Background Comparisons for Radionuclides

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REVISION HISTORY

Document No./ Revision No.	**Issue Date**	**Action**	**Description**
EP-ERSS-SOP-5087, R0	02/09/07	Reformatted and renumbered, supersedes SOP-15.13	E
EP-SOP-5246,R0	10/06/09	New number sequence assigned. Supersedes EP-ERSS-SOP-5087. Added process for performing statistical comparisons.	T
EP-SOP-5246,R1	8/26/2010	Deleted references to data review appendix and other editorial changes.	E
EP-SOP-10073,R0	1/6/2015	Major changes on how to eliminate or retain COPCs. Editorial changes; reformatted to template, minor edits. Supersedes SOP-5246.	T/E

CONTENTS

1.0 PURPOSE

This standard operating procedure (SOP) describes the process for performing background/fallout comparisons on radionuclides for the Los Alamos National Laboratory (LANL) Environmental Programs (EP) Directorate. This procedure integrates the criteria of the Quality Assurance Plan for the EP Directorate.

2.0 SCOPE

All EP Directorate participants and subcontractors shall implement this procedure when identifying radionuclide chemicals of potential concern (COPCs) for sites investigated by the Corrective Actions Project, Technical Area 21 Closure Project, and TA-54 Closure Project.

3.0 BACKGROUND AND PRECAUTIONS

3.1 Background

The purpose of this procedure is to describe the process for performing background/fallout comparisons on radionuclides on sites investigated by EP Directorate projects. The procedure involves the comparison of site data sets to background/fallout data sets established for the Pajarito Plateau and associated canyons. LANL has received informal approval from the New Mexico Environmental Department's (NMED's) Hazardous Waste Bureau to use the soil, sediment, and tuff background/fallout values (BVs/FVs) and data from LANL's background document "Inorganic and Radionuclide Background Data for Soils, Canyon Sediments, and Bandelier Tuff at Los Alamos National Laboratory," LA-UR-98-4847 (LANL 1998, 059730).

3.2 Precautions

In addition to the process described herein, professional experience and judgment are needed in determining whether radionuclides are eliminated or retained as COPCs. The intent of the procedure is to be **inclusive rather than exclusive** so that the nature and extent of contamination and the potential doses are representative. However, it is recognized that for some site data sets, there may be a basis for eliminating radionuclides as COPCs if concentrations are interpreted to be equivalent to background and no statistical or nonstatistical methods can be used to justify the elimination. In these cases, lines of evidence must be presented as the bases for eliminating the radionuclide as a COPC. The key component is consistency and NMED's acceptance of this process.

Fallout radionuclides (americium-241, cesium-137, plutonium-238, plutonium-239, strontium-90, and tritium) do not have FVs for the subsurface. Soil FVs are not applicable below the surface (0.0–0.5 ft or 0.0–1.0 ft) and are never applicable in tuff. Sediment FVs are applicable to alluvial sediment regardless of depth. The tritium soil FV is not applied to surface soil because it requires a transformation from pCi/mL to pCi/g using the sample soil moisture data. Tritium in surface soil is therefore evaluated based on detection status (i.e., detected or not detected). The FVs for fallout radionuclides in tuff are detection limits and do not represent actual levels; fallout radionuclides in tuff are evaluated based on detection status (i.e., detected or not detected).

4.0 REFERENCES

- LA-UR-98-4847, "Inorganic and Radionuclide Background Data for Soils, Canyon Sediments, and Bandelier Tuff at Los Alamos National Laboratory," (LANL 1998, 059730).
- SOP-5250, *Selection and Use of Annotated Outlines/Templates for Consent Order Investigation Work Plans and Investigation Reports*, Attachments 3 and 4
- EP-DIR-SOP-4004, *Records Transmittal and Retrieval Process*

5.0 DEFINITIONS AND ACRONYMS

5.1 Definitions

Background concentration — Naturally occurring concentrations of an inorganic chemical or radionuclide in soil, sediment, or tuff.

Background data — Data representing naturally occurring concentrations of inorganic and radionuclide constituents in a geologic medium. LANL's background data are derived from samples collected at locations that are either within or adjacent to LANL. These locations (1) are representative of geological media found within LANL boundaries, and (2) have not been affected by LANL operations.

Background value (BV) — A statistically derived concentration (i.e., the upper tolerance limit [UTL]) of a chemical used to represent the background data set. If a UTL cannot be derived, either the detection limit or maximum reported value in the background data set is used.

Chemical of potential concern (COPC) — A chemical compound or radionuclide with the potential to adversely affect a receptor as a result of its concentration, distribution, and toxicity.

Fallout radionuclides — Radionuclides present at globally elevated levels in the environment as a result of fallout from worldwide atomic weapons tests. LANL background data sets consist of environmental surveillance samples taken from marginal and regional locations for the following radionuclides associated with fallout: tritium, cesium-137, americium-241, plutonium-238, plutonium-239/240, and strontium-90. Samples were collected from regional and marginal locations in LANL's vicinity representative of geological media found within LANL boundaries, and were not impacted by LANL operations.

Radionuclide — Radioactive particle (human made or natural) with a distinct atomic weight number.

5.2 Acronyms

ALLH	all horizons (soil)
BV	background value
COPC	chemical of potential concern
EP	Environmental Programs
FV	fallout value
LANL	Los Alamos National Laboratory
NMED	New Mexico Environment Department
Qbt	Quarternary Tshirege Member of the Bandelier Tuff
SED	sediment

SOP	standard operating procedure
UTL	upper tolerance limit

6.0 TOOLS AND EQUIPMENT

Essential equipment and tools required to implement this SOP include the following:

- the U.S. Environmental Protection Agency ProUCL computer program containing statistical methods or other statistical packages, as appropriate;
- the LANL background document "Inorganic and Radionuclide Background Data for Soils, Canyon Sediments, and Bandelier Tuff at Los Alamos National Laboratory," LA-UR-98-4847 (LANL 1998, 059730);
- Microsoft Excel; and
- the annotated outlines for the investigation report (see SOP-5250, Attachments 3 and 4).

7.0 STEP-BY-STEP PROCESS DESCRIPTION

Note: See Attachment 1 for overall process flow.

7.1	**Prepare for BV/FV Comparisons**	
Project Members	1.	Obtain current list of BV/FVs from the LANL background document "Inorganic and Radionuclide Background Data for Soils, Canyon Sediments, and Bandelier Tuff at Los Alamos National Laboratory," LA-UR-98-4847 (LANL 1998, 059730).
	2.	Determine the sample preparation and analytical methods used to generate results from the background/fallout samples from the background data sets. NOTE: Background/fallout data sets are available upon request from the data stewards.
	3.	Obtain the site (i.e., solid waste management unit, area of concern, and consolidated unit being evaluated) data set from the data steward, including at least the following information: • sample concentration results, • reporting units of the sample concentrations , • final sample result qualifiers, • sample analytical methods, and • sample preparation methods.
	4.	Determine the comparability of the methods used to prepare and analyze the site samples and the background/fallout samples. NOTE: If site sample methods differ from the LANL background/fallout sample methods, consult a chemist.
	5.	Verify that a chemist (or other subject matter expert) has reviewed the analytical data report and has determined the detection status.
7.2	**Eliminate Radionuclides from Evaluation**	
Project Members	1.	Eliminate gamma-emitting radionuclides included for quality assurance/quality control purposes and those that are not typically evaluated as potential historical contaminants. NOTE: If potassium-40 was identified for investigation at the site, it should be treated in the

		same manner as other naturally occurring radionuclides [i.e., compared with the appropriate BV].
	2.	Eliminate radionuclides as COPCs if no results are reported as detected.
7.3	**Select Appropriate Background/Fallout Values**	
Project Members	1.	If the site samples were collected from soil media and a fallout radionuclide was detected in surface samples 0.0–0.5 ft or 0.0–1.0 ft), compare with the LANL soil FVs. NOTE: Soil media includes any soil or fill material. Soil is designated as all horizons [ALLH] and fill is designated as FILL. NOTE: The tritium soil FV is not applied to surface soil because it requires a transformation from pCi/mL to pCi/g using the sample soil moisture data. Tritium in surface soil is evaluated based on detection status [i.e., detected or not detected].
	2.	If the site samples were collected from soil and a fallout radionuclide was detected in any subsurface samples (below 0.0–0.5 ft or 0.0–1.0 ft), identify the radionuclide as a COPC. If the site samples were collected from fill and a fallout radionuclide was detected in any subsurface samples (below 0.0–0.5 ft or 0.0–1.0 ft), eliminate as a COPC if it can be determined that fill came from a source containing radionuclides. If not, retain as a COPC.
	3.	If the site samples were collected from tuff, identify any detected fallout radionuclide as a COPC. NOTE: Tuff samples are evaluated on the basis of detection status alone for fallout radionuclides. Although FVs for tuff units are listed in the LANL background document [LANL 1998, 059730], the values listed are nominal minimum detectable activity levels and are not used to determine COPCs.
	4.	If the site samples were collected from sediment samples, compare to sediment FVs. NOTE: Sediment FVs are applicable to alluvial sediment, regardless of depth. Sediment is designated as SED.
	5.	For site samples containing naturally occurring radionuclides (e.g., isotopic thorium and isotopic uranium) in soil, compare with the soil BVs, regardless of the depth.
	6.	For site samples containing naturally occurring radionuclides in tuff units Qbt 2, Qbt 3, Qbt 4, Qbt 1v, Qbt 1g, Qct, and/or Qbo, compare with the appropriate BV(s), regardless of the depth.
	7.	For site samples containing naturally occurring radionuclides in sediment, compare with the sediment BVs, regardless of the depth.
7.4	**Comparing Site Data with BV/FV and Data**	
Project Members	1.	If the radionuclide is detected but has no BV (or FV), identify the radionuclide as a COPC.
	2.	If the maximum detected activity is not greater than the BV (or FV), eliminate the radionuclide as a COPC.

	3.	If there are fewer than 8 samples and/or fewer than 5 detected sample results for the environmental medium and the radionuclide being evaluated, either provide lines of evidence why the radionuclide is not a COPC or retain as a COPC. The lines of evidence include, but are not limited to, the following: • the maximum detected concentration was less than the maximum background concentration, • detected activity was only slightly above the BV (e.g., 0.01 pCi/g above the BV), • detected only slightly above BV in only 1or 2 samples, and • radionuclide was not detected above BV in the other samples (provide number of samples). **Example Text** Uranium-234 was detected above the soil BV (2.59 pCi/g) in one sample at an activity of 2.62 pCi/g. The activity was only 0.03 pCi/g above the BV, and uranium-234 was not detected above BVs in the other 11 samples. Uranium-234 is not a COPC. Uranium-235/236 was detected above the Qbt 2,3,4 BV (0.09 pCi/g) in one sample at an activity of 0.151 pCi/g. The activity was only 0.061 pCi/g above the BV, and uranium-235/236 was not detected above BVs in the other 15 samples. Uranium-235/236 is not a COPC.
	4.	If there are at least 8 samples <u>and</u> 5 detected sample results for the environmental medium and the radionuclide being evaluated and the maximum detected concentration is greater than the BV/FV, statistical comparisons can be conducted to determine if the data are statistically different or not (see Step 7.5). **NOTE**: The project person may opt out of doing statistical comparisons and just retain the radionuclide(s) as a COPC. The key is to be consistent for all sites evaluated in a given report.
	5.	Report in a table for each site the concentrations of all radionuclides detected or detected above BVs/FVs .
	6.	In addition, present all <u>detected</u> concentrations (if no BV/FV) and all <u>detected</u> concentrations above BVs/FVs for each site on the data figures for radionuclides.Clearly state the conditions of the comparisons being conducted in the text of the data review. For example, state that there were fewer than 8 samples or fewer than 5 detected sample results for the environmental medium (soil, sediment, and tuff) and the radionuclide evaluated so statistical analyses cannot be conducted.
7.5	**<u>Statistical Comparisons of Site Data to Background/Fallout Data</u>**	
Project Members	1.	If statistical comparisons are appropriate as stated above, consult a statistician on how to proceed and which statistical tests to run. The preferred tests are the Gehan, Quantile, and Slippage tests (these are the tests historically used for background comparisons).
	2.	Run all three statistical tests or explain why a test is not applicable, i.e., too many nondetects in the data sets so Gehan test is not possible. The Gehan test requires more than 50% detects in the background or site data sets. (The Gehan test is not recommended if either of the two data sets has more than 50% nondetects.) If more than 50% detects, use only the Quantile and Slippage tests (Quantile test cannot be performed if more than 80% of the combined data are nondetected values). To eliminate as a COPC, the radionuclide must

		pass 2 of 3 tests (i.e., p-value >0.05); if fail two tests (p-value <0.05), then retain as COPC. Run the Slippage test as the third test; if the Gehan and Quantile both pass or both fail, there is no need to perform the Slippage test. NOTE: ProUCL contains several statistical tests, including the Gehan and Quantile tests. ProUCL or other statistical programs can be used to run these tests. The Slippage test is not included in ProUCL and requires a different statistical package (e.g., download the freeware "R" at http://www.r-project.org/ and follow instructions) or an alternative approach such as using the Excel function =HYPGEOMDIST(n.exceed,n.site,n.exceed,n.total) for the Slippage test (Attachment 3). The statistical ProUCL programs are commercial programs that have been validated to run on the platform used. Before running the program, a test verification calculation that exercises all necessary subroutines should be run to ensure that the program is operating properly.
	3.	Present statistical results for each radionuclide statistically evaluated in a table for each medium (see Attachment 4 for example of the table) in an appendix (see previous reports for examples). Present the p-values for each statistical test conducted and indicate whether radionuclide is retained as a COPC. If a test was not performed, indicate by n/a (not applicable).
	4.	Construct box plots for all radionuclides included in the statistical comparisons, and provide the box plots in the same appendix as statistical tests above of the investigation report (see SOP-5250, Attachment 9). NOTE: Although ProUCL produces box plots, the box plots are not report quality. The ProUCL box plots also do not plot the concentrations on the graph. Use another statistical package or program to construct box plots for the report.
	5.	When constructing the box plots, plot the concentrations as points overlying the box plot. When a data set contains both detected concentrations and nondetected concentrations (i.e., detection limits), the detected concentrations are plotted as Xs, and the nondetected concentrations are plotted as Os. Define Xs and Os in figure caption for each box plot presented.
7.6	**Records Management**	
Project Members or Project Leader	1.	Maintain and submit records and/or documents generated to the Records Processing Facility according to EP-DIR-SOP-4004, *Records Transmittal and Retrieval Process*.

8.0 ATTACHMENTS

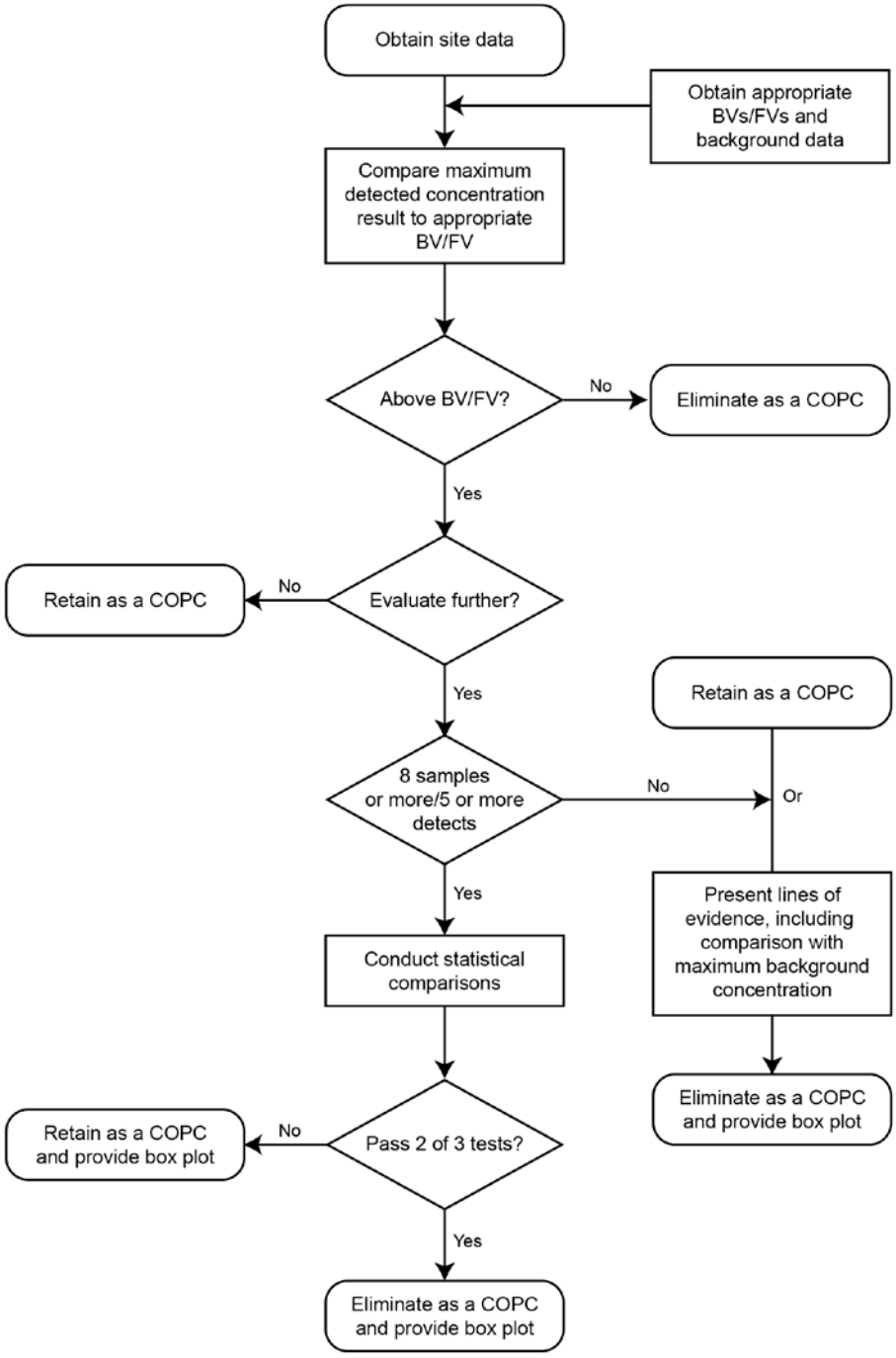
Attachment 1: Flow Diagram for the COPC Identification Process

Attachment 2: Example of Box Plot

Attachment 3: Example of Excel function HYPGEOMDIST

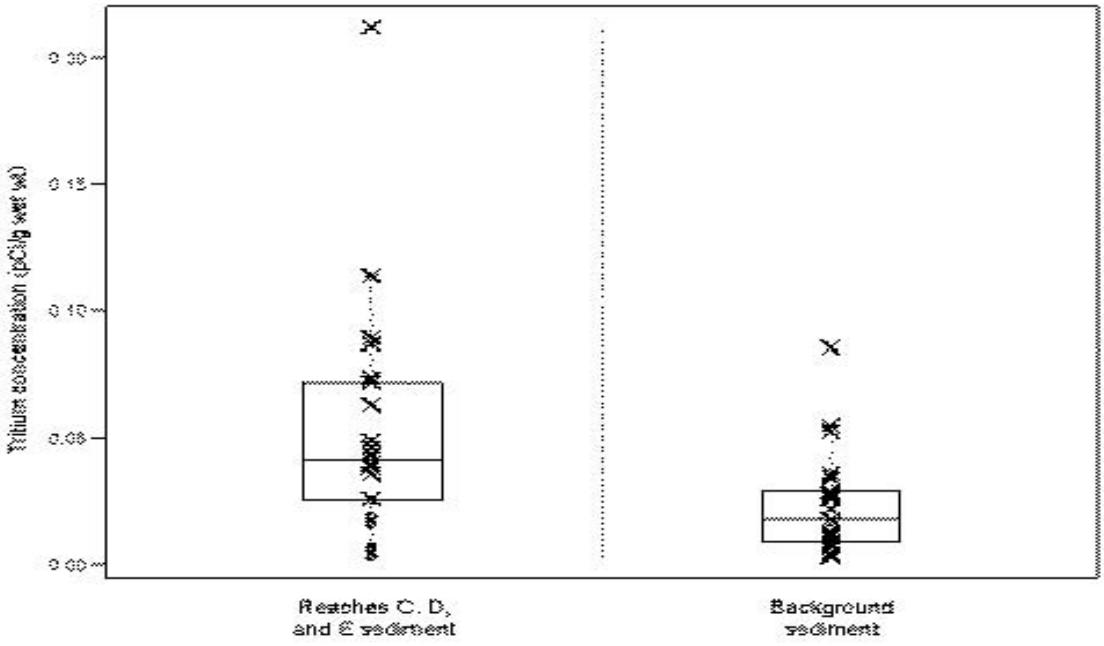
Attachment 4: Example of Table Summarizing Statistical Result

Attachment 1
Process Flow Chart



Flow diagram for the COPC identification process.

Attachment 2
Examples of Box Plots



Box plot of tritium concentrations in Reaches C, D, and E sediment and sediment background data (x's indicate detected concentrations and o's indicate nondetects)

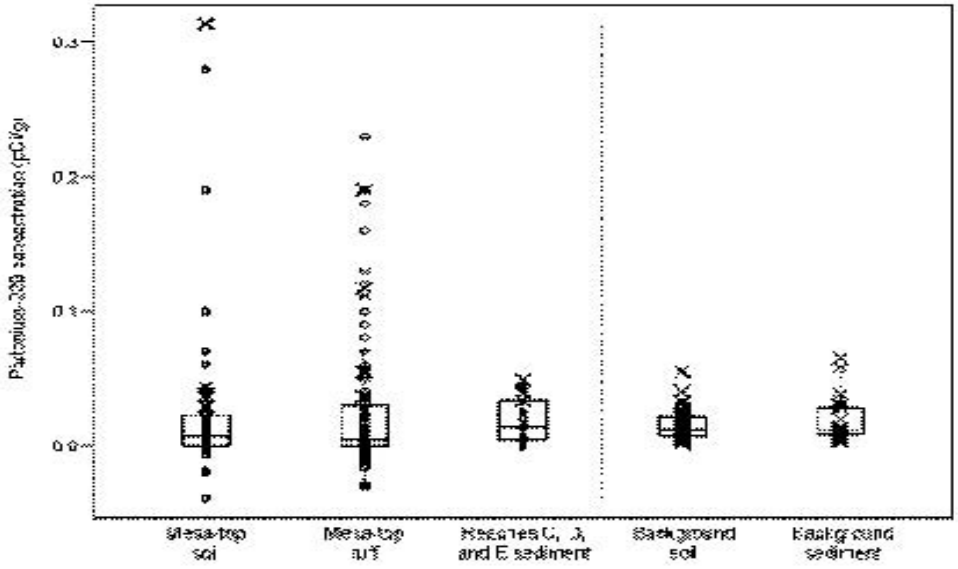


Figure D-4.2-2. Box plot of plutonium-239 concentrations in mesa-top soil; mesa-top tuff; Reaches C, D, and E sediment; ALLH background data; and sediment background data

Attachment 3
Example of Excel Function HYPGEOMDIST

Slippage test. This test is based on the maximum observed concentration in the background data set and the number "*n*" of site concentrations that exceed the maximum concentration in the background set. The result (p-value) of the slippage test is the probability that *n* site samples (or more) exceed the maximum background concentration by chance alone. The test accounts for the number of samples in each data set (number of samples from the site and number of samples from background) and determines the probability of *n* (or more) exceedances if the two data sets came from identical distributions. This test is similar to the hot-measurement test in that it evaluates the largest site measurements. It is more useful than the BV comparison because it is based on a statistical hypothesis test, not simply on a statistic calculated from the background distribution.

p-value of slippage test via Excel function =HYPGEOMDIST(n.exceed,n.site,n.exceed,n.total)

where n.exceed = number of site samples>maximum background concentration
n.site = number of site samples
n.total = combined number of samples for site and background

Examples For 10 site samples and 15 background samples, the probability that 2 site samples will exceed the maximum result in background is 0.15; =HYPGEOMDIST(2,10,2,25)=0.15

For 12 site samples and 23 background samples, the probability that 3 site samples will exceed the maximum result in background is p = 0.034; =HYPGEOMDIST(3,12,3,35)=0.034

Attachment 4
Example of Table Summarizing Statistical Results

Results of Statistical Rests for Radionuclides above the BV/FV

Analyte	Gehan p-value	Quantile p-value	Slippage p-value	COPC?
Americium-241	n/a*	1	0.947	No
Cesium-137	n/a	0.003	0.01	Yes
Plutonium-238	<0.001	0.023	n/a	Yes
Plutonium-239/240	0.005	0.055	n/a	Yes
Strontium-90	n/a	0.988	0.977	No

*n/a = Not applicable.