

Radiation Dose, Risk, and Cleanup Standards

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Presented to the Santa Susana Mountain Park Association (SSMPA)
September 21, 2026

Disclosure

- Much of this presentation is generic, dealing with open-source, industry-standard material
- References to Santa Susana specific issues represent my views, opinions and analysis. They do not necessarily reflect the views and opinions of The Boeing Company or the Department of Energy
- The genesis of some of this presentation is in the paper “[Nuclear Decommissioning at the Santa Susana Field Laboratory: 20+ Years of Politics vs. Science](#)”

Radiation Dose, Risk and Cleanup Standards

- What are radiation cleanup standards?
- How have they changed over the years?
- Who or what has caused that change?
- Are we limiting “measured dose” or “theoretical calculated risk”?
- What is “reasonable “ in “as low as reasonably achievable” (ALARA)?
- What is the linear no threshold (LNT) “theory” of radiation risk?
- What are the illogical consequences of LNT?
- What does one-in-a-million mean?
- How clean is clean?
- How safe is safe?
- How low do we need to go in order to achieve a desired level of safety?
- Do we need to go to zero?

Background Radiation

- We are constantly exposed to low levels of radiation from outer space
- Low levels of naturally occurring radioactive materials are in our environment, soil, rocks, water and the food we eat
- Some consumer products also contain small amounts of radioactive material

Aurora Borealis



Lantern Mantle



Smoke Detector

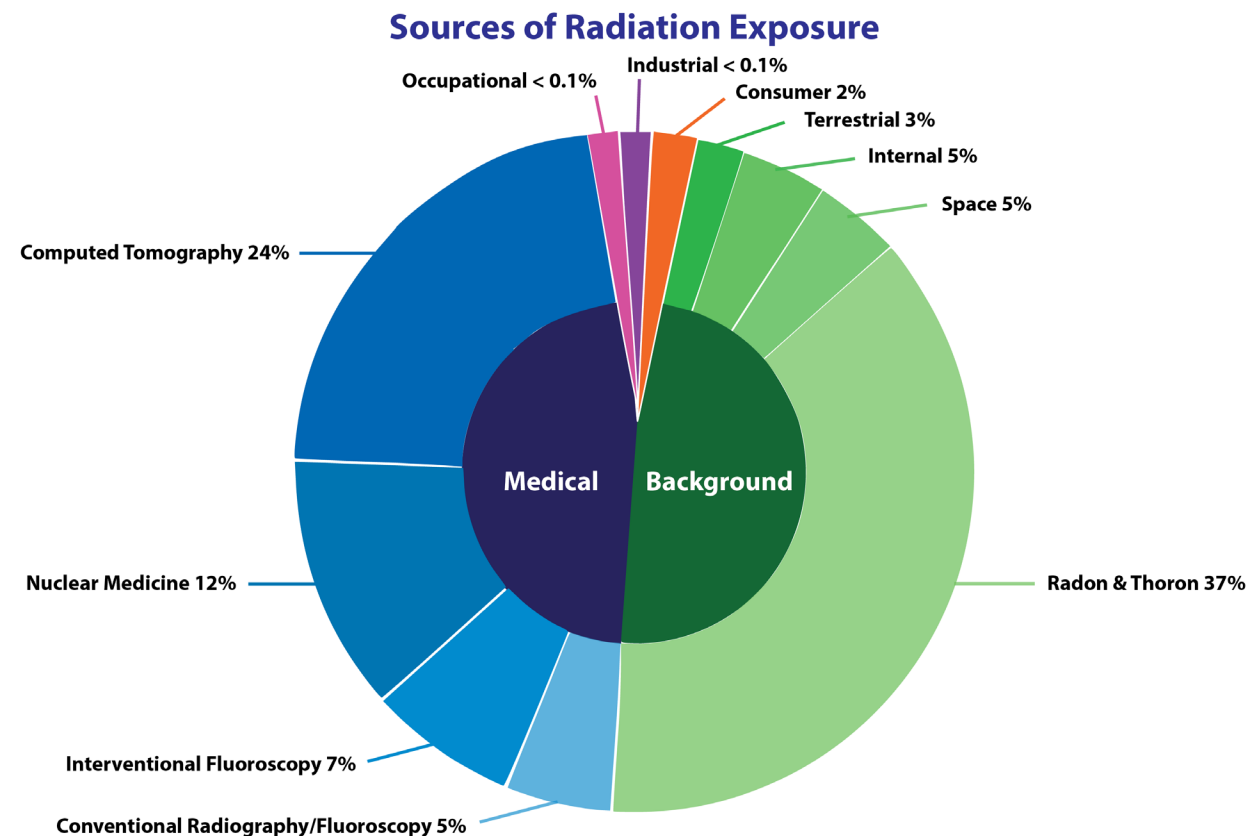
No Salt



Fiestaware

Background Radiation Dose

Lesson 1



Average Annual Radiation Dose											
Sources	Radon & Thoron	Computed Tomography	Nuclear Medicine	Interventional Fluoroscopy	Space	Conventional Radiography/Fluoroscopy	Internal	Terrestrial	Consumer	Occupational	Industrial
Units											
mrem (United States)	228 mrem	147 mrem	77 mrem	43 mrem	33 mrem	33 mrem	29 mrem	21 mrem	13 mrem	0.5 mrem	0.3 mrem
mSv (International)	2.28 mSv	1.47 mSv	0.77 mSv	0.43 mSv	0.33 mSv	0.33 mSv	0.29 mSv	0.21 mSv	0.13 mSv	0.005 mSv	0.003 mSv

(Source: National Council on Radiation Protection & Measurements, Report No. 160)

Background and Lifestyle Radiation Sources*

Source	Dose Rate (mrem/y)	
Indoor radon (Rn-220, Rn-222)	228	
Cosmic rays (Denver)	80	
Cosmic rays (Sea level)	30	
Human body from food we eat (K-40)	29	
Soil & rocks (K-40, uranium, thorium & progeny)	21	
Weapons test fallout (Cs-137, Sr-90, Pu-239, etc.)	1	
Living within 50 miles of a coal fired power plant	0.03	
Living within 50 miles of a nuclear power plant	0.009	
Total	309	
Smoking one pack of cigarettes per day for one year	$0.5 \times 365 = 183$	
One round trip plane ride from LA to NY per year	5	

* EPA, [Radiation Sources and Doses](#)

1 rem = unit of radiation dose
 1 rem/y = unit of radiation dose rate
 1 mrem/y = 1/1000 rem/y

Potassium and Potassium-40

- Natural potassium (K-nat) contains 0.0117% of radioactive K-40
- K-40 half-life = 1.248 billion years
- K-40 specific activity = 7,100,000 pCi/g
- K-nat specific activity = 831 pCi/g
- Potassium chloride (KCl) is a substitute condiment for sodium chloride (NaCl) and can be bought in the supermarket
- KCl specific activity is 436 pCi/g
- Human body contains 1.5 pCi/g of K-40
- Banana contains 2.5 pCi/g of K-40
- AMA recommended daily allowance of potassium = 3.5 g of K = 2,900 pCi K-40
- EPA SSFL background threshold value (BTV) for uncontaminated soil is 30.5 pCi/g
- Rutherford, [Potassium-40 Facts and Figures](#), August 2002

1 curie = unit of radioactivity
= 37 billion decays per second
1 picocurie (pCi) = 1 trillionth of a curie
= 0.037 decays per second

Potassium-40 in Food

- Bananas are reputed to be a good source of potassium and contain 2.5 pCi/g of K-40
- However, many foods are a better source of potassium and therefore contain higher levels of potassium-40
 - Dried fruits contain up to 10 pCi/g (dried apricots)
 - Cereals contain up to 8.8 pCi/g (wheat germ)
 - Potatoes contain 4.3 pCi/g
 - Cod contains 4.3 pCi/g
- Rutherford, [Potassium-40 in Food](#), August 9, 2002

Definitions

- Non-stochastic (deterministic)
 - **Severity of a health effect** is proportional to the dose
 - Threshold below which no effect occurs
 - Applies to immediate effects
- Stochastic (probabilistic)
 - **Probability of a health effect** is proportional to the dose
 - Applies to low level radiation exposure (LNT)
 - Applies to cancer incidence and cancer fatality
 - Applies to delayed effects (leukemia 2-10 y, solid tumors 10-40 y)

Examples of Non-Radiation, Non-Stochastic Hazards and Health Effects with Thresholds

- Thermal burns
- Frostbite
- Chemical burns
- Alcohol intoxication
- Carbon monoxide poisoning
- Hearing damage from intense noise
- Oxygen deprivation
- Lead poisoning
- Drug overdose
- Dehydration or heat stroke
- Electric shock

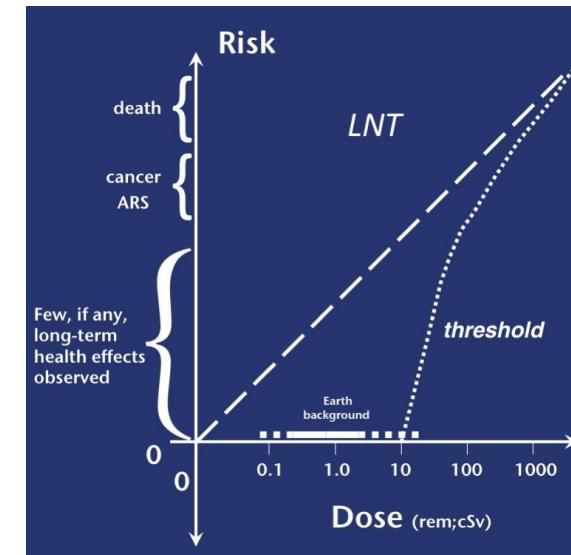
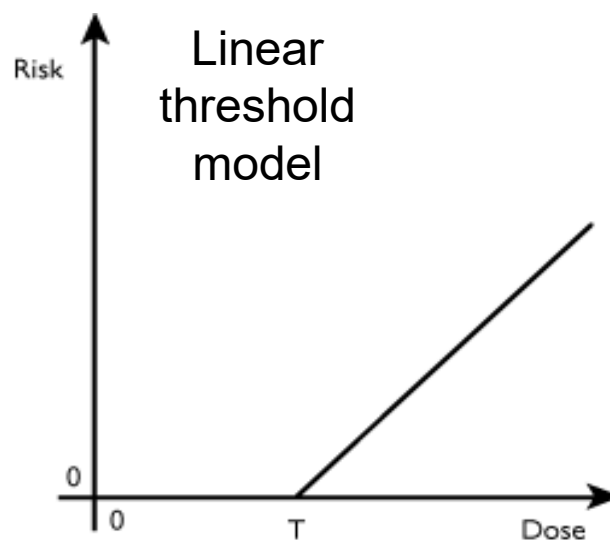
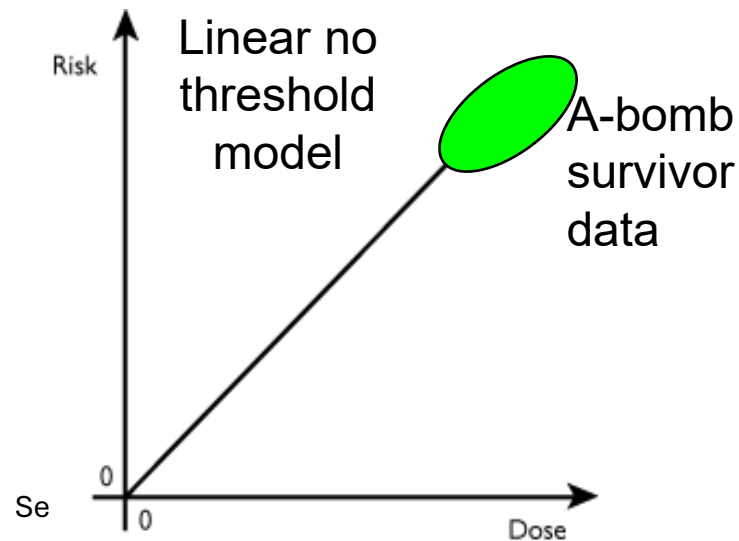
Stochastic Radiation Cancer Risk and LNT (Theoretical)

All subsequent references to “radiation risk” refers to the “theoretical” cancer incidence risk calculated using the linear no threshold (LNT) model of radiation risk.

LNT posits that the smallest of exposures, well below natural background levels, will cause an incremental increase in the risk (probability) of cancer incidence and cancer fatality.

Linear No Threshold Model of Radiation Risk

- Regulatory bodies require the use of the linear-no-threshold (LNT) model of radiation risk
- LNT assumes that the risk of cancer is proportional to the radiation dose level (no matter how small)
- Radiation risk at low doses is extrapolated from observed cancer effects at high doses (e.g. from atomic bomb survivors)
- No physical effects have been observed at low doses typical of background radiation levels
- Controversial, conservative, assumes no threshold, lack of health effects in high background regions



Biological Effects of Ionizing Radiation (BEIR VII) - 2006

- *“42 out of 100 people will be diagnosed with cancer during their lifetimes from causes unrelated to radiation (42%)”*
- *“1 cancer in 100 people could result from a single exposure of 10 rem of radiation (1%)”*
 - **99 out of 100 people would be unaffected**
- *“At doses of 10 rem or less, statistical limitations make it difficult to evaluate cancer risk in humans”*
- **1 rem equates to an individual theoretical risk of one-in-a thousand (10^{-3})**
- **1 millirem equates to an individual theoretical risk of one-in-a-million (10^{-6})**
- National Academy of Sciences, [BEIR VII, “Health Risks from Exposure to Low Levels of Ionizing Radiation”](#), June 2006 [BEIR VII Summary](#), June 2006

Background and Lifestyle Radiation Risks

Source	Dose (mrem/y)*	80-year Lifetime Risk**
Indoor radon (Rn-220, Rn-222)	228	$18,240 \times 10^{-6}$
Cosmic rays (Denver)	80	$6,400 \times 10^{-6}$
Cosmic rays (Sea level)	30	$2,400 \times 10^{-6}$
Human body from food we eat (K-40)	29	$2,320 \times 10^{-6}$
Soil & rocks (K-40, uranium, thorium & progeny)	21	$1,680 \times 10^{-6}$
Weapons test fallout (Cs-137, Sr-90, Pu-239, etc.)	1	80×10^{-6}
Living within 50 miles of a coal fired power plant	0.03	2.4×10^{-6}
Living within 50 miles of a nuclear power plant	0.009	0.72×10^{-6}
Total	309	$24,723 \times 10^{-6} = 2.5\%$
Smoking one pack of cigarettes per day for one year	$0.5 \times 365 = 183$	
One round trip plane ride from LA to NY in one year	5	

* EPA, [Radiation Sources and Doses](#)

** BEIR VII cancer risk of 10^{-6} per mrem

Consequences of LNT at Background

- BEIR VII (June 2005) states that 1 rem of exposure results in a 0.1% increase in cancer incidence risk. Therefore,
 - 1 mrem = 10^{-6} risk
 - 80-year exposure to 300 mrem/y background radiation = 2.4% risk
 - **Background radiation exposure will result in 8 million cancers and 4 million deaths from cancer during the lifetimes of today's U.S. population**
- EPA's risk goal of 10^{-6} for a 30-year exposure duration is equivalent to a dose goal of 0.033 mrem/y
 - **~10,000 times less than U.S. background of 300 mrem/y**
 - ~1,000 times less than NRC's 25 mrem/y License Termination Rule (Decommissioning)

LNT Analogy of Jumping off a Roof

Jumping off a ...	Probability of death
100 foot, 10 story building	~100%
10 foot shed	10%
1 foot step	1%
1 inch thick book	~0.001
0.1 inch thin magazine	10^{-4}
0.001 inch thin split hair	10^{-6}



LNT Analogy to Drinking Alcohol

- Alcohol is a poison
- Consumption of 30 shots of 70 proof alcohol in one evening will kill you
- LNT says that if 30 people at a party each drink one shot
 - 29 will have no ill effects
 - 1 person will die
 - **population risk**
- LNT says that if one person drinks one shot per day for a month
 - that person will die
 - **cumulative individual risk**



Overdosing Medications in a LNT World

- Almost all medications taken for beneficial reasons at low doses will kill you if taken at high doses ... overdosing
- We know that taking 100 sleeping pills will kill you
- But we will readily take one sleeping pill and not worry about a potential 1% chance of dying in one's sleep based on LNT
- Medications are an example of a **threshold model of risk**

Sources of Risk Compared to the EPA's Acceptable Risk Range*

Sources of Risk	10 ⁻⁴ Risk	10 ⁻⁶ Risk
30-year cancer incidence risk from drinking orange juice (contains radioactive potassium-40)	1 small glass per day	0.4 teaspoon per day
30-year cancer incidence risk from elevation change (increasing exposure to cosmic radiation)	Increase in risk moving from Santa Monica to the foothills of Beverly Hills (600-foot elevation)	Difference in risk between the feet and head of a 6-foot person
Fatal accident risk from driving for 30 years	Driving an extra 127 miles per year	Driving an extra 1 mile per year

* Rutherford, "[Radiation Risks in Everyday Life](#)", 43rd Annual Health Physics Society Meeting, January 2010

Fallacy of the Geometric Scale of Safety

Contributions to Lifetime Cancer Risk	Radiation Exposure (mrem/year)	Lifetime Cancer Incidence Risk		
		Individual Risk (probability)	Incremental Population Risk (cancers)	Total Population Risk (cancers)
U.S. average cancer incidence	N/A	0.42	336	336
Upper EPA CERCLA risk range (1 in 10,000)	-	0.0001	0.08	336.08
Geometrical mean of CERCLA risk range (1 in 100,000)	-	0.00001	0.008	336.008
Lower EPA CERCLA risk range (1 in 1,000,000)	-	0.000001	0.0008	336.0008
Zero incremental risk level (2010 AOC Cleanup to Background)	-	0	0	336

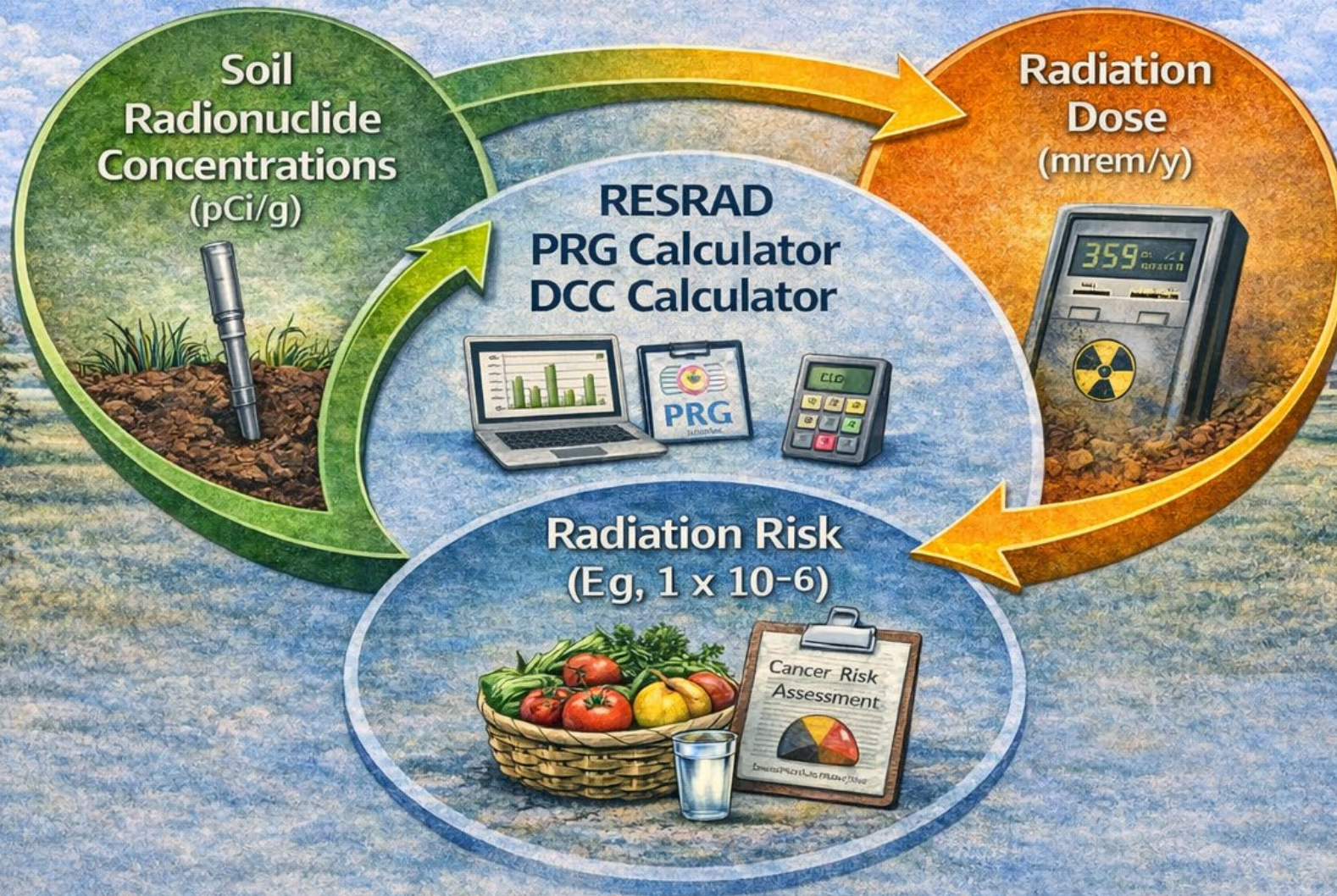
Habitable area of Area IV of SSFL $\approx$ 200 acres. Assumed home lot size of 1 acre consistent with neighboring Bell Canyon community to the south. Assumed 4 people per home to give 800 residents.
Incremental population risk = individual risk x 800

Radiation Cleanup Standards

Who Has To Cleanup To What?

Responsible Party (RP)	Consent Order	Radionuclides in Soil Remedial Goal	Chemicals in Soil Remedial Goal
DOE	2010 AOC	Background	Background
NASA	2010 AOC	Background	Background
Boeing	2022 Settlement Agreement	Background	Residential risk with 100% produce consumption

Relationship Between Soil Radionuclide Concentration, Radiation Dose, and Radiation Risk



Principal Cleanup Standard Software

- Argonne National Laboratory, RESRAD, RESidual RADioactivity
<https://resrad.evs.anl.gov/>
- EPA, Preliminary Remediation Goal (PRG) Calculator for Radionuclides at Superfund Sites
<https://epa-prgs.ornl.gov/radionuclides/>
- EPA, Dose Compliance Concentrations (DCC) for Radionuclides at Superfund Sites
<https://epa-dccs.ornl.gov/>
- Oak Ridge National Laboratory, Risk Assessment Information System
<https://rais.ornl.gov/#>

MARSSIM

- Multi-Agency Radiation Survey and Site Investigation Manual, NUREG-1575
 - [Revision 1. August 2000](#)
 - [Revision 2. Volume 1. March 2026](#)
 - [Revision 2. Volume 2. Appendices. March 2026](#)
- EPA, NRC, DOE and DOD
- Provides guidance dose-based final status surveys
 - Number and location of soil samples, static and scanning instrument measurements
 - Non-parametric statistical methods of hypothesis testing to prove (or disprove) that building surface contamination and soil volumetric contamination goals have been met

EPA Superfund Evaluation Criteria

- National Oil and Hazardous Substances Pollution Contingency Plan (NCP) Subpart E (1990) [40 CFR 300.400](#)
- Outlines the process that selects a remedy and remedial risk goal within the **acceptable risk management range of 10^{-6} and 10^{-4}** (40 CFR 300.430(e)(2)(i)(A)(2))
- 40 CFR 300.430(e)(9)(iii) – Nine evaluation criteria
 - A. Overall protection of human health and the environment
 - B. Compliance with ARARs
 - C. Long-term effectiveness
 - D. Reduction of toxicity, mobility, or volume through treatment
 - E. Short-term effectiveness
 - F. Implementability, feasibility**
 - G. Cost
 - H. State acceptance
 - I. Community acceptance

Features of Cleanup Frameworks

	MARSSIM	CERCLA Superfund	2010 AOC
Authors	EPA, NRC, DOE, DOD	EPA	DTSC, CBG
Sites	All radiologically contaminated sites	All Superfund sites and sites where EPA is the lead or co-regulator	SSFL only
Hypothesis Testing	Compares reference area distribution to sampled area distribution using non-parametric hypothesis testing	Compares reference area distribution to sampled area distribution using non-parametric hypothesis testing	Compare single sample data to single parametric LUTV
Reasonable maximum exposure (RME)	Not applicable	Yes	No
Exposure point concentration (EPC) - area averaging	Not applicable	Yes	No
Where to sample	Yes	Yes	No
How many samples to take	Yes	Yes	No
Performs risk assessment	Not applicable	Yes	No
Remedial Goal	Dose = 15 to 25 mrem/y	Cancer risk = 10^{-6} to 10^{-4}	Background

Wide Range of Regulatory “Safe” Dose Standards for the Public

Dose (mrem/y)	Standard	Citation
100	Annual dose limit for members of the public at a site boundary, NRC and DOE	10 CFR 20.1301 DOE O 458.1
50	NRC Airborne Effluent	10 CFR 20.1302, Appendix B
25	NRC License Termination Rule (1997)	10 CFR 20.1402 Subpart E
15	EPA Safe Dose (1994)	40 CFR 196 (Draft)
15	EPA Annual dose limit for members of the public around Yucca Mountain	40 CFR 197
12	EPA Safe Dose (2014)	OSWER 9285.6-20
10	EPA Airborne NESHAPS dose limit for DOE Facilities	40 CFR 61 Subpart H
4	EPA dose limit for beta/gamma emitters in drinking water	40 CFR 9, 141 and 142
1	De minimis dose limit	ANSI/HPS N13.12-2013

SSFL Radiation Dose Cleanup Standards (1998)

- March 1996 - N001SRR140127, “Proposed Sitewide Release Criteria for Remediation of Facilities at the SSFL”
- August 1996 - Approved by [California Department of Health Services](#)
- September 1996 - Approved by [DOE](#)
- December 1998 - N001SRR140131, “[Approved Sitewide Release Criteria for Remediation of Radiological Facilities at the SSFL](#)”
- Soil
 - SSFL dose-based standard of 15 mrem/y for residential land use
 - Consistent with EPA and NRC dose standards at the time
- Building structures
 - SSFL surface contamination limits based on
 - NRC Regulatory Guide 1.86
 - DOE Order 5400
 - CDHS DECON-1
 - Consistent with ANSI/HPS N13.12-2013 based on 1 mrem/y

Politics, Legislation, Litigation and SSFL Consent Orders Impacting Radiation Cleanup Standards (2000 - Present)

California Legislation

- 2000-2004 Sacramento legislation seeking to ...
 - oppose established federal and state decommissioning regulations
 - impose zero risk goals at SSFL
 - mandate waste disposal of decommissioned material as LLRW
 - transfer of regulation of radioactive materials at SSFL from CDPH/RHB to DTSC
- SB-243, SB-1970, SB-1444, AB-2214, SB-13, SB-201, SB-208, SB-415, SB-1456

SB-1970 (2002) and E.O. D-62-02

- SB 1970 attempted to legislate that all “decommissioned material” that had met all federal and state cleanup standards and had been “released for unrestricted use “ should nevertheless go to a licensed LLRW disposal facility
- California Governor, Gray Davis vetoed this bill, but as a compromise, issued Executive Order D-62-02, prohibiting the disposal of “decommissioned material” at Class III or unclassified landfills in California
- Effectively, D-62-02, known as the Governor’s Moratorium, required that “decommissioned material” be disposed to Class I, hazardous waste disposal facilities, or Class II facilities in the State of California.
- D-62-02 did NOT require decommissioned material to be shipped out of State to LLRW disposal sites
- D-62-02 was silent on recycling and imposed no restrictions on recycling decommissioned material in the State
- Subsequently, Boeing complied with D-62-02, and with the approval of DOE and DTSC disposed of all decommissioned material at Class I hazardous waste facilities in California from 2002 to 2014

Litigation

- CBG vs CDHS (2002)
 - Plaintiffs object to adoption of NRC 25 mrem/y License Termination Rule
 - DHS loses and rescinds all numerical decommissioning guidelines
- NRDC and CBG vs DOE (2004-2007)
 - Plaintiffs object to DOE's choice of 15 mrem/y soil cleanup goal in an Environmental Assessment: demand an Environmental Impact Statement
 - DOE loses and delays soil cleanup by 20+ years
 - Norm Riley (DTSC) halts all DOE D&D work in 2007 until ~2020
- [PSR-LA vs DTSC, CDPH and Boeing](#) (2013-2023)
 - Plaintiffs claimed decommissioned material from 5 Boeing-owned buildings in Area IV is LLRW and “underground” cleanup standards were not approved
 - Plaintiffs lose in all three California Superior, Appeals and Supreme Courts

Senate Bill SB-990 (2007)

- Mandated agricultural (rural residential) land use instead of “reasonably anticipated future land use” of recreational open space, or even conservative residential land use
- Transferred authority for radiological remediation in California from the Department of Public Health Radiologic Health Branch (DPH/RHB) to the DTSC
 - DPH/RHB enforces federal NRC rules under the Agreement State law
 - DTSC has no expertise in regulation of radioactive material and only one health physicist
- Boeing issues a white paper [Technical Feasibility of Detecting Radionuclide Contamination in Soil at a \$10^{-6}\$ Risk Level for Agricultural Land Use](#)
- **Boeing sues the State and wins**

2010 AOC - Cleanup to Background

- 2010 AOC is not a law, regulation, or regulatory guidance. It is a “contract” between two parties
- Dispensed with all EPA CERCLA risk assessment guidance and MARSSIM procedures
- Every analyte of every soil sample should not exceed look-up table values (LUTV) based on background threshold values (BTV)
- Soil defined to include all anthropogenic building structures, even though no BTV established for structural surfaces
- Chemical soil disposal recognized non-haz. vs. haz. soil, but radionuclides not accorded the same flexibility
- 2010 AOCs violated CEQA and NEPA, in that it predetermined cleanup goals and remedies, before completion of the DTSC EIR and the DOE and NASA EISs

DTSC and DOE Challenged to Terminate 2010 AOC

- On April 6, 2026, an [open letter](#) was sent to DTSC Director Kathrine Butler and Energy Secretary Chris Wright, proposing that DTSC and DOE agree to terminate the 2010 AOC and replace it with more conventional cleanup remedies consistent with those used in the rest of the U.S.
 - No other remedial site in California or U.S. is required to cleanup-to-background
 - Violates NEPA and CEQA
 - Violates California Executive Order D-62-02 (2002)
 - Violates Presidential Executive Order 14300 (2025)
 - Violates California Appeals Court Decision in C088821, PSR-LA vs. DTSC/CDPH/Boeing (2023)
 - Violates DOE-STD-1241-2023
- Four months later, both parties responded without addressing issues
 - [DTSC 8/11/2026 response](#). Thanne Berg, DTSC Deputy Director
 - [DOE 8/25/2026 response](#). Timothy Walsh, DOE Assistant Secretary for Environmental Management

Problems With Implementing Radiation Cleanup Standards

Moving the Goal Posts

- Dose 25 mrem/y
- Dose 15 mrem/y
- Dose 12 mrem/y
- Risk 10^{-6} to 10^{-4}
- Residential 25% produce consumption
- Residential 100% produce consumption
- Agricultural 100% all food consumption (SB-990)
- Exposure duration from 30 years to 26 years
- Zero dose, zero risk (2010 AOC)



Needle in a Haystack

- Signal to noise ratio $\ll 1$
- It's hard to prove the negative
- “Absence of evidence” is not the same as “evidence of absence”
- You have not looked hard enough!!!
- Scientific method
 - Define null hypothesis as “existence of risk or contamination”
 - Test to either reject or accept



- LNT - Search for cancer risk from low doses $\ll$ background doses
- SSFL - Search for levels of contamination $\ll$ background variability

Reducing the “Remedial Goal / Background” Ratio to $\ll 1$

- Gross cleanup goal = Background + incremental net cleanup goal
- 15 mrem/y net soil concentration goals were $\gg$ soil background therefore detailed knowledge of background was unimportant
- 10^{-6} net soil concentrations are $\ll$ soil background therefore detailed knowledge of background is very important
- Cesium-137
 - 9.2 pCi/g $\gg$ 0.193 pCi/g (15 mrem/y)
 - 0.06 pCi/g $<$ 0.193 pCi/g (residential, 10^{-6})
 - 0.04 pCi/g $<$ 0.193 pCi/g (residential, 10^{-6} , 100% fruit/veg. consumption)
 - 0.00008 pCi/g $\lll$ 0.193 pCi/g (agricultural, 10^{-6} , SB-990, 100% all food consumption)
 - 0.00 pCi/g $\lll$ 0.193 pCi/g (2010 AOC background)

Principal Land Use Scenarios in Risk Assessment

Land Use	Exposure Pathways			
	External / Direct	Ingestion	Inhalation	On-site Food Consumption
Recreator / Open Space	Yes	Yes	Yes	No
Residential 0% Garden	Yes	Yes	Yes	No
Residential 100% Garden	Yes	Yes	Yes	100% of fruit & vegetable diet
Agricultural Family Farm	Yes	Yes	Yes	100% of all diet incl. meat, dairy, fish

Recreator Land Use Scenario for Radionuclide PRGs

Hiking

Fishing

Camping

Berry Picking

Exploring Old
Structures

ATV Riding

Swimming & Boating

External
Exposure



Ingestion of
Soil & Water



Inhalation
of Dust



Ingestion of
Wild Foods



Ingestion of
Wild Foods



Potential Radiation Pathways & Exposure Routes

Residential Land Use Scenario for Radionuclide PRGs



Agricultural (Farmer) Land Use Scenario for Radionuclide PRGs

Crop Farming

Animal Farming

External
Exposure



Ingestion of Soil & Water



Inhalation of Dust



Ingestion of
Crops & Livestock



Potential Radiation Pathways & Exposure Routes

EPA PRGs (10^{-6}) for Key Land Uses vs. Soil Background

Radionuclide	Source	Background (BTV) (pCi/g)	Open Space, Recreational* (pCi/g)	Residential 0% produce consumption ** (pCi/g)	Residential 25% produce consumption ** (pCi/g)	Residential 100% produce consumption ** (pCi/g)	Agricultural 100% all food consumption ** (pCi/g) ***
Potassium-40	NORM	30.5	5.21	0.144	0.0207	0.00581	0.00230
Uranium-238	NORM	1.68	13.6	0.0124	0.00491	0.00174	0.000359
Thorium-232	NORM	2.95	0.703	0.00987	0.00449	0.00170	0.000838
Radium-226	NORM	1.82	0.497	0.0128	0.00529	0.00191	0.000399
Cesium-137	Man-made	0.193	2.31	0.0605	0.0537	0.0401	0.00970
Strontium-90	Man-made	0.075	36.5	4.21	0.0190	0.00477	0.00325
Plutonium-239	Man-made	0.0142	18.3	3.80	1.32	0.445	0.247

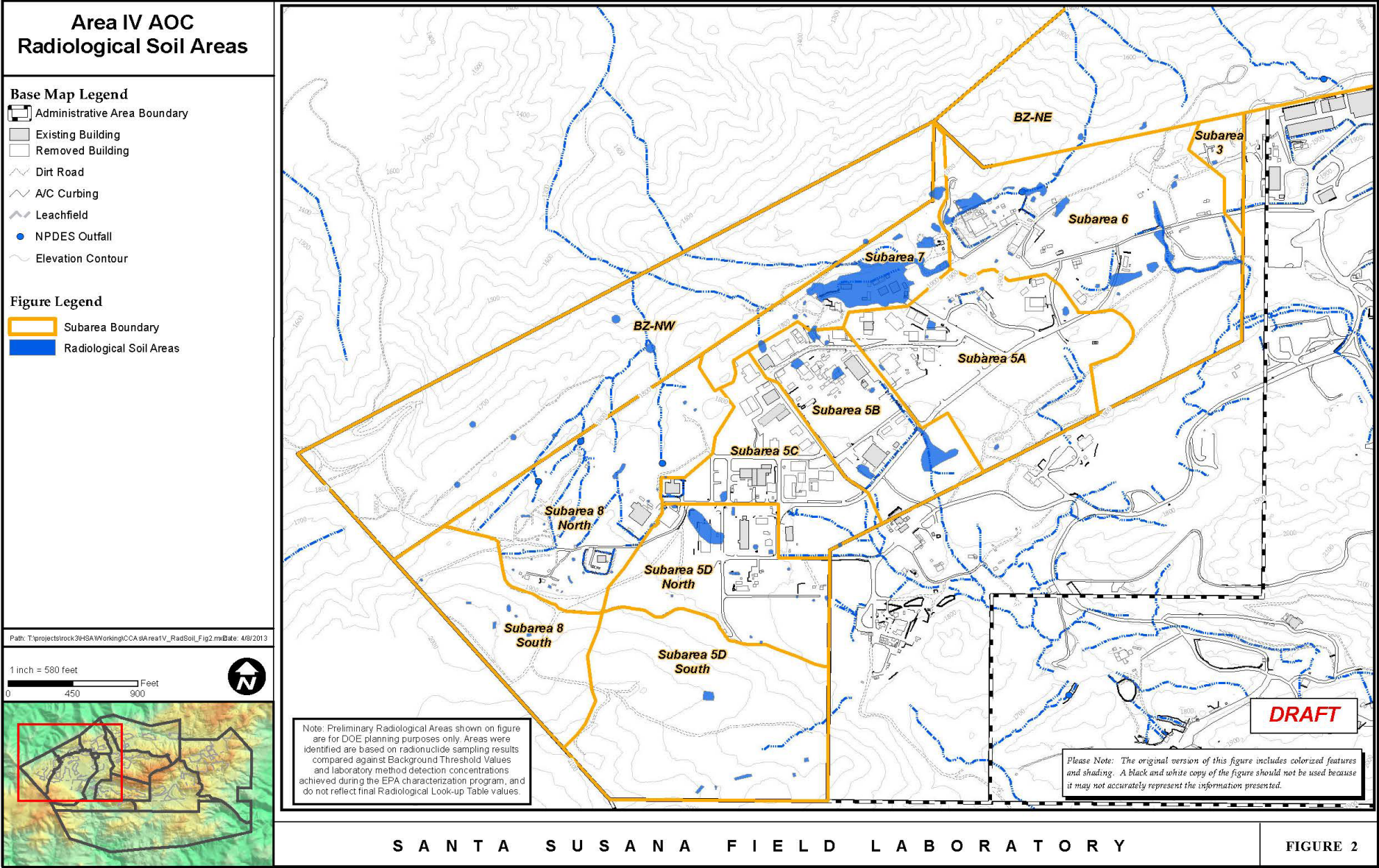
* [RAIS Radionuclide PRG Calculator](#), February 3, 2026

** [EPA Preliminary Remediation Goals for Radionuclides](#), February 3, 2026

*** excludes finfish & shellfish

EPA Radiological Survey of Area IV (2008 – 2012)

EPA Found
Soil Above
Background
in a Few
Scattered
Locations



Summary of EPA Soil Sample Exceedances (2012)

- EPA analyzed 3,735 Area IV soil samples
- EPA reported results for ~128,000 analytes

Radionuclide	DOE & State Approved 1998 Dose Limit (15 mrem/y)*		Background Threshold Value (BTV)	
	pCi/g	Exceedances	pCi/g	Exceedances
Cesium-137	9.2	8 (0.2%)	0.193	291 (7.8%)
Strontium-90	36	0 (0.0%)	0.075	153 (4.1%)
Plutonium-239	33.9	0 (0.0%)	0.0142	14 (0.4%)

*Limited number of exceedances demonstrates the effectiveness of prior remediation to the DOE and State approved dose limit

Recent Events Related to Cleanup Standards (Chemical and Radiological)

DOE Disposes Decommissioned Material and Debris from Non-Radiological Buildings as LLRW (2020-2021)

- 2020 Amendment to Order on Consent
 - DTSC requires DOE to dispose of decommissioned material from decommissioned buildings (4019, 4029, 4133) as low-level radioactive waste, in **violation** of the 2002 California Executive Order D-62-02, and in **violation** of the 2023 California Court Order striking down the 2013-2023 PSR-LA Complaint
 - DTSC orders DOE to dispose of demolition debris from buildings with no history of radiological use (4038, 4057, 4462, 4463) as low-level radioactive waste in **violation** of common sense
- DOE mis-characterizes NRC manifest data for waste going to EnergySolutions LLRW disposal site

DOE Standard DOE-STD-1241-2023 (2023)

- “Implementing Release and Clearance of Property Requirements”
- [DOE-STD-1241-2023](#) adopts and promulgates for all DOE sites
 - 25 mrem/y plus ALARA for real property based on NRC [10 CFR 20.1402](#)
 - 1 mrem/y for personal property
 - Surface contamination limits for personal property identical to [Reg. Guide 1.86](#) and [NUREG-1757, Vol. 1, Rev. 2, Section 15.11.1.1](#)
 - Volumetric contamination limits based on ANSI/HPS N13.12-2013
 - 5 pCi/g of radium-226 in soil based on EPA [UMTRCA regulations](#)
- Nowhere does the standard require
 - cleanup to background
 - CERCLA risk assessment
 - 10^{-6} risk limits

DTSC Soil Smarts

Multiple Lines of Evidence (2024-2026)

- DTSC has recognized that the 2010 AOCs are impossible to implement for chemicals
- DTSC's choice of chemical “lookup table values” (LUTV) to represent background remedial goals has been based on unrealistic and unachievable chemical “method reporting limits” (MRL)
- This has led to DTSC implementing a process known as “multiple lines of evidence” (MLE) to select alternate remedial goals
- The public has viewed this as reneging on the promise of background cleanup
- Rutherford, “[Chemical Questions on Data Presented in Soil Smarts Workshops](#)”, December 7, 2024

DOE Supplemental Environmental Impact Statement (SEIS) (2024-2026)

- DOE follows DTSC's lead and proposes implementation of MLE in its attempt to comply with the 2010 AOCs
- The public has viewed this as reneging on the promise of background cleanup

GAO-25-107565 Compares Eight DOE Cleanup Sites (2025)

- The non-partisan U.S. Government Accountability Office (GAO) summarized cleanup status at eight DOE cleanup sites, Hanford, Los Alamos, Oak Ridge, Savannah River, Idaho, Livermore, Nevada and ETEC
- Hanford, Idaho, Livermore, Oak Ridge, and Savannah River are on the National Priorities List (NPL) and DOE has entered into an interagency agreement with EPA whereby remediation under EPA CERCLA risk assessment guidance is implemented
- Other than ETEC, none of the other seven DOE sites use background as a cleanup goal
- Why does DOE allow itself to be railroaded by DTSC at ETEC?
- GAO-25-107565, [Nuclear Waste Cleanup](#), September 26, 2025
- Rutherford, [GAO-25-107565](#), September 29, 2025

Is NRC a Dose-based or Risk-based Agency?

- [10 CFR 20 - Standards for Protection Against Radiation](#)
- All numerical limits are expressed in terms of measurable quantities (dose and activity)
- There are no limits for theoretical risk based on LNT

Keywords in 10CFR20	No. Used
Radiation	177
Dose	333
Exposure	113
Risk	11
Radiation Dose	11
Radiation Exposure	7
Radiation Risk	0

Is DOE a Dose-based or Risk-based Agency?

- [10 CFR 835 – Occupational Radiation Protection](#)
- All numerical limits are expressed in terms of measurable quantities (dose and activity)
- There are no limits for theoretical risk based on LNT

Keywords in 10CFR835	No. Used
Radiation	131
Dose	213
Exposure	91
Risk	7
Radiation Dose	6
Radiation Exposure	9
Radiation Risk	0

Superfund or ...

- 1989-2003 - USEPA conducts four assessments of SSFL (1) and Area IV (3) and concludes Superfund listing is not justified
- November 30, 2007 - In a fifth assessment, USEPA finally concludes *“the site is recommended for further assessment under CERCLA”* based on TCE contamination of groundwater
- December 6, 2007 - USEPA recommended to Governor Schwarzenegger that SSFL be added to the NPL and designated a Superfund site
- Activists, legislators and the community are overjoyed
- December 21, 2007 - Dan Hirsch of CBG is quoted in the [Daily News](#), saying, *“the community has been praying for a decade that this site would be added to the Superfund list. If the governor blocks Superfund listing, he would be doing a favor to the polluter and a grave injustice to the people who live near the site.”*

... Or Not Superfund

- January 15, 2008 - Only twenty-five days later, CBG, along with a multitude of other activist organizations changed their tune, and sent a letter to CalEPA demanding that the State [defer supporting Superfund listing](#), preferring instead the more restrictive “agricultural land use” requirements of SB-990 to the “reasonably anticipated future land use” requirements of CERCLA guidance (open space), and ultimately preferring the “cleanup-to-background” requirements of the 2010 AOCs.
- January 15, 2008 – The same day, Linda Adams (Secretary of CalEPA) concurred with activist demands and replied to the USEPA that California requests [deferment of Superfund listing](#).
- Demonstrates a **pre-planned agreement** between CalEPA and activists to derail a prior Boeing/Schwarzenegger/Kuehl agreement to donate land to the State in return for Senator Kuehl amending SB-990 to suburban residential land use
- Linda Adams sent several subsequent letters to USEPA, again requesting deferment
- DOE and the Water Board supported Superfund listing
- SSFL is still not a Superfund site today

Recommendations

- For radiation cleanup standards
- Use **measurable** properties as cleanup goals
 - Radiation dose (instruments)
 - Volumetric soil & structure concentrations (lab analyses)
 - Surficial building structural activities (instruments, wipe tests)
- Do **NOT** use **theoretical** radiation risk values based on LNT at dose levels much less than background
- Do **NOT** use a one-in-a-million risk goal
- Do **NOT** use background as a zero-dose, zero-risk goal

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- Radiation Cleanup Standards
https://philrutherford.com/radiation_cleanup_standards.html
- Radiation Risk
https://philrutherford.com/radiation_risk.html
- Radiation Dose, Risk and Cleanup Standards (This presentation)
<https://philrutherford.com/ssfl.html#rdrcs>
- Santa Susana Field Laboratory
<https://philrutherford.com/ssfl.html>
- Proposal to Terminate the 2010 AOCs
<https://philrutherford.com/ssfl.html#doeaoc>
- Offsite Impact of the Santa Susana Field Laboratory
https://philrutherford.com/SSFL/Offsite_Impact_of_SSFL.pdf
- Nuclear Decommissioning at the Santa Susana Field Laboratory:
20+ Years of Politics vs. Science
https://philrutherford.com/SSFL/Nuclear_Decommissioning_at_SSFL.pdf