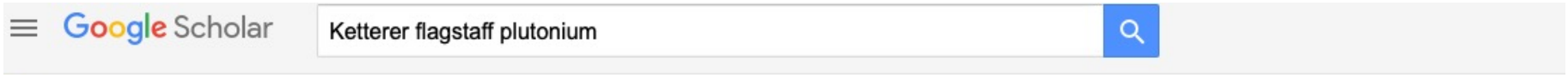
Slides supporting the testimony of Michael E. Ketterer, PhD

Fifth Meeting of the Radioactive and Hazardous Materials Committee

November 15, 2024

State Capitol, Room 317, Santa Fe



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A Percich, A Husic, ME **Ketterer** - Geophysical Research Letters, 2022 - Wiley Online Library
… sensitivity analysis has not been performed on **plutonium** sediment fingerprinting. The objective of this study was to assess the utility of **plutonium** isotopes as tracers of fluvial sediment …
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$^{239, 240, 241}$Pu fingerprinting of plutonium in western US soils using ICPMS: solution and laser ablation measurements
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…) of electrodeposited alpha sources to characterize **plutonium** activities and atom ratios prevalent in … Nevada Test Site (NTS) **plutonium**. This study illustrates two different ICPMS-based …
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Applications of transuranics as tracers and chronometers in the environment
ME **Ketterer**, J Zheng, M Yamada - Handbook of Environmental Isotope …, 2012 - Springer
… **Plutonium** that has been subjected to lengthy reactor irradiation (ie, "burn-up") also contains relatively larger abundances of the heavier isotopes. As is seen in Fig. 20.2, the Pu isotopic …
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Geophysical Research Letters®

RESEARCH LETTER
10.1029/2021GL094497

Plutonium Isotopes: An Effective Tool for Fluvial Sediment Sourcing in Urbanized Catchments

Abigal Percich[1], Admin Husic[1], and Michael E. Ketterer[2]

[1]Department of Civil, Environmental and Architectural Engineering, University of Kansas, Lawrence, KS, USA, [2]Department of Chemistry and Biochemistry, Northern Arizona University, Flagstaff, AZ, USA

Key Points:

- $^{239+240}$Pu activity is a robust tracer for describing sediment sources and fluvial mixtures in a rapidly urbanizing landscape
- Frequentist and Bayesian models were consistent in estimating increased bank erosion with increasing urban land use
- Sediment sourcing is dependent on discharge in rural watersheds whereas it is independent of discharge in urban watersheds

Supporting Information:

Supporting Information may be found in the online version of this article.

Correspondence to:

A. Husic,
ahusic@ku.edu

Citation:

Percich, A., Husic, A., & Ketterer, M. E. (2022). Plutonium isotopes: An effective tool for fluvial sediment sourcing in urbanized catchments. *Geophysical Research Letters*, *49*, e2021GL094497. https://doi.org/10.1029/2021GL094497

Received 24 MAY 2021
Accepted 6 JAN 2022

Abstract Sediment management is currently limited by uncertainties in the applicability of existing radionuclide tracers and the effects of urbanization. Here, we use plutonium isotopes ($^{239+240}$Pu) from weapons-testing fallout to trace sediment transport across five watersheds in an urbanizing landscape in Kansas, USA. Historic flooding in the region provided an opportunity to assess extreme connectivity of sediment sources. $^{239+240}$Pu activity of transported sediment decreased as catchments urbanized, indicating a greater contribution from subsurface bank sediment; Bayesian modeling predicted 50% (8%–80%) bank sourcing in the most rural watershed, which rose to 93% (73%–100%) in the most urban catchment. $^{239+240}$Pu activity provides explanatory information on the superposition of sediment sources, which is beyond that given by traditional organic and geochemical tracers that primarily infer vegetative and geologic sourcing, respectively. Our study demonstrates the utility of $^{239+240}$Pu as a sediment tracer for managing erosion under anthropogenic change.

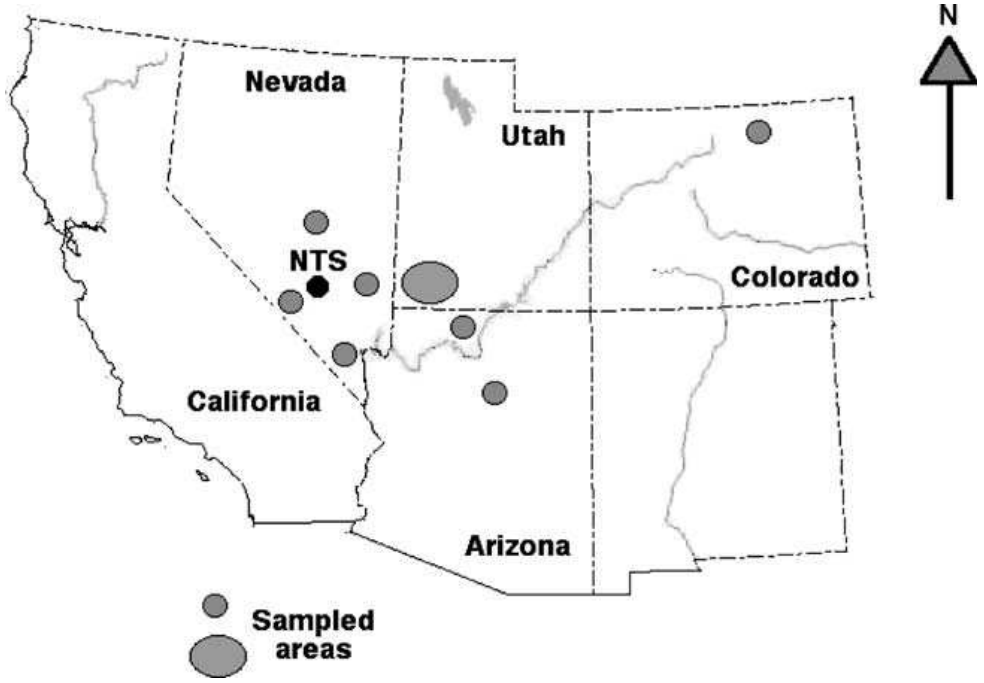
Plain Language Summary Sediment is one of the most common contaminants in rivers around the globe. The susceptibility of soil to erosion increases as humans convert natural landscapes into rural and urban systems. Uncertainties remain regarding how urbanization alters sediment pathways and what tools are appropriate for quantifying this alteration. Radioactive isotopes, generated from nuclear weapons testing in the 1950s, have proven useful in this regard, although the most prominent tracer, for example, cesium, is losing some utility due to a short half-life and extensive radioactive decay. We suggest that plutonium isotopes, which have longer half-lives, are a viable option for tracing sediment in modern landscapes. Plutonium results suggest that in rural basins the source of sediment transitions from upland soil during low-flows to bank material at high-flows. On the other hand, urban streams always deliver bank sediment, regardless of storm intensity. Our study demonstrates the utility of plutonium as an alternate sediment tracer and highlights how urbanization changes the pathways and mechanisms of fluvial sediment transport.

Anal Bioanal Chem (2008) 390:521–530
DOI 10.1007/s00216-007-1741-x

ORIGINAL PAPER

$^{239,\ 240,\ 241}$Pu fingerprinting of plutonium in western US soils using ICPMS: solution and laser ablation measurements

James V. Cizdziel · Michael E. Ketterer · Dennis Farmer · Scott H. Faller · Vernon F. Hodge



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Journal of Environmental Radioactivity 73 (2004) 183–201
JOURNAL OF ENVIRONMENTAL RADIOACTIVITY
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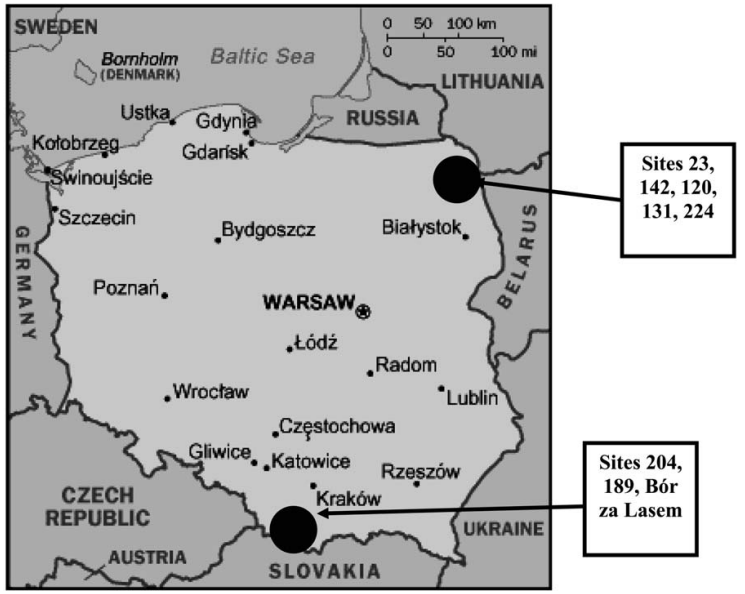
Resolving Chernobyl vs. global fallout contributions in soils from Poland using Plutonium atom ratios measured by inductively coupled plasma mass spectrometry

Michael E. Ketterer [a,*], Kevin M. Hafer [a], Jerzy W. Mietelski [b]

[a] *Department of Chemistry, Northern Arizona University, Box 5698, Flagstaff, AZ 86011-5698, USA*
[b] *Environmental Radioactivity Laboratory, The Henryk Niewodniczański Institute of Nuclear Physics, PL 31-324 Kraków, Radzikowskiego 152, Poland*

Received 18 December 2002; received in revised form 21 August 2003; accepted 3 September 2003



LA-UR-15-22380 (Accepted Manuscript)

Distribution of neptunium and plutonium in New Mexico lichen samples (Usnea arizonica) contaminated by atmospheric fallout

Oldham, Warren James
Hanson, Susan Kloek
Lavelle, Kevin B.
Miller, Jeffrey L.

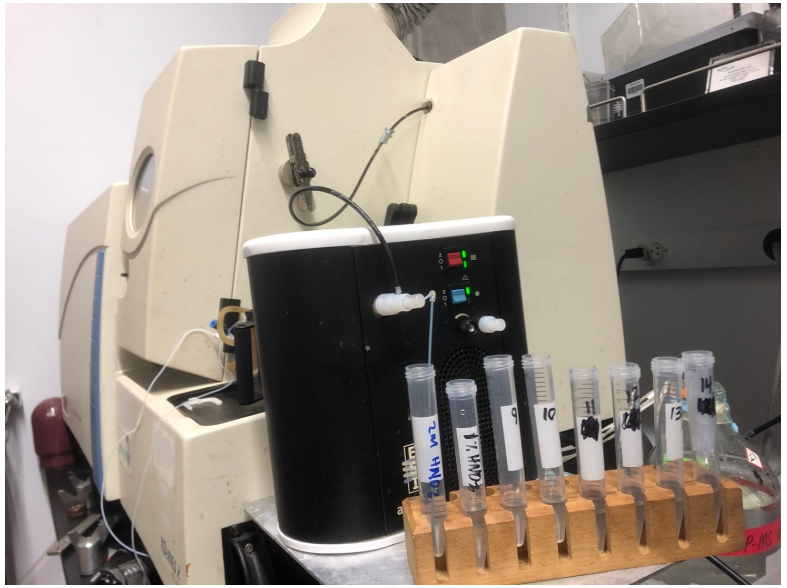
Table 2 Analytical parameters and settings of ICP-MS Xseries II

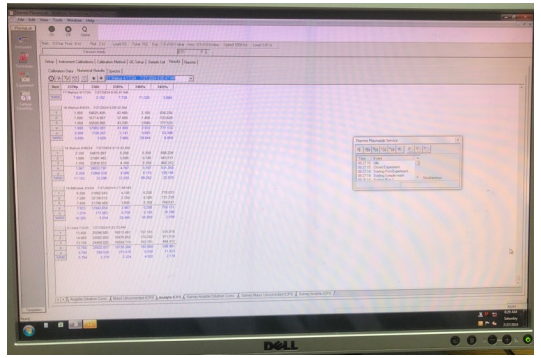
Parameters	ICP-MS Xseries II
Power	1400 W
Gas flows	Cool gas: 13 L/min Auxiliary gas: 0.60-0.65 L/min Nebulizer gas: 0.74-0.78 L/min
Sensitivity (^{238}U)	3 x 10^6 cps/ppb
Backgrounds (2% HNO_3)	<0.5 cps
Oxides (Ce) and double charge ions (Ba)	< 3%
Sample Inlet System	ESI APEX IR
Spray and flow rate	Self-aspirating PFA nebulizer: 0.28 mL/min
Cones	Ni sample and skimmer cones (Xs)
Standard resolution	0.75 amu (10% of peak height)
$^{238}U^1H/^{238}U$	3 x 10^{-5}

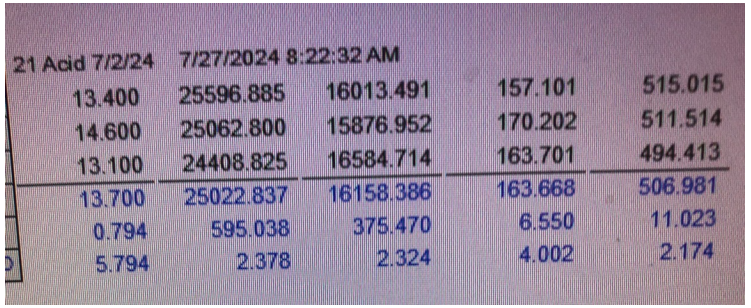
To be published in: Journal of Radioanalytical and Nuclear Chemistry ; 30 August 2015

DOI to publisher's version: 10.1007/s10967-015-4402-0

Permalink to record: http://permalink.lanl.gov/object/view?what=info:lanl-repo/lareport/LA-UR-15-22380

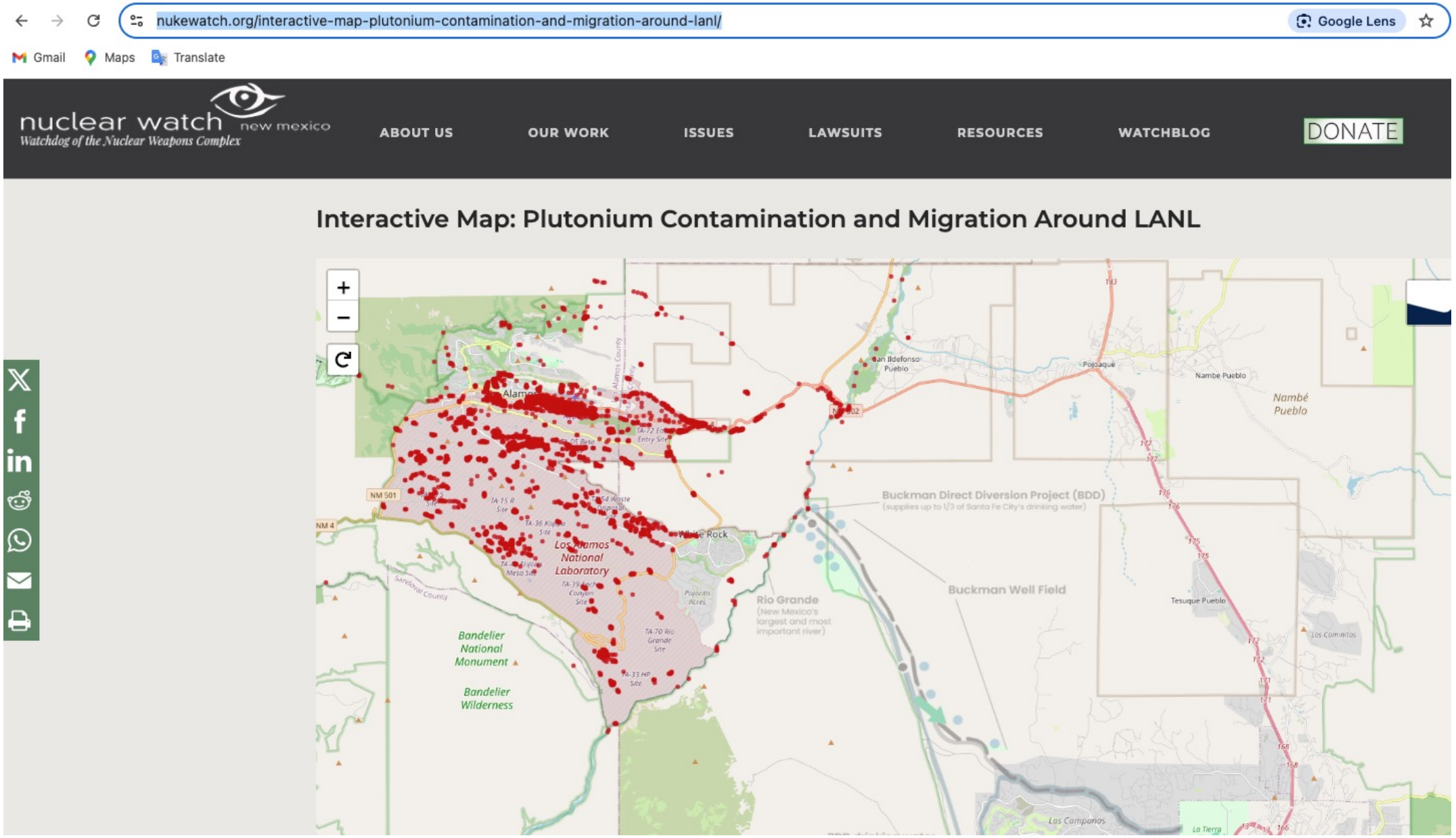




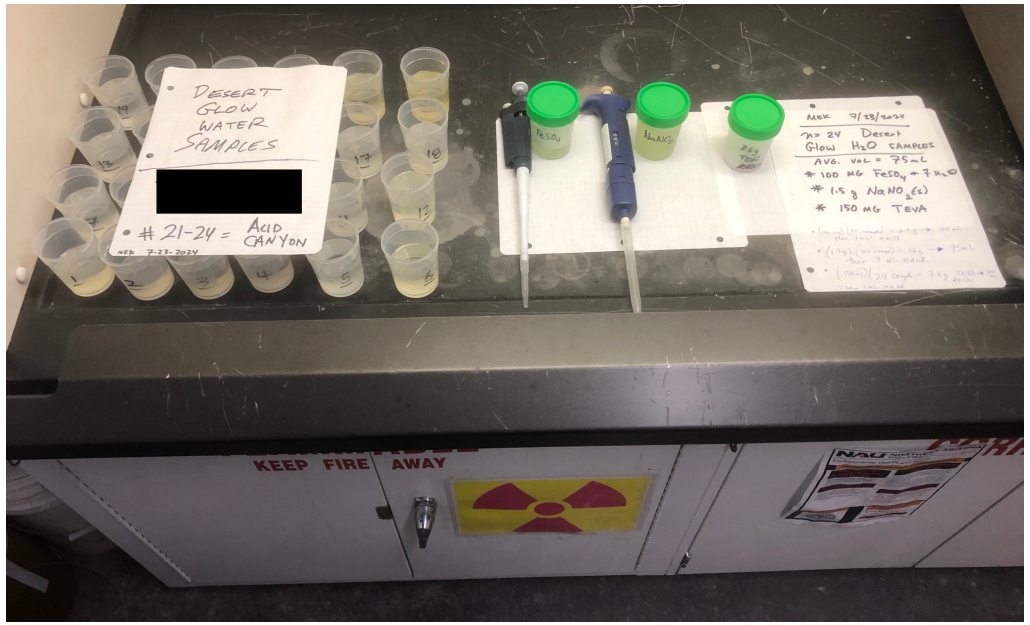


21 Acid 7/2/24	7/27/2024 8:22:32 AM			
13.400	25596.885	16013.491	157.101	515.015
14.600	25062.800	15876.952	170.202	511.514
13.100	24408.825	16584.714	163.701	494.413
13.700	25022.837	16158.386	163.668	506.981
0.794	595.038	375.470	6.550	11.023
5.794	2.378	2.324	4.002	2.174

Ketterer LANL study 13Aug2024



https://nukewatch.org/interactive-map-plutonium-contamination-and-migration-around-lanl/



ARRA-3 Page 1 of 4

ARIZONA DEPARTMENT OF HEALTH SERVICES
BUREAU OF RADIATION CONTROL

RADIOACTIVE MATERIAL LICENSE

Pursuant to Chapter 4, Title 30, Arizona Revised Statutes, and Title 9, Chapter 7 of the Arizona Administrative Code, and in reliance on statements and representations made to the Department by the licensee, a license is hereby issued authorizing the acquisition, reception, possession, use and transfer of the radioactive material listed in this license for the purposes and at the places specified. This license is subject to all applicable rules and Department orders now or hereafter in effect and to the conditions specified. **In accordance with application dated November 29, 2021 signed by Bjorn Flugstad, License Number 03-026 is hereby renewed in its entirety to read as follows: ALL CHANGES ARE IN BOLD**

LICENSEE

1. **NAME:** Board of Regents
d/b/a Northern Arizona University

2. **ADDRESS:** Office of Regulatory Compliance
P.O. Box 4137
Flagstaff, AZ 86011-4137

3. a. **LICENSE NUMBER:** 03-026
b. **AMENDMENT NO.:** 44

4. **EXPIRATION DATE:** December 31, 2026

5. **CATEGORY:** A4-Limited Academic

6. Radioactive material (element and mass number)	7. Chemical or physical form	8. Maximum quantity licensee may possess at any time
A. Hydrogen-3	A. Any	A. 3.7 GBq (100 millicuries)
B. Carbon - 14	B. Any	B. 925 MBq (25 millicuries)
C. Phosphorus-32	C. Any	C. 1.85 GBq (50 millicuries)
D. Nickel-63	D. Sealed Source	D. 3.7 GBq (100 millicuries)
E. Iodine-125	E. Any	E. 370 MBq (10 millicuries)
F. Plutonium-242	F. Any	F. 1.85 GBq (50 millicuries)
G. Uranium-233	G. Any	G. 3.7 kBq (100 nanocuries)
H. Thorium-229	H. Any	H. 3.7 kBq (100 nanocuries)
I. Cadmium-109	I. Sealed Source	I. 3.7 GBq (100 millicuries)

9. **Authorized Use:**

A. through C. Laboratory demonstrations, exercises, experiments, and research and development.

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Kinnikinnik Park is one of many popular recreation areas located along the Acid Canyon trail system. Nadav Soroker/Searchlight New Mexico

A nuclear legacy in Los Alamos

After three cleanups, independent analysis shows 80-year-old plutonium persists in Acid Canyon and beyond

by **Alicia Inez Guzmán** August 15, 2024

More

Super weapons grade $^{239+240}$Pu as a contaminant of concern in sediment, soil, water and vegetation: Acid Canyon and Los Alamos Canyon, New Mexico

Michael E. Ketterer, PhD

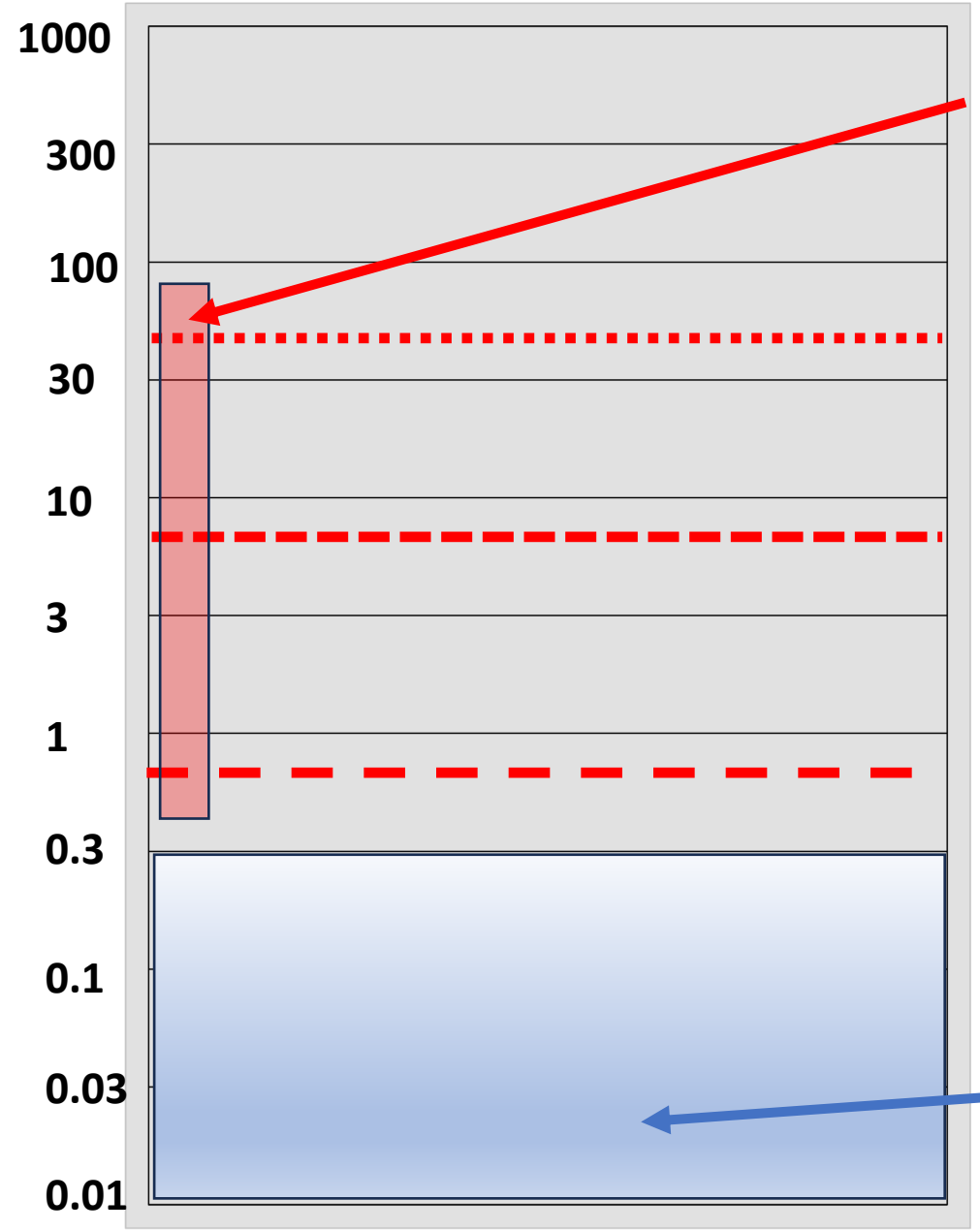
Professor Emeritus, Chemistry and Biochemistry, Northern Arizona University

Flagstaff, AZ 86911-5698 USA Michael.Ketterer@nau.edu

Phone: +1 928 853 7188

NAU NORTHERN ARIZONA UNIVERSITY

$^{239+240}$Pu in sediment, picocuries per gram (pCi/g)



Sediments from Acid Canyon exhibited a wide range of $^{239+240}$Pu activities, all of LANL provenance min 0.43; max 78, geometric mean 14 pCi/g

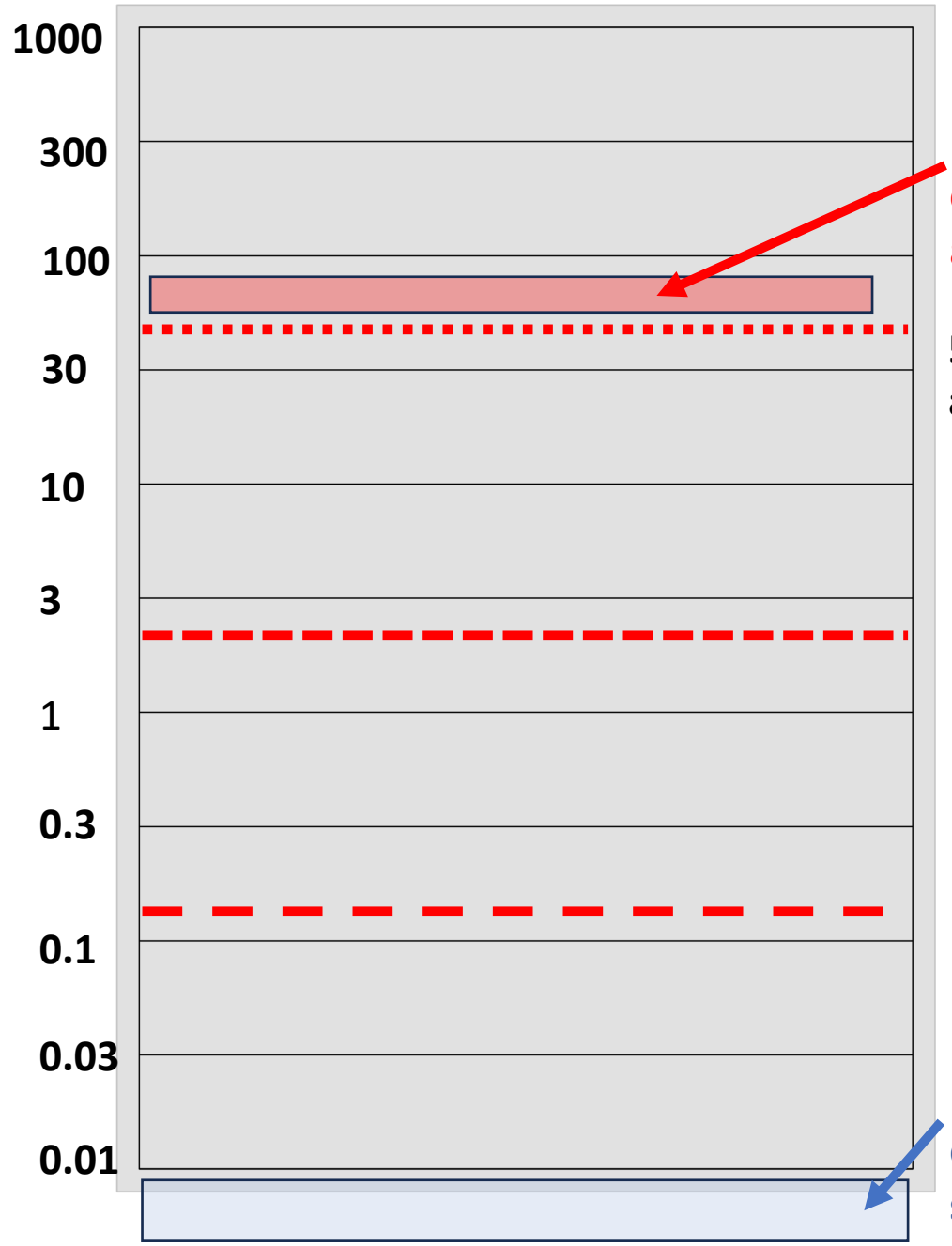
50 pCi/g, remediation standard applied by DOE to the COU at Rocky Flats (not accessible by public)

8 pCi/g, remediation standard applied by USAF at the Fort Dix BOMARC missile silo fire site (not accessible by public)

2 dpm/g = 0.9 pCi/g, State of Colorado, construction dust standard for workers in areas with contaminated soils

Surface soils and post-bomb sediments typically contain well under 1 pCi/g $^{239+240}$Pu from 1950's-1960's atmospheric nuclear tests with a characteristic ^{240}Pu/^{239}Pu = 0.18; lower activities are expected in arid areas

$^{239+240}$Pu in water, picocuries per liter (pCi/L)



Four samples of Acid Canyon water collected on July 2 and 17, 2024 contained 78, 70, 51 and 86 pCi/L of $^{239+240}$Pu of LANL provenance

50 pCi/L, enforceable Federal gross alpha activity standard for water

2 pCi/L, State of New Mexico, guidance for the Rio Grande only

0.15 pCi/L, State of Colorado, enforceable under the Rocky Flats Legacy Management Agreement

Most natural waters contain $^{239+240}$Pu at concentrations too low to be plotted on this scale, and that are challenging to detect at all

ROCKY FLATS LEGACY MANAGEMENT AGREEMENT

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
and
THE STATE OF COLORADO

IN THE MATTER OF:	)	FEDERAL FACILITY AGREEMENT AND CONSENT ORDER
UNITED STATES DEPARTMENT OF ENERGY	)	
ROCKY FLATS SITE	)	CERCLA 8-96-21 RCRA(3008(h)) 8-96-01
	)	STATE OF COLORADO DOCKET # 96-07-19-01

ROCKY FLATS LEGACY MANAGEMENT AGREEMENT

PART 1 PARTIES AND JURISDICTION

1. The Parties to this Agreement are the United States Environmental Protection Agency, Region 8 (EPA), the Colorado Department of Public Health and Environment (CDPHE or "State"), and the United States Department of Energy (DOE).

Table 1. Surface Water Standards (continued)

Analyte	CAS Reference Number	Standards [a] (mg/L)	Basis [a, b]	PQLs [c] (mg/L)	Analyte Category [d]
Pyrene	129-00-0	2.10E-01	W+F, WS		SVOCs
Selenium [e]	7782-49-2	4.60E-03	AL		Metals
Silver, dissolved	7440-22-4	6.00E-04	TVS [h]	5.00E-03	Metals
Styrene	100-42-5	1.00E-01	WS		VOCs
1,1,2,2-Tetrachloroethane	79-34-5	1.70E-04	W+F	2.00E-03	VOCs
Tetrachloroethene	127-18-4	5.00E-03	W+F, WS		VOCs
Toluene	108-88-3	1.00E+00	W+F, WS		VOCs
1,2,4-Trichlorobenzene	120-82-1	3.50E-02	W+F		VOCs
1,1,1-Trichloroethane	71-55-6	2.00E-01	WS		VOCs
1,1,2-Trichloroethane	79-00-5	2.70E-03	W+F		VOCs
Trichloroethene	79-01-6	2.50E-03	W+F		VOCs
Vinyl chloride	75-01-4	2.30E-05	W+F	5.00E-04	VOCs
Xylene (total)	1330-20-7	1.00E+01	WS		VOCs
Zinc, dissolved	7440-66-6	1.68E-01	TVS [h]		Metals
RADIONUCLIDES [l]					
Americium 241 [e]	14596-10-2	0.15 (pCi/L)	BS		Other
Plutonium 239/240 [e]	10-12-8	0.15 (pCi/L)	BS		Other
Uranium, total [e]	7440-61-1	16.8 (µg/L)	SS		Other

https://lmpublicsearch.lm.doe.gov/lmsites/1679-rflma.pdf

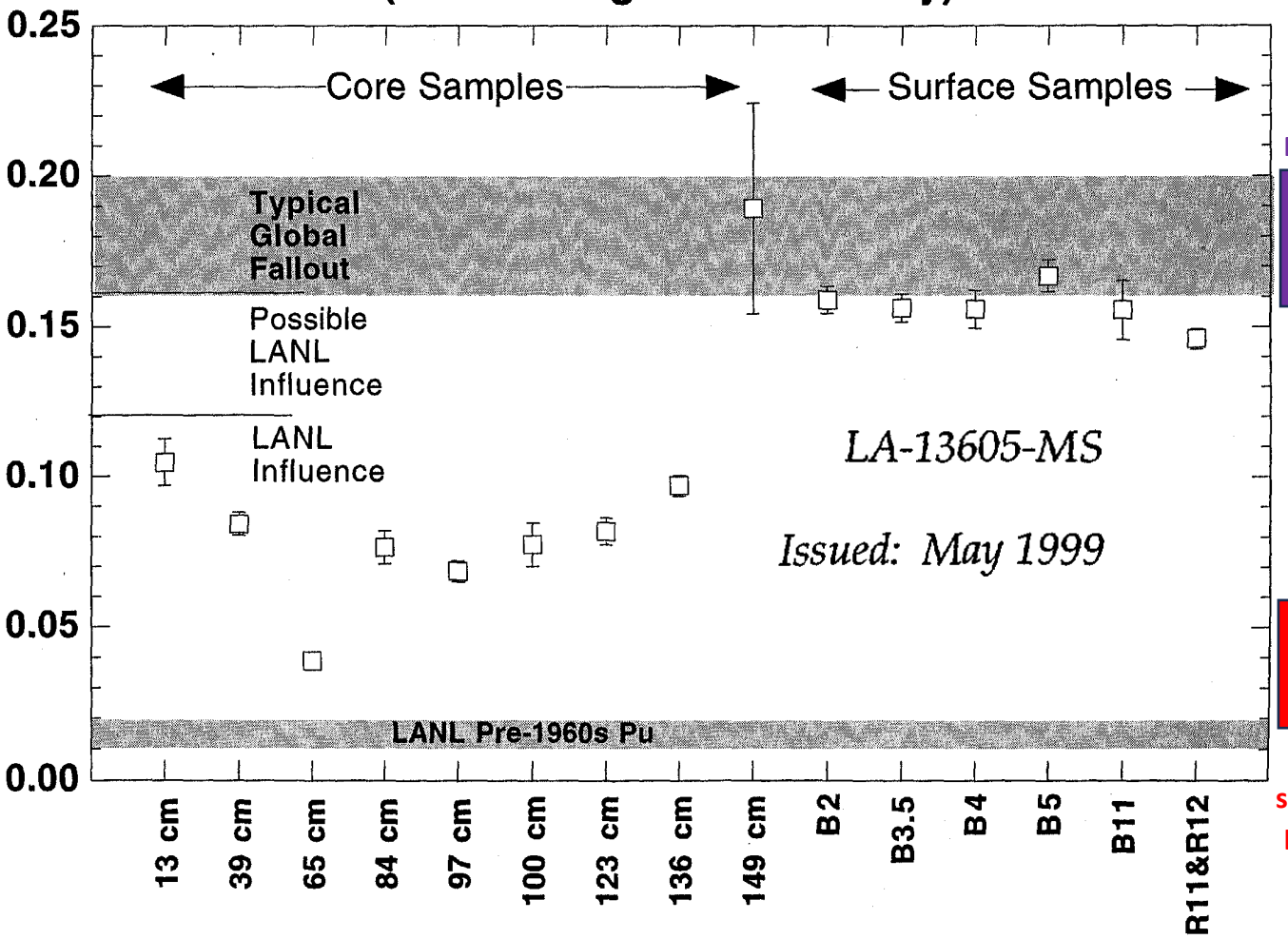
Plutonium and Uranium Atom Ratios and Activity Levels in Cochiti Lake Bottom Sediments Provided by Pueblo de Cochiti

B. M. Gallaher[1]
D. W. Efurd[2]
D. J. Rokop[3]
T. M. Benjamin[2]

[1]*Water Quality and Hydrology Group*
[2]*Radiochemistry Group*
[3]*Environmental Science and Waste Technology Group*

Los Alamos
NATIONAL LABORATORY
Los Alamos, New Mexico 87545

Figure 5
Cochiti Lake Sediments Pu Ratios
(ratio + 3 sigma uncertainty)



$^{240}Pu/^{239}Pu$ ratios in New Mexico samples analyzed by mass spectrometry at Northern Arizona University