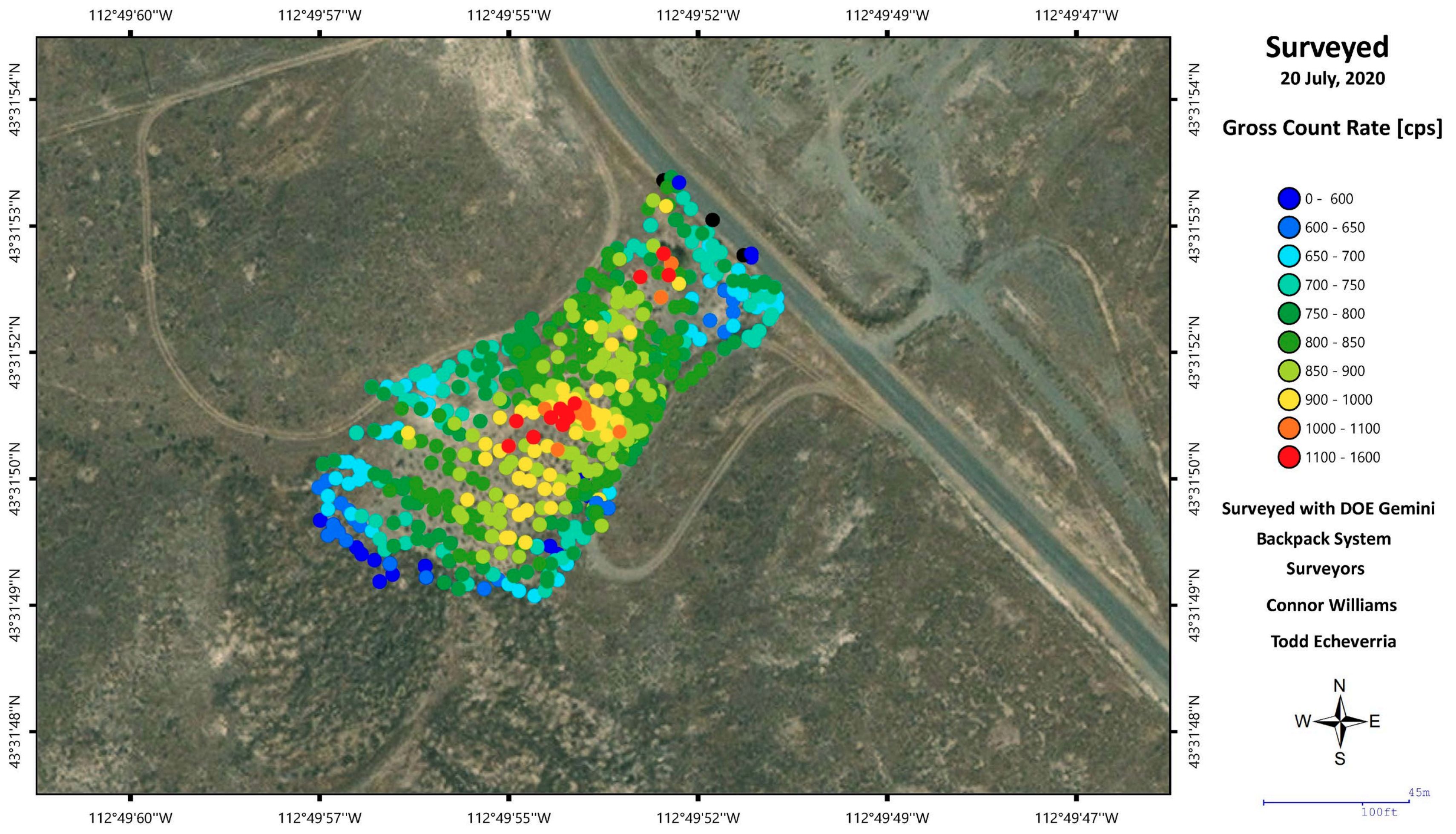
GCRE Liquid Waste Handling System

It became apparent early in the checkout program that large quantities of potentially radioactive liquid waste, containing very low levels of contamination, would be generated in the normal operation of the facility, In view of the limited capacity of the low-level liquid waste storage tank, provision was made for gravity transfer of material from this tank (after determination of the radioactive content) to a leaching bed west of the GCRE facility. This modification involved the installation of several hundred feet of 6-in. concrete pipe along the north side of the test building. Operating procedures were established which specified that the liquid waste in the storage tank be monitored prior to release to the bed and that the bed be monitored on a periodic basis to prevent buildup of dangerous levels of contamination. No problems were experienced with this system throughout the program.

ARA-III Soil Contamination Area

ARA-III Radiation Intensity Mapping

Auxiliary Reactor Area No. 3 (ARA-III) Soil Contamination Area



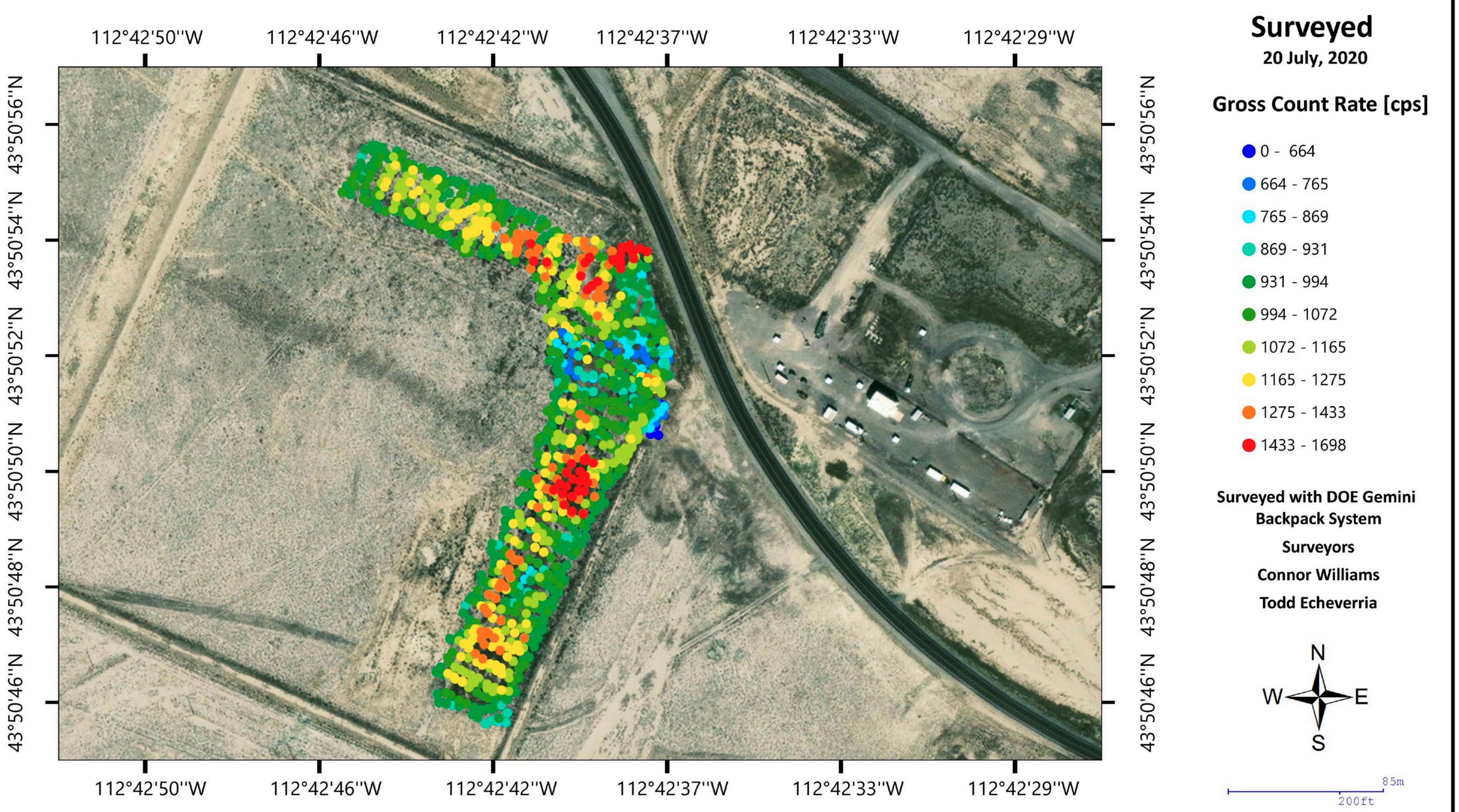
Technical Support Facility Soil Contamination Area

Technical Support Facility (TSF) Disposal Pond

The Technical Support Facility (TSF) Disposal Pond was built in the 1970’s to replace the TSF injection well. The disposal pond received effluent from a variety of sources which included low-level radioactive waste, cold process waste, and treated sewage effluent from the Test Area North facilities. The diked disposal pond covers an area of about 35 acres, but the SCA covers only a small portion of the northeast corner of the pond (380 m^2). Prior sampling has found Cs-137, Co-60, Sr-90, and gross alpha activity in the surface soils of the area. The area is fenced and a posting of the CERCLA site and SCA status.

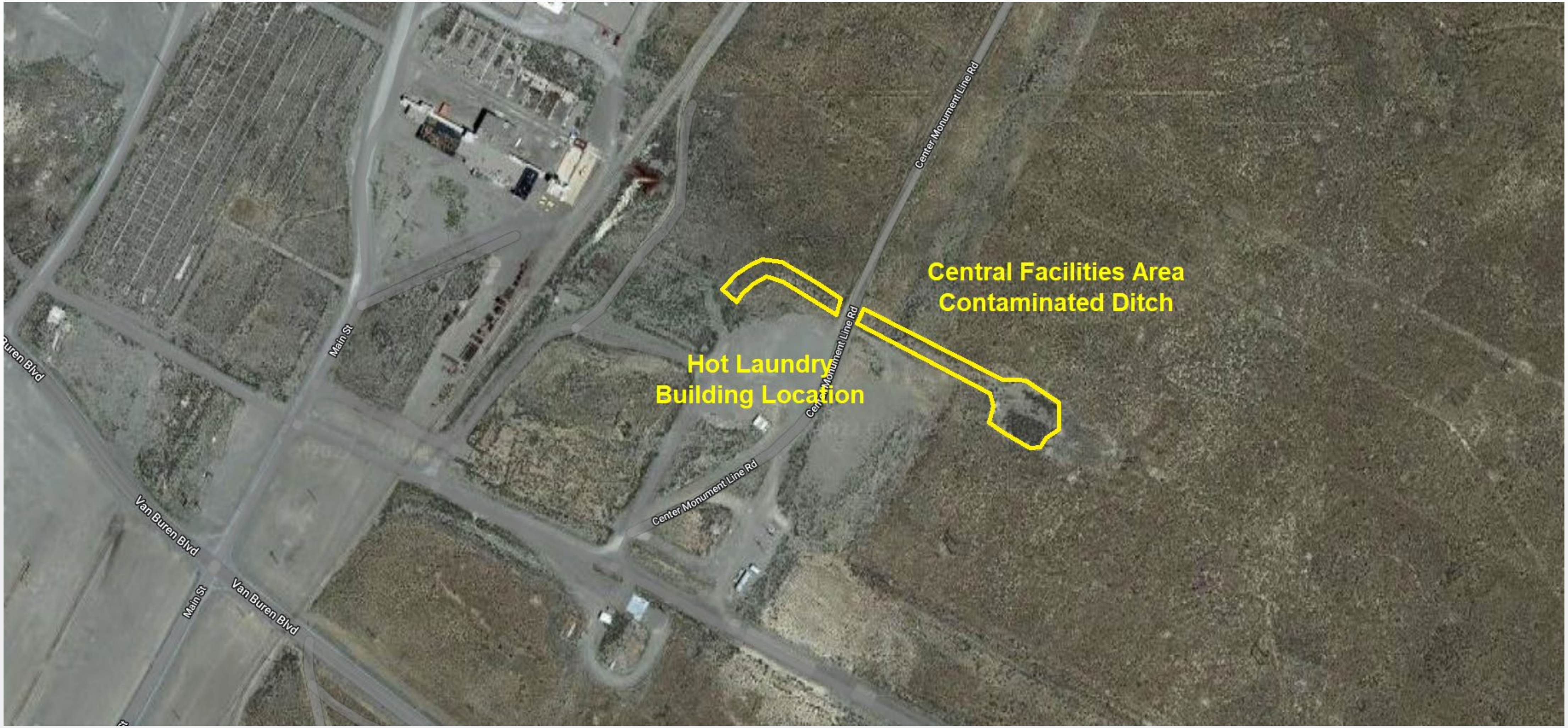
Technical Support Facility Radiation Intensity Mapping

Technical Support Facility (TSF-07) Soil Contamination Area

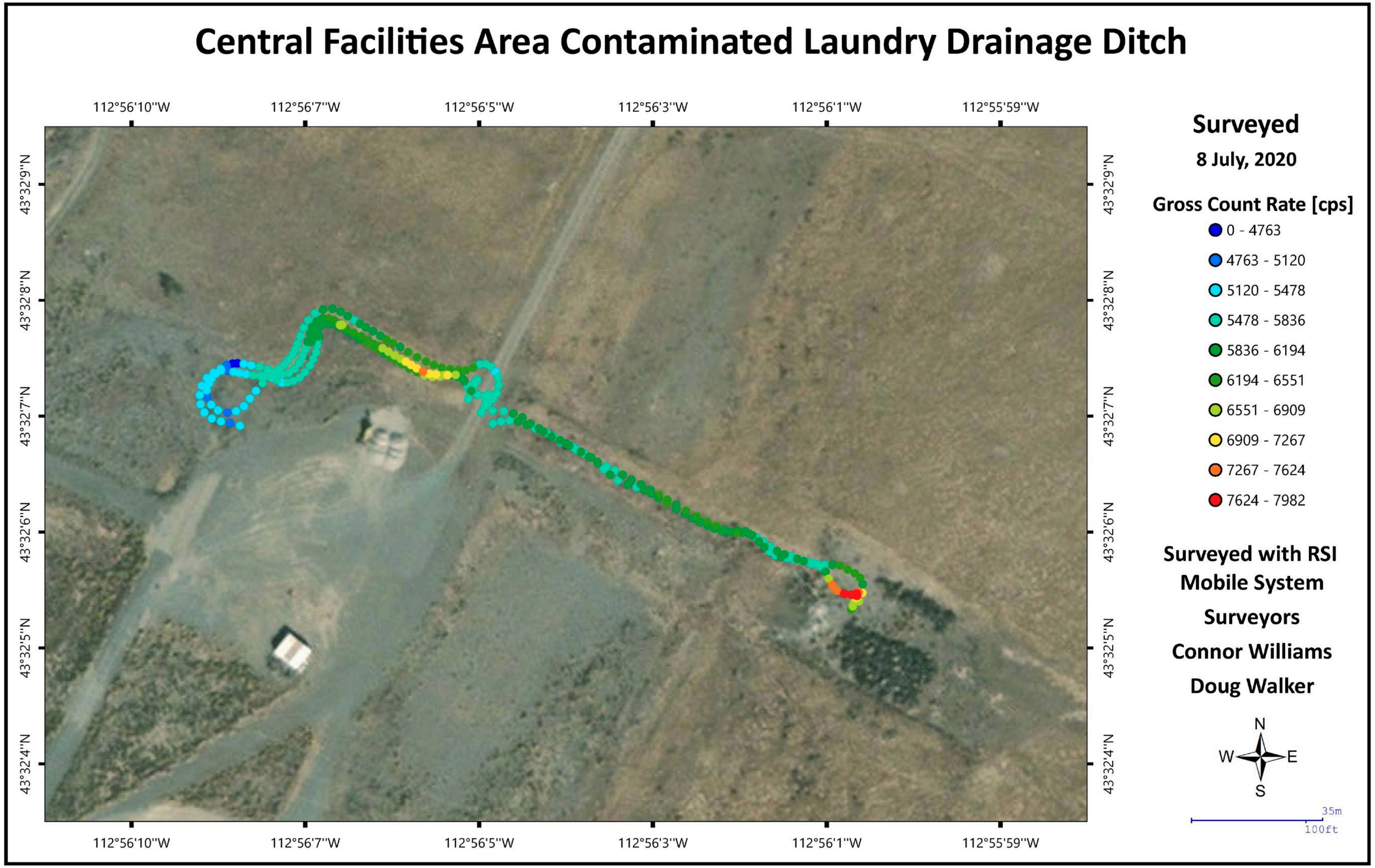


Central Facilities Area Contaminated Ditch

West End of Ditch with Gamma Spectroscopy


Central Facilities Area
Contaminated Ditch
Hot Laundry
Building Location
Center Monument Line Rd
Center Monument Line Rd
Main St
Main St
Van Buren Blvd
Van Buren Blvd

Central Facilities Area Contaminated Laundry Drainage Ditch



Experimental Breeder Reactor No. 1 (EBR-I)

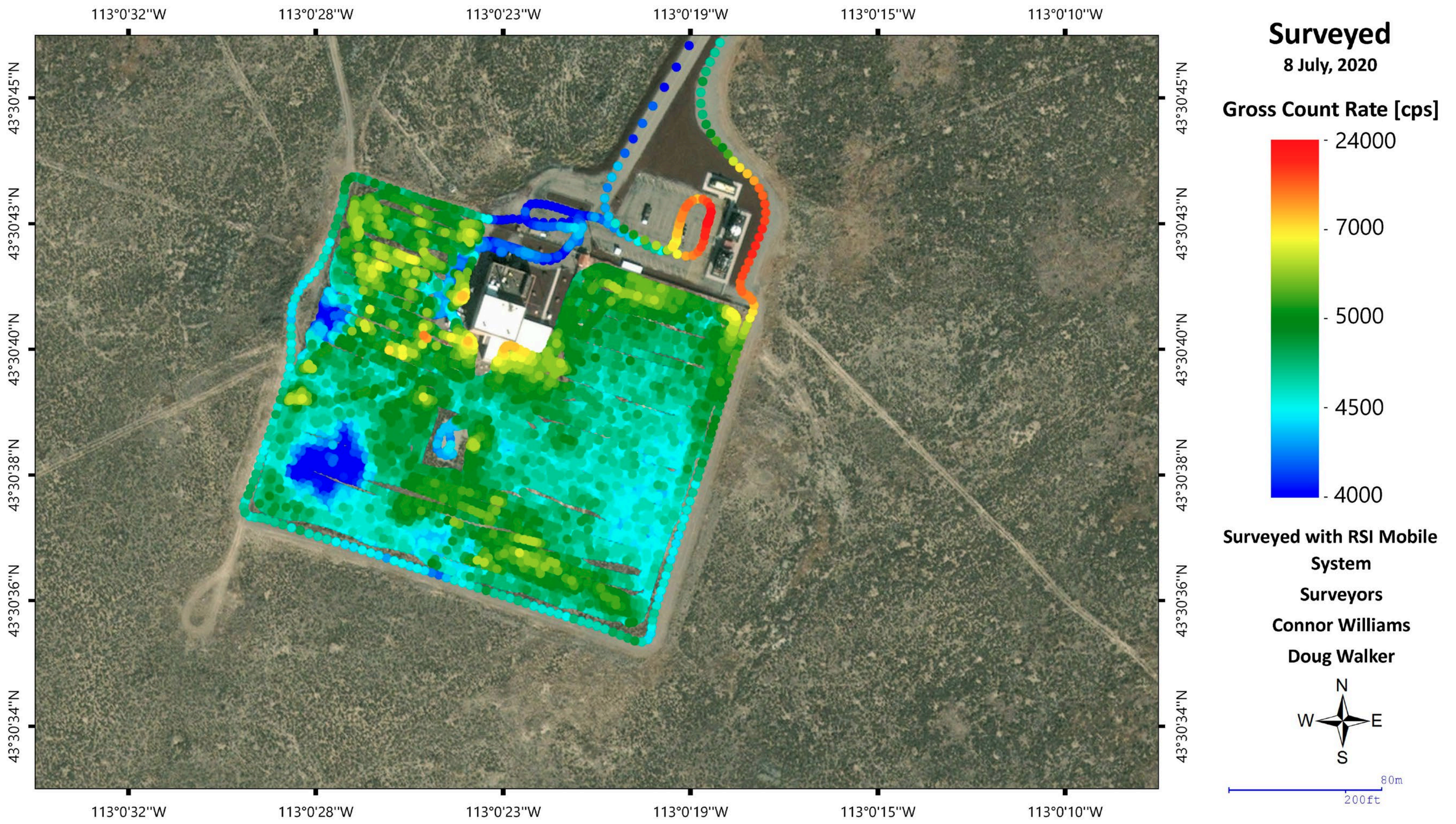
Experimental Breeder Reactor No. 1 (EBR-I)

EBR-I Soil Contamination Area

EBR-I Soil Contamination Area

EBR-I Radiation Intensity Mapping

EBR-I Underground Radioactive Material Area



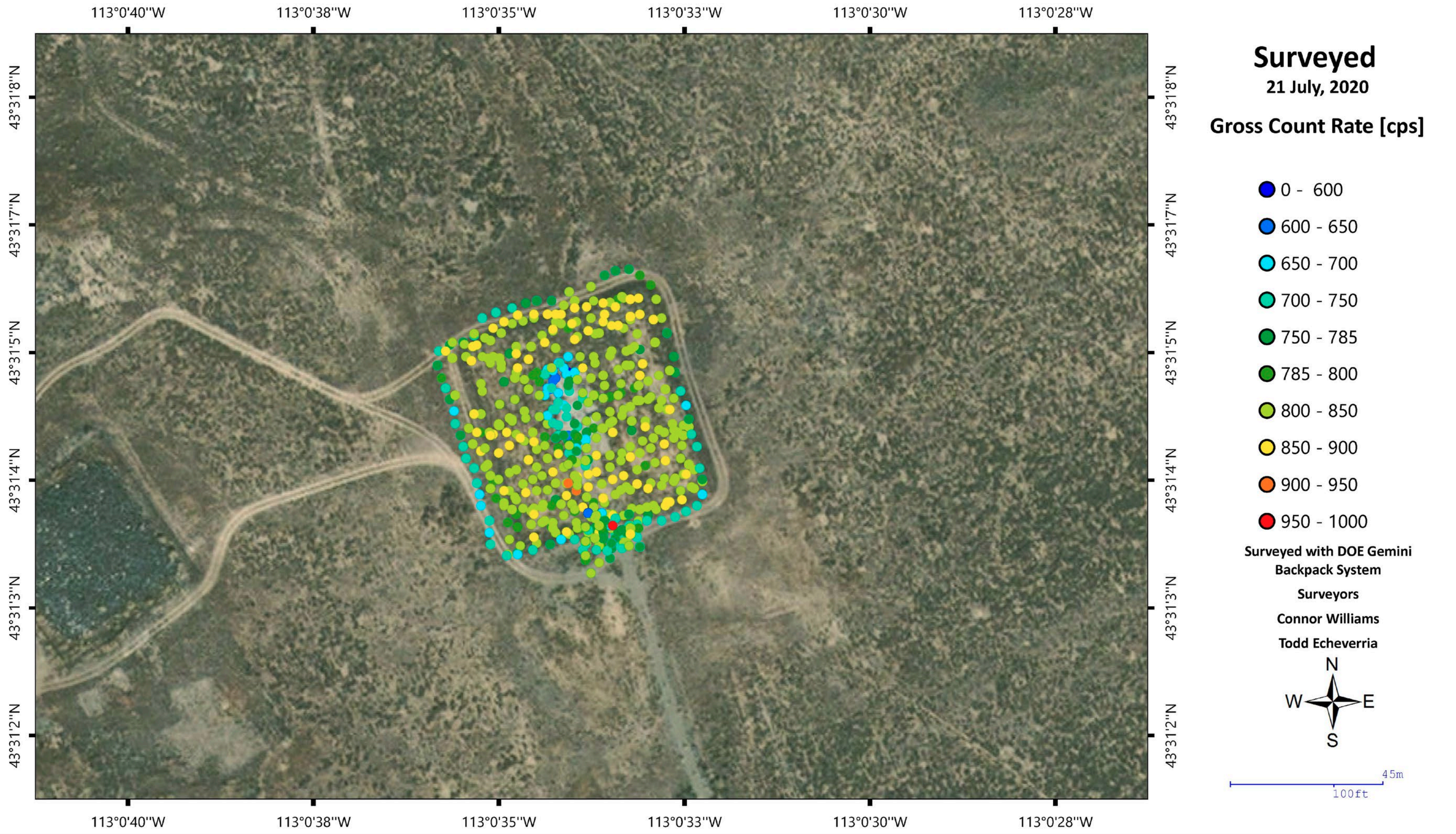
Boiling Reactor Experiment (BORAX)

BORAX-III Underground Radioactive Material Area

BORAX-III

View from BORAX to EBR-I where the BORAX Control Trailers were Located

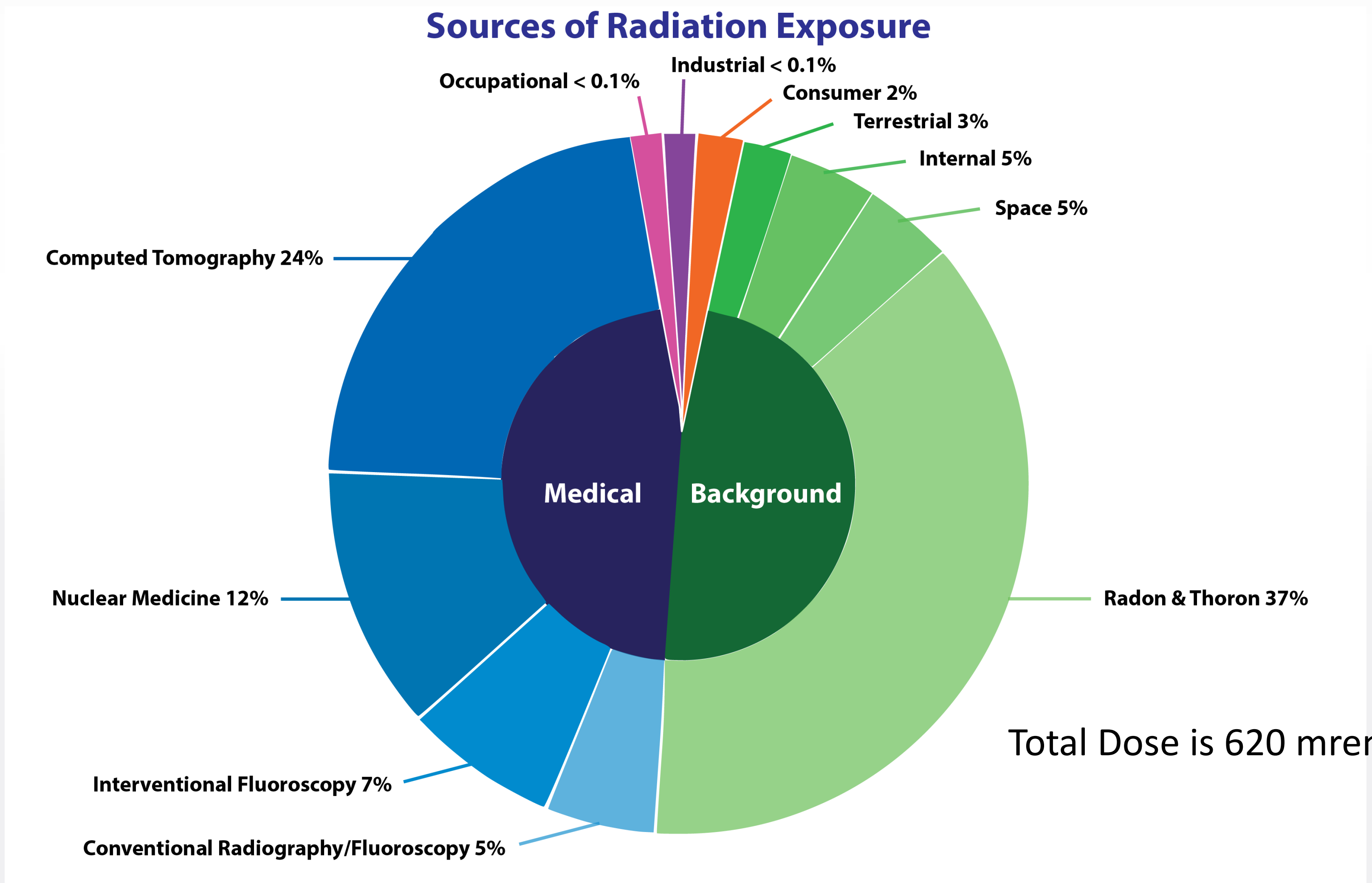
CERCLA Site BORAX-09 Underground Radioactive Material Area



Perspective on Radiation Dose

- Humans have been constantly bombarded by radiation daily from many sources found in nature and due to technology.
- The amount of radiation from natural sources vary broadly based upon location, altitude and time of day.
- On average, American receive about 620 mrem per year from all sources.
- Quantities of radioactive material are significantly less in soil contamination areas outside of the main complexes when compared to the amounts found inside the nuclear facilities.

US Average Ambient Radiation Dose



Total Dose is 620 mrem

Background Radioactivity in the Soil

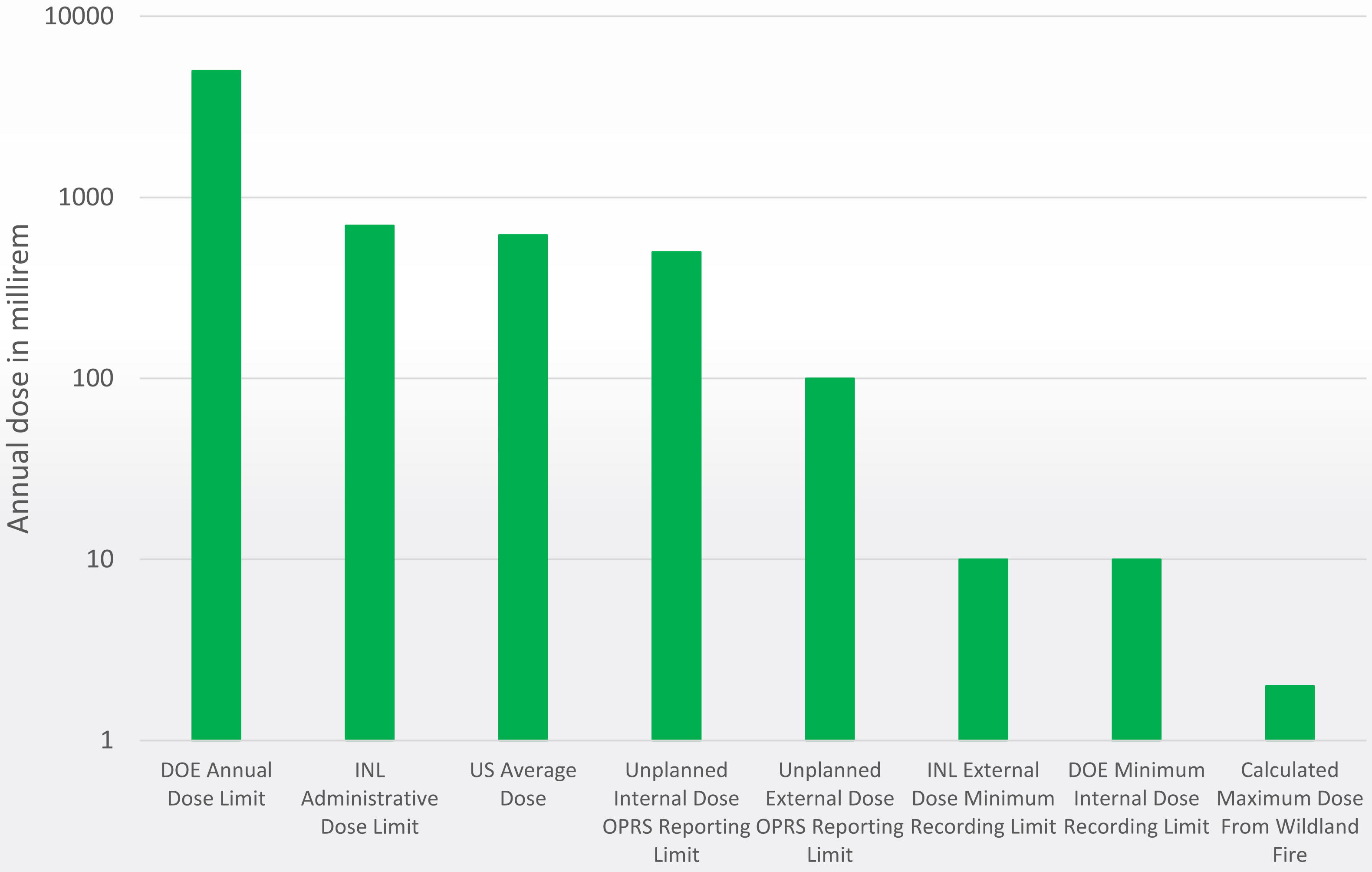
The Idaho National Laboratory was downwind of several nuclear weapons test that occurred in 1940s through the 1960s. As a result, the Snake River Plain was contaminated with nuclear fission products and activation products. They are now part of the radioactive background of the area. In 2019, the background in soil from nuclear fallout was evaluated by the INL (see TEV-3638) to be:

- 1.0 pCi/g	Cs-137
- 0.3 pCi/g	Sr-90
- 0.02 pCi/g	Transuranic

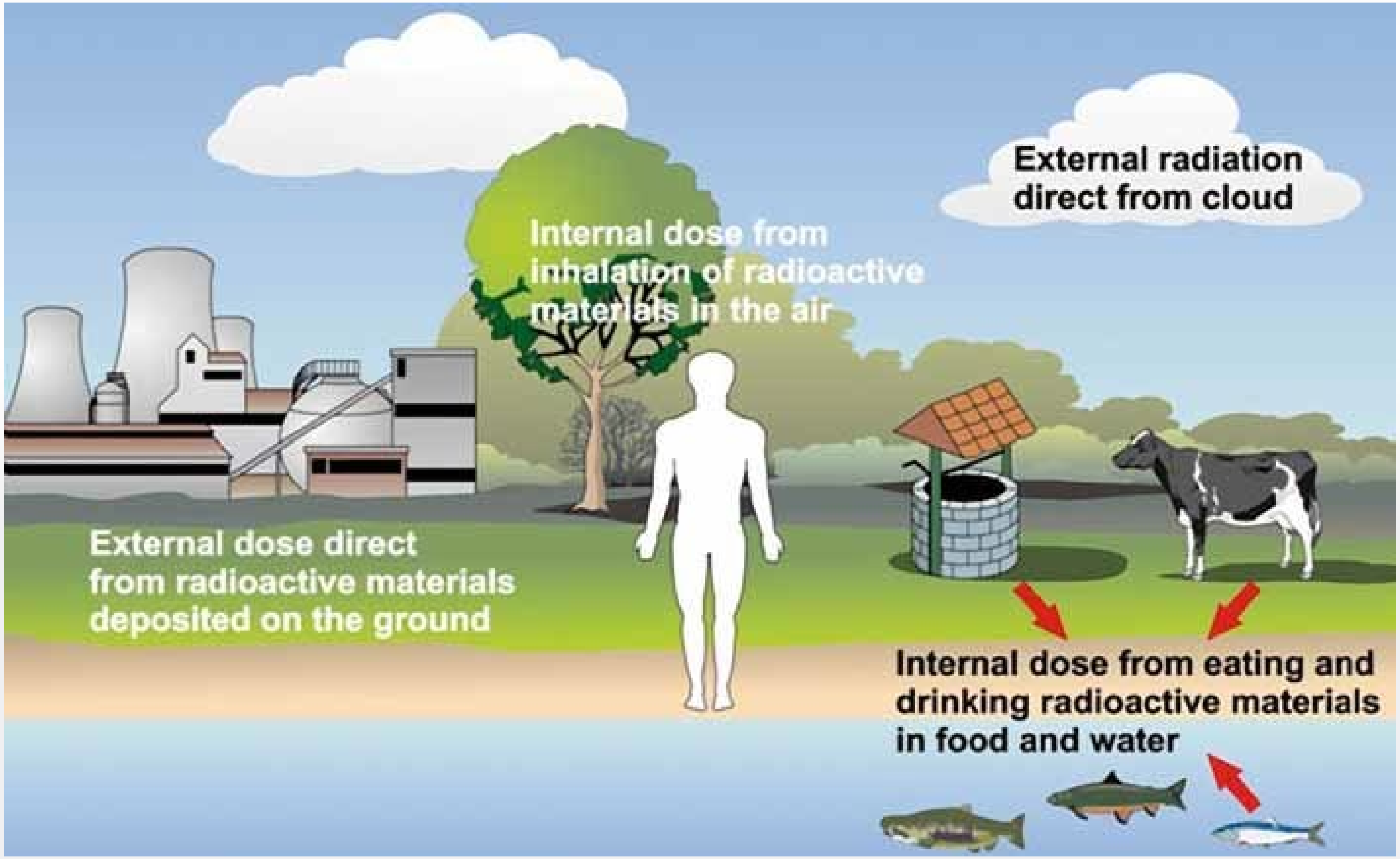
or

- 15 nCi/m^2	Cs-137
- 5.0 nCi/m^2	Sr-90
- 1.0 nCi/m^2	Transuranic

Radiation Dose Limits and Triggers

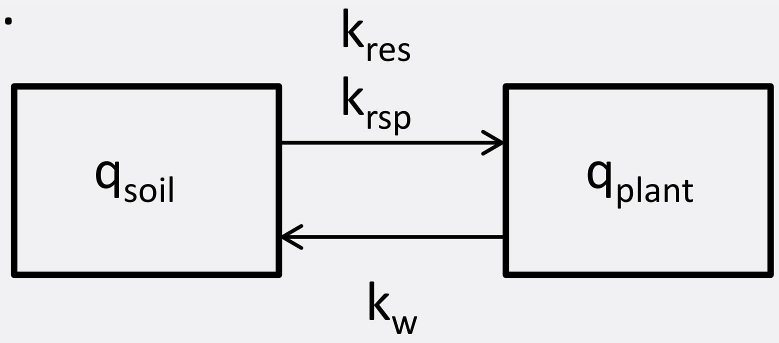


Radiological Exposure Pathways



Wildland Fire Emission Model

The wildland fire emission model assumes when the biomass is burned, all radionuclides both within the plant tissue and on the plant surface are released. 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.



Plant Surface Model

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

Plant Tissue Model

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:

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

where

V = fraction of soil that is vegetated (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).

Dispersion Modeling

Once the emission rates are calculated, the dispersion was modeled using EPA's AERMOD Regulatory Model.

The input parameters like burn duration (1 hour to annual) and burn path length (100 m to 5000 m) were varied to determine the minimum soil concentration for radionuclides of interest that would result in a dose of 10 mrem effective dose. These are used by the Environmental Management group as a screening soil contamination level.

All the INL Soil Contamination Areas were below the minimum screening level of 10 mrem effective dose.

The minimum soil screening levels were compared to the INL Soil Contamination Area average levels to determine a conservative dose for wildland fires and resuspension.

Average Soil Contamination Values Decayed from the Original Evaluation

SCA	Location	Radionuclide	Average Activity
ARA-12	SCA across from ARA-III	Ag-108m	20.1 pCi/g
ARA-23	SCA near ARA I & II & SL-1 burial site	Cs-137	55.8 pCi/g
		Sr-90	0.52 pCi/g
CFA/DP	CFA ditch and pit	Cs-137	58.0 pCi/g
TS-07	TAN Disposal Pond	Am-241	0.2 pCi/g
		Cs-137	32.1 pCi/g
		Co-60	4.0 pCi/g
CPP-95	INTEC Windblown Area	Cs-137	8.2 pCi/g

Wildland Fire Radiation Dose Summary

Radiological dose that occurs during an active fire comes from inhalation of combustion products containing radioactive material, being present in the cloud of radioactive material and from ground shine from deposited radioactive material. The resuspension dose is due to resuspension of contaminated soil that is greatly enhanced due to the denuded soil. It also includes inhaled radioactive material, passage of the radioactive cloud and ground shine from deposition.

Area	Fire Dose	Resuspension Dose
TSF-07	1.93 mrem	2.01 mrem
CPP-95	0.08 mrem	0.03 mrem
CFA Ditch	0.54 mrem	0.23 mrem
ARA-III	0.22 mrem	0.08 mrem
SL-1	0.65 mrem	0.23 mrem

Acknowledgements

- INL Emergency Management would like to acknowledge the support and efforts of the following individuals and groups who participated in this effort.
  - Connor Williams, Colorado State University – INL Intern
  - Laura Ziegler, University of Utah – Fluor Intern
  - Todd Echeverria, CFA Radiological Engineer
  - Seth Kanter, INL Radiological Engineering Manager
  - Scott Lee, INL Environmental Monitoring Manager
  - CFA Radiological Control Technicians
  - US DOE Region 6 Radiological Assistance Program

References

- Abbott, M.L. and A.S. Rood, 1993, COMIDA: A Radionuclide Food Transport Model for Acute Fallout Deposition. EGG-GEO-10367. Idaho National Engineering Laboratory
- Cowherd, C., G.E. Muleski, P.J. Englehart, and D.A. Gillette, 1985. *Rapid Assessment of Exposure to Particulate Emissions from Surface Contaminated Sites*. EPA/600/8-85/002. Office of Health and Environmental Assessment U.S. Environmental Protection Agency, Washington D.C.
- Engineering Design File 1873 (EDF-1873), Rev 0, 2001. Analysis of potential airborne radionuclide emissions during and after fires through contaminated soil areas on the INEEL. October 30, 2001
- EPA, 2004a, User’s Guide for the AMS/EPA Regulatory Model –AERMOD, EPA-454/B-03-001, U.S. EPA, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.
- EPA, 2004b, User’s Guide for the AERMOD Meteorological Preprocessor (AERMET), EPA-454/B-03-002, U.S. EPA, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.
- Whicker, F.W., and A.S. Rood, 2008, “Terrestrial Food Chain Pathways” In: Radiological Risk Assessment and Environmental Analysis, J.E. Till and H.A. Grogan Editors. Oxford University Press, New York.
- Whicker, F.W., and T.B. Kirchner, 1987, “PATHWAY: A Dynamic Food-Chain Model to Predict Radionuclide Ingestion After Fallout Deposition.” Health Physics, 52(6), pp 717-737