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Contractor For U.S. Department of Energy, Office of River Protection, under Contract DE-AC27-08SR14800

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<th>Name</th>
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<td>03/27/2017</td>
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8. Description of Change and Justification

New document describing radiological characterization at the 241-UX-302A Catch Tank

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10. Related Structures, Systems, and Components

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12. Impacted Documents (Outside SPF):

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13. Related Documents

☑ N/A

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241-UX-302A Catch Tank Hard-to-Detect Analysis

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Abstract: Radiological characterization demonstrates that Hard-to-Detect nuclide evaluations are not necessary for activities associated with the 241-UX-302A Catch Tank.

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Approved For Public Release
EXECUTIVE SUMMARY

Recent sampling and characterization data confirms that an evaluation of Hard-to-Detect nuclides is not necessary when performing surveys associated with the 241-UX-302A Catch Tank.

ACRONYMS

CL Confidence Level
dpm Disintegrations per Minute
ETD Easy to Detect
GM Geiger Muller
HTD Hard to Detect
MDA Minimum Detectable Activity

1.0 PURPOSE

The purpose of this analysis is to substantiate that an evaluation of Hard-to-Detect nuclides is not necessary when performing release surveys, shipment surveys and job coverage surveys associated with the 241-UX-302A Catch Tank.

2.0 SCOPE

This analysis is specific to surveys performed at the 241-UX-302A Catch Tank. Any other application is not intended.
3.0 ADMINISTRATIVE REQUIREMENTS

The technical basis for determining when Hard-to-Detect surveys are required is driven by RPP-53057, *TOC Technical Basis for Evaluation of Hard-to-Detect Beta-Emitting Radionuclides*. The current revision to RPP-53057 was issued November 02, 2016 and it identified that an evaluation of Group 4 Hard-to-Detect nuclides is necessary for surveys performed at the 241-UX-302A Catch Tank.


RPP-53057 states:

*Deviations from the ETD and HTD classifications in this document are permissible provided the following two conditions are met:*

- **Representative sample data is obtained to support any conclusions made concerning the current radiological characterization of the tank/location in question.**
- **All conclusions that deviate from this RPP are documented in a technical basis document (RPP) containing assumptions, calculations and supporting evidence that is equivalent in rigor to this RPP and approved by the Radiological Engineering Manager.**
- **New data is incorporated into this document at the next revision.**

This document utilizes representative sample data and constitutes a technical basis that is equivalent in rigor to RPP-53057. It requires approval from the Radiological Engineering Manager prior to becoming effective.

This document is specific to Group 4 beta-emitting nuclides because the existing technical basis in RPP-53057 already excludes Group 1 nuclides and tritium from Hard-to-Detect evaluation requirements.

4.0 CHARACTERIZATION DATA

The sampling campaign for the 241-UX302-A Catch Tank was performed by Washington River Protection Solutions (WRPS) Integration and Control utilizing an approved sampling plan (RPP-PLAN-61150, *Sampling and Analysis Plan for Catch Tank 241-UX-302A Liquid*). The results were published in RPP-RPT-59852, *Final Report for Catch Tank 241-UX-302A Grab Samples in Support of Tank Farm Waste Compatibility*. 
Sampling methods and laboratory analysis methods are described exhaustively in the final report and are not detailed here. Table 1 summarizes the pertinent results drawn from the final sampling report. These results are used over the remainder of this document in all subsequent calculations.

<table>
<thead>
<tr>
<th>Nuclide</th>
<th>ETD or HTD</th>
<th>Value used (µCi/ml)</th>
<th>Technical Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antimony-125</td>
<td>ETD</td>
<td>0</td>
<td>No credit taken as an ETD for conservatism (RPP-59852 page 28)</td>
</tr>
<tr>
<td>Barium -137m</td>
<td>ETD</td>
<td>1.03E-02</td>
<td>Assumed to be in equilibrium with Cs-137</td>
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<tr>
<td>Cadmium-113m</td>
<td>ETD</td>
<td>0</td>
<td>No credit taken as an ETD for conservatism (RPP-59852 page 25)</td>
</tr>
<tr>
<td>Carbon-14</td>
<td>HTD</td>
<td>1.46E-06</td>
<td>Not detected - conservatively chosen at MDA in RPP-59852 (page 21)</td>
</tr>
<tr>
<td>Cesium-134</td>
<td>ETD</td>
<td>0</td>
<td>No credit taken as an ETD for conservatism (RPP-59852 page 28)</td>
</tr>
<tr>
<td>Cesium-137</td>
<td>ETD</td>
<td>1.03E-02</td>
<td>Nominal value from RPP-59852 (page 21)</td>
</tr>
<tr>
<td>Cobalt-60</td>
<td>ETD</td>
<td>0</td>
<td>No credit taken as an ETD for conservatism (RPP-59852 page 28)</td>
</tr>
<tr>
<td>Europium-152</td>
<td>ETD</td>
<td>0</td>
<td>No credit taken as an ETD for conservatism (RPP-59852 page 28)</td>
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<tr>
<td>Europium-154</td>
<td>ETD</td>
<td>0</td>
<td>No credit taken as an ETD for conservatism (RPP-59852 page 28)</td>
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<tr>
<td>Europium-155</td>
<td>HTD</td>
<td>1.46E-04</td>
<td>Not detected - conservatively chosen at MDA in RPP-59852 (page 28)</td>
</tr>
<tr>
<td>Nickel-59</td>
<td>HTD</td>
<td>0</td>
<td>Total nickel is not present in significant amounts (RPP-59852 page 26)</td>
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<tr>
<td>Nickel-63</td>
<td>HTD</td>
<td>6.62E-07</td>
<td>Not detected - conservatively chosen at MDA in RPP-59852 (page 32)</td>
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<tr>
<td>Niobium-93m</td>
<td>HTD</td>
<td>0</td>
<td>Not present in significant amounts (RPP-59852 page 26)</td>
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<tr>
<td>Plutonium-241</td>
<td>HTD</td>
<td>2.69E-05</td>
<td>Nominal value from RPP-59852 (page 21)</td>
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<tr>
<td>Ruthenium-106</td>
<td>HTD</td>
<td>6.54E-04</td>
<td>Not detected - conservatively chosen at MDA in RPP-59852 (page 28)</td>
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<tr>
<td>Samarium-151</td>
<td>HTD</td>
<td>0</td>
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<tr>
<td>Selenium-79</td>
<td>HTD</td>
<td>1.37E-06</td>
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<tr>
<td>Strontium-90</td>
<td>ETD</td>
<td>2.21E-01</td>
<td>Nominal value from RPP-59852 (page 28)</td>
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<tr>
<td>Technicium-99</td>
<td>ETD</td>
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<tr>
<td>Tin-126</td>
<td>HTD</td>
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<tr>
<td>Yttrium-90</td>
<td>ETD</td>
<td>2.21E-01</td>
<td>Assumed to be in equilibrium with Sr-90</td>
</tr>
<tr>
<td>Zirconium</td>
<td>HTD</td>
<td>0</td>
<td>Not present in significant amounts (RPP-59852 page 27)</td>
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</table>
5.0 CALCULATIONS

One of the technical requirements for a deviation from RPP-53057 is that the deviating document is equivalent in rigor to the analysis in RPP-53057. For that purpose the following formulas are taken directly from, and used exactly as intended by, RPP-53057.

The weighted MDA (MDA_w) for the UX-302 source term is calculated using the calculations identified in RPP-53057, *Technical Basis for the Evaluation of Hard-to-Detect Beta-Emitting Radionuclides*. Specifically, Equation 6-1 is applied with the exception that activity is expressed in units of µCi/ml instead of Curies.

\[
MDA_w = \left( \frac{A_{90 SrY}}{A_{ETD}} (MDA_{90 SrY}) + \frac{A_{137 Cs}}{A_{ETD}} (MDA_{137 Cs}) + \frac{A_{rest}}{A_{ETD}} (MDA_{99 Tc}) \right)
\]

Where:

- \(MDA_w\) = Weighted MDA for the mixture of eleven ETD nuclides (dpm/100cm²)
- \(A_{90 SrY}\) = Concentration of \(^{90}\)Sr + \(^{90}\)Y (µCi/ml)
- \(MDA_{90 SrY}\) = MDA \(^{90}\)SrY for Hanford GM at 2”/sec 67% CL (2,000 dpm/100cm²)
- \(A_{ETD}\) = Total Activity of \(^{137}\)Cs, \(^{137m}\)Ba, \(^{90}\)SrY, \(^{60}\)Co, \(^{99}\)Tc, \(^{113m}\)Cd, \(^{134}\)Cs, \(^{154}\)Eu, \(^{152}\)Eu, \(^{125}\)Sb (µCi/ml)
- \(A_{137 Cs}\) = Activity of \(^{137}\)Cs + \(^{137m}\)Ba (µCi/ml)
- \(MDA_{137 Cs/137m Ba}\) = MDA \(^{137}\)Cs/\(^{137m}\)Ba for Hanford GM at 2”/sec 67% CL (2,900 dpm/100cm²)
- \(A_{rest}\) = Activity of \(^{60}\)Co, \(^{99}\)Tc, \(^{113m}\)Cd, \(^{134}\)Cs, \(^{154}\)Eu, \(^{152}\)Eu, \(^{125}\)Sb (µCi/ml)
- \(MDA_{99 Tc}\) = MDA \(^{99}\)Tc for Hanford GM at 2”/sec 67% CL (4,400 dpm/100cm²)

Applying the values identified in Table 1, MDA_w is:

\[
\left( \frac{4.42E-01 \mu Ci/ml}{4.63E-01 \mu Ci/ml}\right)(2,000 \text{ dpm/100cm}^2) + \left( \frac{2.06E-02 \mu Ci/ml}{4.63E-01 \mu Ci/ml}\right)(2,900 \text{ dpm/100cm}^2) + \left( \frac{0 \mu Ci/ml}{4.63E-01 \mu Ci/ml}\right)(4,400 \text{ dpm/100cm}^2) = 2,038 \text{ dpm/100cm}^2
\]
The MDA\textsubscript{w} represents the combined activity of all eleven ETD radionuclides when the decision is made that there is a detectable count rate above background. From this, the fractional activity limit for ETDs is:

\[
F_{\text{ETD Limit}} = \left( \frac{\text{MDA}_{\text{w}}}{5,000 \text{ dpm/100cm}^2} \right) = \left( \frac{2.038 \text{ dpm/100cm}^2}{5,000 \text{ dpm/100cm}^2} \right) = 0.408
\]

This fractional limit for ETD constitutes the numerator of the screening criteria for HTD surveys. The next step is to calculate the fraction of actual ETD activity for Group 4 MFP as the denominator of the screening criteria as follows:

\[
F_{\text{ETD Actual}} = \left( \frac{A_{\text{ETD}}}{A_{\text{Total MFP}}} \right)
\]

Where:

\[
F_{\text{ETD Actual}} = \text{Total fraction of Group 4 MFP that is detectable (decimal)}
\]

\[
A_{\text{ETD}} = \text{Total Activity of } ^{137}\text{Cs, } ^{137m}\text{Ba, } ^{90}\text{SrY, } ^{99}\text{Co, } ^{113m}\text{Cd, } ^{134}\text{Cs, } ^{154}\text{Eu}
\]

\[
A_{\text{Total MFP}} = \text{Total Activity of } ^{59}\text{Ni, } ^{63}\text{Ni, } ^{79}\text{Se, } ^{93m}\text{Nb, } ^{93}\text{Zr, } ^{106}\text{Ru, } ^{125}\text{Sn, } ^{151}\text{Sm, } ^{152}\text{Eu, } ^{155}\text{Eu, } ^{241}\text{Pu, } ^{14}\text{C, and all ETD nuclides}
\]

Applying the values identified in Table 1, \(F_{\text{ETD Actual}}\) is:

\[
\left( \frac{4.42E-01 \text{ uCl/ml}}{4.43E-01 \text{ uCl/ml}} \right) = 0.998
\]

In accordance with RPP-53057, if the ratio of \(F_{\text{ETD Limit}}/F_{\text{ETD Actual}}\) is < 1.00, no HTD surveys are necessary for Group 4 MFP. In the case of UX-302 the ratio is:

\[
(0.408 / 0.998) = 0.409
\]

Therefore, HTD surveys are not necessary for Group 4 MFP.

REFERENCES

