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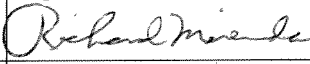
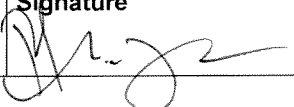
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Environmental Programs Directorate Engineering & Technology

Standard Operating Procedure

for **BACKGROUND VALUE COMPARISONS -
RADIONUCLIDES**

APPROVAL SIGNATURES:

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1.0 PURPOSE AND SCOPE

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

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.

2.0 BACKGROUND AND PRECAUTIONS

2.1 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. The Laboratory 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 the Laboratory 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).

2.2 Precautions

In addition to the process described herein, there is a need to apply professional experience and judgment in determining whether radionuclides are 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 risk or dose are adequately presented. 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 slightly above background and no statistical or nonstatistical methods can be used to justify the elimination. In addition, some background data sets are small and/or the maximum concentration is less than the BVs/FVs. If detected concentrations are interpreted to be slightly above the BVs/FVs, professional experience or judgment may be used to eliminate the radionuclide on this basis. The key component is consistency among all investigation reports 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 typically not applicable below the surface (0–0.5 ft or 0-1 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).

3.0 EQUIPMENT AND TOOLS

Essential equipment and tools required to implement this SOP include the following: the U.S. Environmental Protection Agency (EPA) ProUCL computer program containing statistical methods or other statistical packages, as appropriate; the Laboratory 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).

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4.0 STEP-BY-STEP PROCESS DESCRIPTION

4.1 Prepare for BV/FV Comparisons

- Project Members
1. Obtain current list of BV/FVs from the Laboratory 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 fields of information:
 - sample concentration results
 - reporting units of the sample concentrations
 - final sample result qualifiers
 - sample analytical methods
 - sample preparation methods**NOTE:** The site data set may be provided to the user in the same format as it is recorded in the Sample Management Database. Data dictionaries and code definitions are available from the data stewards.

 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 Laboratory 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.

4.2 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.

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4.3 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 (0–0.5 ft or 0–1 ft), compare with the Laboratory 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 media and a fallout radionuclide was detected in any subsurface samples (below 0–0.5 ft or 0–1 ft), identify the radionuclide as a COPC.

 3. If the site samples were collected from tuff material, 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 Laboratory 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, select sediment FVs.
NOTE: Sediment FVs are applicable to alluvial sediment, regardless of depth.

 5. For site samples that contain naturally occurring radionuclides (e.g., isotopic thorium and isotopic uranium) in soil media, compare with the soil BVs, regardless of the depth.

 6. For site samples that contain naturally occurring radionuclides in tuff units Qbt 2, Qbt 3, and/or Qbt 4, compare with the BVs for Qbt 2, 3, 4, regardless of the depth.

 7. For site samples that contain naturally occurring radionuclides in tuff units Qbt 1v, compare with the BVs for Qbt 1v, regardless of the depth.

 8. For site samples that contain naturally occurring radionuclides in tuff units Qbt 1g, Qct, and/or Qbo, compare with the BVs for Qbt 1g, Qct, Qbo, regardless of the depth.

 9. For site samples that contain naturally occurring radionuclides in sediment, compare with the sediment BVs, regardless of the depth.

4.4 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.

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Project Members (cont.)

3. If the maximum result for a radionuclide (naturally occurring or fallout) from a site is greater than the BV/FV and exceeds the maximum background/fallout concentration for that radionuclide, and the site data are interpreted as being substantially above background, identify the radionuclide as a COPC.

NOTE: If this is the case, there is no need to perform statistical comparisons and construct box plots.

4. If there are fewer than 10 sample results for the environmental medium and the radionuclide being evaluated and the site data are not interpreted as being substantially above background, compare maximum detected concentration with the maximum background/fallout concentration.
 - If the maximum detected concentration is less than the maximum background concentration, do not identify the radionuclide as a COPC.
 - If the maximum detected concentration is greater than the maximum background concentration, identify the radionuclide as a COPC.

5. For the conditions in the above step, present the site data and BV/FV data being compared in a box plot(s) and provide the box plots in the investigation report (see Attachment 1 for examples of box plots).

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 x's, and the nondetected concentrations are plotted as o's. Define x's and o's in figure caption for each box plot presented.

NOTE: Although ProUCL provides 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.

6. If there are at least 10 sample results for the environmental medium and the radionuclide being evaluated, the maximum detected concentration is greater than the BV/FV, and the site data are not interpreted as being substantially above background, conduct statistical comparisons of the site data set with the BV/FV data set (see Step 4.5).

7. Report the site concentrations of all radionuclides detected or detected above BVs/FVs for all samples collected in a table.

In addition, present all detected 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 10 sample results for the environmental medium (soil, sediment, and tuff unit) and the radionuclide evaluated and, therefore, the site data were compared with the maximum background concentration.

4.5 Statistical Comparisons of Site Data to Background/Fallout Data

Project Members

1. If statistical comparisons are appropriate and warranted as stated above, consult a statistician on how to proceed and which statistical tests to run. The preferred tests include the Gehan, Quantile, and Slippage tests (these are the tests historically used for background comparisons).

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Project Members (cont.)

- Choose two statistical tests to run—paired as either the Gehan and Quantile tests or the Quantile and Slippage tests. 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 less than 50% detects, use the Quantile test as the primary test (this test cannot be performed if more than 80% of the combined data are nondetected values). To eliminate as a COPC, the radionuclide must pass both tests (i.e., p-value >0.05); if fail one test (p-value <0.05) and pass the other, then retain as COPC. Therefore, if the first test fails, there is no need to perform the second test. However, if the first test passes then the second test must be conducted.

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 2).

The Statistical ProUCL programs are commercial programs that have been validated to run on the platform used. Prior to running the program a test verification calculation, that exercises all necessary subroutines, will be run to ensure the program is properly operating.

- If the number of nondetects prevents the use of the statistical tests even though there are an adequate number of samples, compare the maximum detected concentration with the maximum background concentration as described in Step 4.4 above.

- Present statistical results for each radionuclide statistically evaluated in a table for each medium (see Attachment 3 for example of the table) in an appendix (see SOP-5250, Attachment 9). Present the p-values for each statistical test conducted and indicate whether radionuclide is retained as a COPC.

- Construct box plots for all radionuclides included in the statistical comparisons and provide the box plots in an appendix 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.

- 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 x's, and the nondetected concentrations are plotted as o's. Define x's and o's in figure caption for each box plot presented.

4.6 Site Data Slightly above BV/FVs

Project Members

- When only a comparison to BVs/FVs is applicable only because the BV/FV is equal to or exceeds the maximum concentration of the background/fallout data set, professional judgment or experience may be used to eliminate radionuclides as COPCs if the site data are interpreted as being slightly and infrequently above the BV/FV.
- Slightly above background is defined as equivalent to or less than 20% above the BV/FV. Infrequently detected above BV/FV is defined as one to five samples of the total number of samples, depending upon the number of samples in the data set.

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Project Members (cont.)

NOTE: If the number of samples in the data set is 100 then infrequently detected above BV may be as many as 10 samples. In addition, EPA's Risk Assessment Guidance for Superfund, Part A, section 5.9.3, page 5-22 uses a frequency of detection of 5% as an example of infrequent detection. However, the exact number of samples used to define infrequently above BV/FV is dependent on the data set and the data assessor and is entirely subjective.

For example, cesium-137 is detected above the sediment FV of 0.9 pCi/g in two of eight samples. The concentrations range from 0.94 to 1.1 pCi/g. Another example is americium-241 in soil detected above the soil FV of 0.013 pCi/g in 4 of 25 samples. The concentrations range from 0.014 to 0.016 pCi/g. In both cases, professional judgment or experience may be used to eliminate radionuclides as COPCs as not being different from background/fallout.

3. If the site data meet the conditions described above for slightly and infrequently above background/fallout, the radionuclide may be eliminated as a COPC. The rationale must be presented for each radionuclide eliminated in this fashion.

Alternatively, the radionuclide is retained as a COPC, regardless of how slight and infrequent the concentration is above the BV/FV (if only comparing to BV/FV no box plots are necessary). The basis for all decisions must be presented in the report to clearly explain assumptions made in identifying COPCs. (NOTE: Consult the subject matter expert and the project leader before implementing this process.)

4.7 Records Management

1. Project Members or Project Leader: Maintain and submit records and/or documents generated to the Records Processing Facility according to EP-DIR-SOP-4004, Records Transmittal and Retrieval Process.

5.0 DEFINITIONS

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

Background Data— Data that represent naturally occurring concentrations of inorganic and radionuclide constituents in a geologic medium. Los Alamos National Laboratory's (the Laboratory's) background data are derived from samples collected at locations that are either within or adjacent to the Laboratory. These locations (1) are representative of geological media found within Laboratory boundaries, and (2) have not been affected by Laboratory 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 detected chemical compound or element that has the potential to adversely affect human receptors as a result of its concentration, distribution, and toxicity.

Fallout Radionuclides— Radionuclides that are present at globally elevated levels in the environment as a result of fallout from worldwide atomic weapons tests. The Laboratory 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 the Laboratory's vicinity that were representative of geological media found within Laboratory boundaries, and were not impacted by Laboratory operations.

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

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5.1 ACRONYMS

- ALLH all horizons (soil)
- BV background value
- COPC chemical of potential concern
- EP Environmental Programs
- EPA Environmental Protection Agency (U.S.)
- FV fallout value
- LANL Los Alamos National Laboratory (Laboratory)
- NMED New Mexico Environment Department
- Qbt Quarternary Tshirege Member of the Bandelier Tuff
- SED sediment
- SOP standard operating procedure

6.0 PROCESS FLOW CHART

Flow diagram for the COPC identification process – Figure 1

7.0 ATTACHMENTS

- Attachment 1 Example of Box Plot
- Attachment 2 Example of Excel function HYPGEOMDIST
- Attachment 3 Example of Table Summarizing Statistical Results

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8.0 REVISION HISTORY

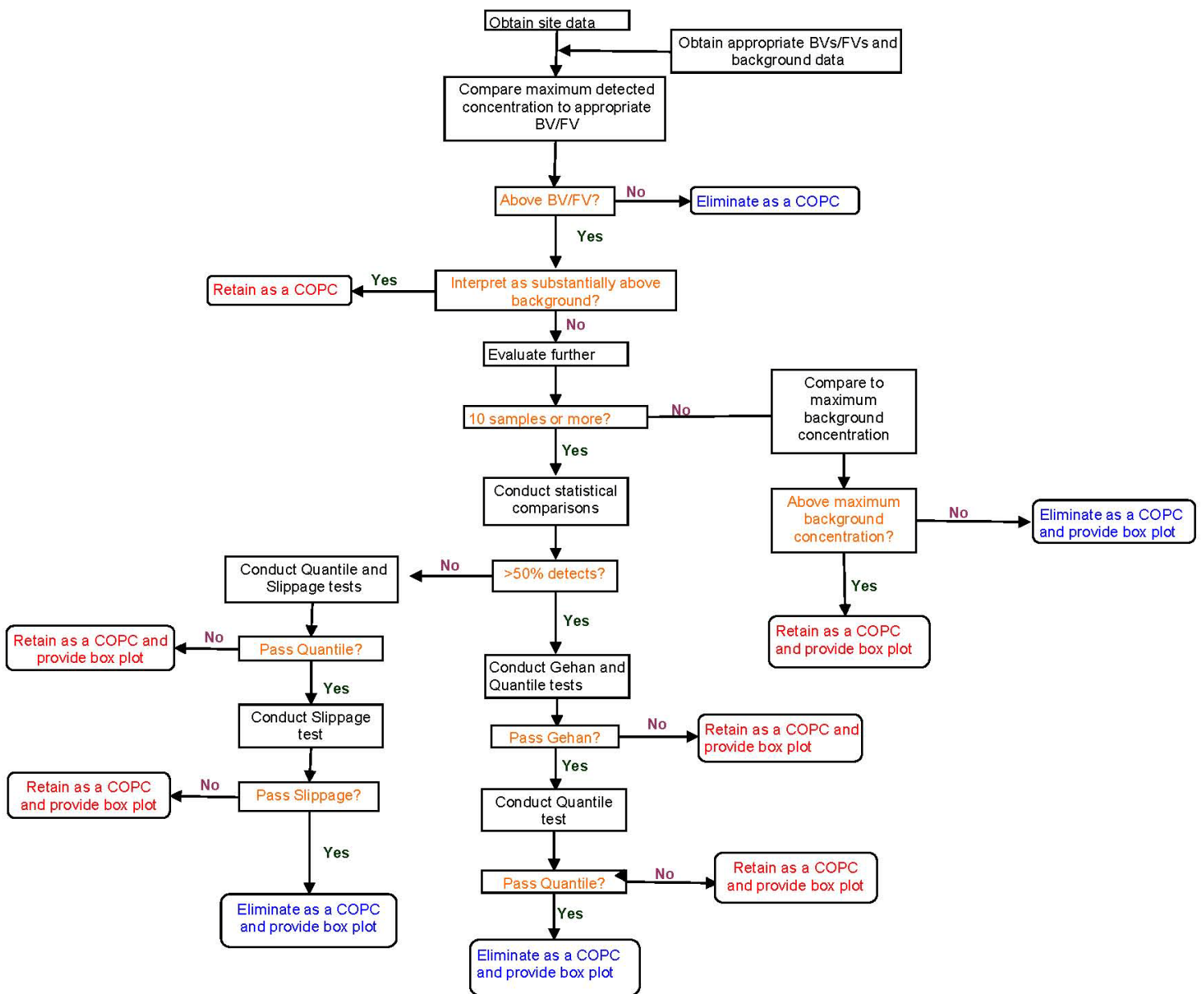
Revision No. <i>[Enter current revision number, beginning with Rev.0]</i>	Effective Date <i>[DCC inserts effective date for revision]</i>	Description of Changes <i>[List specific changes made since the previous revision]</i>	Type of Change <i>[Technical (T) or Editorial (E)]</i>
0	02/09/07	Reformatted and renumbered, supersedes SOP-15.13	E
0	10/06/09	New number sequence assigned. Supersedes EP-ERSS-SOP-5087. Added process for performing statistical comparisons.	T
1	8/26/2010	Deleted references to data review appendix and other editorial changes.	E

FIGURE 1

SOP-5246-Figure 1

FLOW CHART

Records Use only

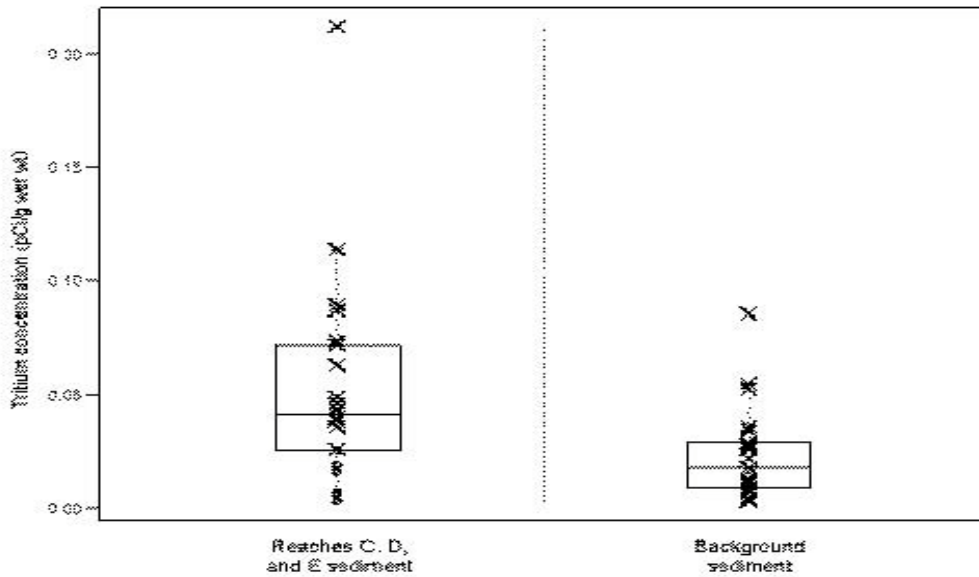


ATTACHMENT 1

SOP-5246-1

Example Box Plot

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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)

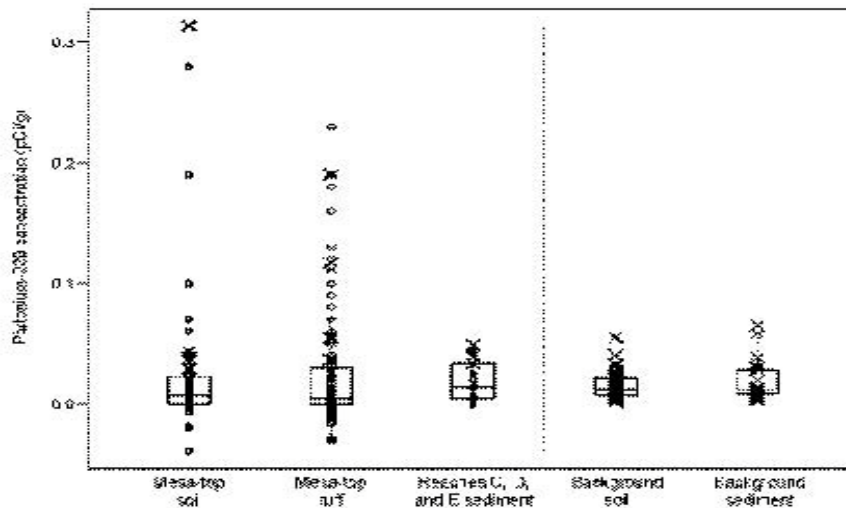



Figure D-4-2-2. Box plot of plutonium-239 concentrations in mesa-top soil; mesa-top tuff; Reaches C, D, and E sediment; ALLH background data; and sediment background data

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ATTACHMENT 2	
SOP-5246-2 EXAMPLE OF EXCEL FUNCTION HYPGEOMDIST	Records Use only 


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 3	
<p>SOP-5246-2</p> <p style="text-align: center;">EXAMPLE OF TABLE SUMMARIZING STATISTICAL RESULTS</p>	<p>Records Use only</p> 

Results of Statistical Tests 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.