**Contract No:**

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# APPENDIX B: SUPPORTING INFORMATION: INVENTORY UNCERTAINTY

## B.1 CHARACTERIZATION UNCERTAINTY IN WASTE STREAM 420DTRITIUM-LLW, VER. 0

The total relative uncertainty, *U*, reported for each isotope in each waste cut is given by (Eq. 2-2) in Section 2.3.5.3. Waste Cut 1 of Container SD00003950 has a total activity of 737.990 Ci distributed among the isotopes H-3 and Am-241. Table B-1 summarizes the calculation results for the best-effort analysis example presented in Section 2.3.5.9.

**Table B-1. Calculation Summary of H-3/Am-241 Distribution, Activity, and Uncertainty for Waste Cut 1, Container SD00003950**

| Radionuclide | Ci Fraction Distribution | Activity (Ci) | *C* (%) | *M* (%) | *U* (%) | Activity Uncertainty (Ci) |
|---|---|---|---|---|---|---|
| H-3 | 9.99998E-01 | 737.9885 | 0.000463% | 120% | 120% | 885.585 |
| Am-241 | 1.72061E-06 | 0.0012698 | 269% | 120% | 294% | 3.7297E-03 |

Notes:

C = characterization uncertainty

M = measurement uncertainty

U = total relative uncertainty

Figure B-1 and Figure B-2 show the data from the technical baseline documents in waste stream characterization SWEWSCF20050055, Revision 0, used to derive the scaling factors. Screening removed all radionuclides except Am-241 and H-3.

The uncertainty in the Ci fraction (scaling factor) is calculated using the data in Table B-2. The calculations are shown in Figure B-3.

| | 98B | 98A | EP-97 | 18B | EP-57 | 18A | 34B | 34A | |
|---|---|---|---|---|---|---|---|---|---|
| Sample # | 300216892 | 300216893 | 300216886 | 300216890 | 300216887 | 300216891 | 300216888 | 300216889 | AVG |
| Alpha (dpm/g) | <1.35E+02 | <1.18E+02 | 5.53E+00 | 2.58E+01 | 6.08E+01 | 1.20E+01 | <5.76E-01 | 8.15E-01 | 2.10E+01 |
| Beta (dpm/g) | <1.86E+02 | <1.59E+02 | <2.59E+01 | 1.62E+02 | 5.79E+02 | 3.40E+01 | <9.05E+00 | <1.46E+01 | 2.58E+02 |
| Tritium (uCi/g) | 6.90E-03 | 2.81E-02 | 1.41E-03 | 2.07E+01 | 4.33E+02 | 1.31E+01 | 3.07E+00 | 2.84E-04 | 5.87E+01 |
| Gamma PHA (dpm/g) | | | | | | | | | |
| Ra-226 | | | 4.93E+01 | | | | | | 4.93E+01 |
| Co-60 | | | | 5.51E+02 | 7.82E+02 | 3.20E+01 | 4.61E+00 | 8.02E+00 | 2.76E+02 |
| Cs-137 | | | | 1.35E+02 | 7.35E+01 | | | | 1.04E+02 |
| Am-241 | | | | 1.01E+02 | 3.47E+02 | | | | 2.24E+02 |
| Eu-152 | | | | | 2.71E+01 | | | | 2.71E+01 |
| Eu-154 | | | | | 2.98E+02 | | | | 2.98E+02 |

**Figure B-1. Sample Data (Part 1) for Waste Stream 420DTRITIUM-LLW, Version 0**

| | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Radionuclide | Radionuclide Designation | Result (dpm/g) | Result (uCi/g) | Reportable Result (dpm/g) | Activity (uCi)/gm | MALLD uCi/g | >2 Orders of magnitude below MALLD? | Percent Activity | Normalized Activity (Ci) | Normalized Percent Activity |
| 2 | Tritium | PA | NA | 5.870E+01 | 1.303E+08 | 5.870E+01 | N/A | N/A | 1.000E+02 | 5.870E-05 | 9.999983E+01 |
| 3 | Cs-137 | | 1.04E+02 | | 1.040E+02 | 4.685E-05 | 1.000E-05 | NO | 7.981E-05 | | |
| 4 | Ba-137m | DAUGHTER(Cs-137) | 9.84E+01 | | 9.838E+01 | 4.432E-05 | 1.000E-05 | NO | 7.550E-05 | | |
| 5 | U-238 | | 4.93E+01 | | 4.930E+01 | 2.221E-05 | 1.000E-06 | NO | 3.783E-05 | | |
| 6 | Am-241 | TRU | 2.24E+02 | | 2.240E+02 | 1.009E-04 | 1.000E-05 | NO | 1.719E-04 | 1.009E-10 | 1.7189E-04 |
| 7 | Co-60 | | 2.76E+02 | | 2.760E+02 | 1.243E-04 | 1.000E-04 | NO | 2.118E-04 | | |
| 8 | Ra-226 | DAUGHTER(U-238) | 4.93E+01 | | 4.930E+01 | 2.221E-05 | 1.000E-06 | NO | 3.783E-05 | | |
| 9 | Th-234 | DAUGHTER(U-238) | 4.93E+01 | | 4.930E+01 | 2.221E-05 | 1.000E-06 | NO | 3.783E-05 | | |
| 10 | Pa-234-m | DAUGHTER(U-238) | 4.93E+01 | | 4.930E+01 | 2.221E-05 | 1.000E-06 | NO | 3.783E-05 | | |
| 11 | Pa-234 | DAUGHTER(U-238) | 4.93E+01 | | 4.930E+01 | 2.221E-05 | 1.000E-06 | NO | 3.783E-05 | | |
| 12 | U-234 | DAUGHTER(U-238) | 4.93E+01 | | 4.930E+01 | 2.221E-05 | 1.000E-06 | NO | 3.783E-05 | | |
| 13 | Th-230 | DAUGHTER(U-238) | 4.93E+01 | | 4.930E+01 | 2.221E-05 | 1.000E-06 | NO | 3.783E-05 | | |
| 14 | Rn-222 | DAUGHTER(U-238) | 4.93E+01 | | 4.930E+01 | 2.221E-05 | 1.000E-06 | NO | 3.783E-05 | | |
| 15 | Po-218 | DAUGHTER(U-238) | 4.93E+01 | | 4.930E+01 | 2.221E-05 | 1.000E-06 | NO | 3.783E-05 | | |
| 16 | Pb-214 | DAUGHTER(U-238) | 4.93E+01 | | 4.930E+01 | 2.221E-05 | 1.000E-06 | NO | 3.783E-05 | | |
| 17 | Pb-210 | DAUGHTER(U-238) | 4.93E+01 | | 4.930E+01 | 2.221E-05 | 1.000E-06 | NO | 3.783E-05 | | |
| 18 | Bi-210 | DAUGHTER(U-238) | 4.93E+01 | | 4.930E+01 | 2.221E-05 | 1.000E-06 | NO | 3.783E-05 | | |
| 19 | Po-210 | DAUGHTER(U-238) | 4.93E+01 | | 4.930E+01 | 2.221E-05 | 1.000E-06 | NO | 3.783E-05 | | |
| 20 | Eu-152 | | 2.71E+01 | | 2.710E+01 | 1.221E-05 | | | 2.080E-05 | | |
| 21 | Eu-154 | | 2.98E+02 | | 2.980E+02 | 1.342E-04 | | | 2.287E-04 | | |
| 22 | Total | | | | | 5.870E+01 | | | 1.000E+02 | 5.870E-05 | 1.000E+02 |

**Figure B-2. Sample Data (Part 2) for Waste Stream 420DTRITIUM-LLW, Version 0**

## Table B-2. Data Used to Compute the Scaling Factor

| Radionuclide | Average Activity (Ci) | St. Dev. Sample (Ci) | Uncertainty (%) | Normalized Activity (Ci $g^{-1}$) | Normalized Uncertainty (Ci $g^{-1}$) | Ci Fraction (Normalized Activity/Total) | Ci fraction % Uncertainty (see below) |
|---|---|---|---|---|---|---|---|
| H-3 | 5.87E+01 | 1.51E+02 | 258% | 5.87E-05 | 1.51E-04 | 9.99998E-01 | 0.000463% |
| Am-241 | 2.24E+02 | 1.74E+02 | 78% | 1.01E-10 | 7.88E-11 | 1.72061E-06 | 269% |

$$Q_{^3H} = \frac{^3H}{^3H + ^{241}Am} = 0.999998$$

$$\delta Q_{^3H} = \sqrt{\left(\frac{\partial Q_{^3H}}{\partial\, ^3H}\delta\, ^3H\right)^2 + \left(\frac{\partial Q_{^3H}}{\partial^{241}Am}\delta^{241}Am\right)^2}$$

$$\delta Q_{^3H} = \sqrt{\left(\frac{^{241}Am}{(^3H + ^{241}Am)^2}\delta\, ^3H\right)^2 + \left(\frac{-\,^3H}{(^3H + ^{241}Am)^2}\delta^{241}Am\right)^2}$$

$$\delta Q_{^3H} = \sqrt{\left(\frac{1.01\text{E-}10}{(5.87\text{E-}5 + 1.01\text{E-}10)^2}1.51\text{E-}4\right)^2 + \left(\frac{-5.87\text{E-}5}{(5.87\text{E-}5 + 1.01\text{E-}10)^2}7.88\text{E-}11\right)^2}$$

$$\delta Q_{^3H} = \sqrt{4.44\text{E-}06^2 + \text{-}1.34\text{E-}06^2} = 4.625\text{E-}06$$

$$\frac{\delta Q_{^3H}}{Q_{^3H}} = \frac{4.625\text{E-}06}{0.999998} = 4.625\text{E-}06 = 4.625\text{E-}04\% \text{ of H-3 distribution}$$

$$Q_{^{241}\text{Am}} = \frac{^{241}\text{Am}}{^3H + ^{241}Am} = 1.72\text{E-}06$$

$$\delta Q_{^{241}\text{Am}} = \sqrt{\left(\frac{\partial Q_{^{241}\text{Am}}}{\partial\, ^3H}\delta\, ^3H\right)^2 + \left(\frac{\partial Q_{^{241}\text{Am}}}{\partial^{241}Am}\delta^{241}Am\right)^2}$$

$$\delta Q_{^{241}\text{Am}} = \sqrt{\left(\frac{\text{-}^{241}Am}{(^3H + ^{241}Am)^2}\delta\, ^3H\right)^2 + \left(\frac{^3H}{(^3H + ^{241}Am)^2}\delta^{241}Am\right)^2}$$

$$\delta Q_{^{241}\text{Am}} = \sqrt{\left(\frac{\text{-}1.01\text{E-}10}{(5.87\text{E-}05 + 1.01\text{x}10^{-10})^2}1.51\text{E-}4\right)^2 + \left(\frac{5.87\text{E-}05}{(5.87\text{E-}05 + 1.01\text{E-}10)^2}7.88\text{E-}11\right)^2}$$

$$\delta Q_{^{241}\text{Am}} = \sqrt{1.34\text{E-}06^2 + \text{-}4.44\text{E-}06^2} = 4.625\text{E-}06$$

$$\frac{\delta Q_{^{241}\text{Am}}}{Q_{^{241}\text{Am}}} = \frac{4.625\text{E-}06}{1.721\text{E-}06} = 2.6953 = 269.53\% \text{ of Am-241 distribution}$$

**Figure B-3. Calculation of Scaling Factor Uncertainty**

## B.2 ACTIVITY AND UNCERTAINTY FOR SELECT ISOTOPES

The bounding constraint on the maximum future inventories for the various DUs is prescribed by their administrative SOF limits. Section 8.7 fully describes this process and how the SOF limits impact the GW and other pathways. The SOF ranking of various isotopes for the GW pathway is the same rank order used to prioritize the best estimate case uncertainty analysis. For example, ET02 uses a SOF ranking of Np-237 (100%), Am-241 (0.43%), and Pu-241 (0.20%). For the inventory uncertainty analysis, priority was given to determining the uncertainty in the inventory of Np-237; followed by other top-ranked SOF isotopes in the other DUs; followed by the second SOF-ranked isotope, and so on.

Figure B-4 through Figure B-7 present inventory activities and uncertainties for prioritized isotopes in selected DUs based on the SOF ranking. At least two isotopes from each DU are shown; some low ranked isotopes have been excluded for clarity. Only isotopes with a SOF ranking of 100% have had some of their waste streams, containers, and cuts explicitly analyzed. The goal has been to analyze enough documentation of the highest-activity containers so that the CDF and bias no longer change as additional analyses are performed. Many of the analyzed waste streams contain some of the lower-ranked isotopes; therefore, they have been analyzed as well – just not explicitly. The figures display, in Curies, the current CWTS inventory, the estimated true inventory (which accounts for the systematic bias found in the waste characterization documentation), and the 2σ uncertainty in these inventories.

Figures are grouped by type of DU: Figure B-4 and Figure B-5 provide results for STs; Figure B-6 displays results for ETs; and Figure B-7 presents results for the LAWV, ILV, and two NRCDAs.

During the closure analysis (Section 9.1.2), the impact of future waste on the exposure pathways is evaluated. For future DUs and isotopes, an average DU has been created for the two types of future DUs: an average ST and an average ET. The average ST and average ET utilize the mean activities of the isotopes in the existing (open and closed) DUs of that type as shown in Figure B-8. The six isotopes shown are usually the most important in the ELLWF PA. The SOF ranking in Figure B-8 is arbitrary and is simply used to visually separate the isotopes.

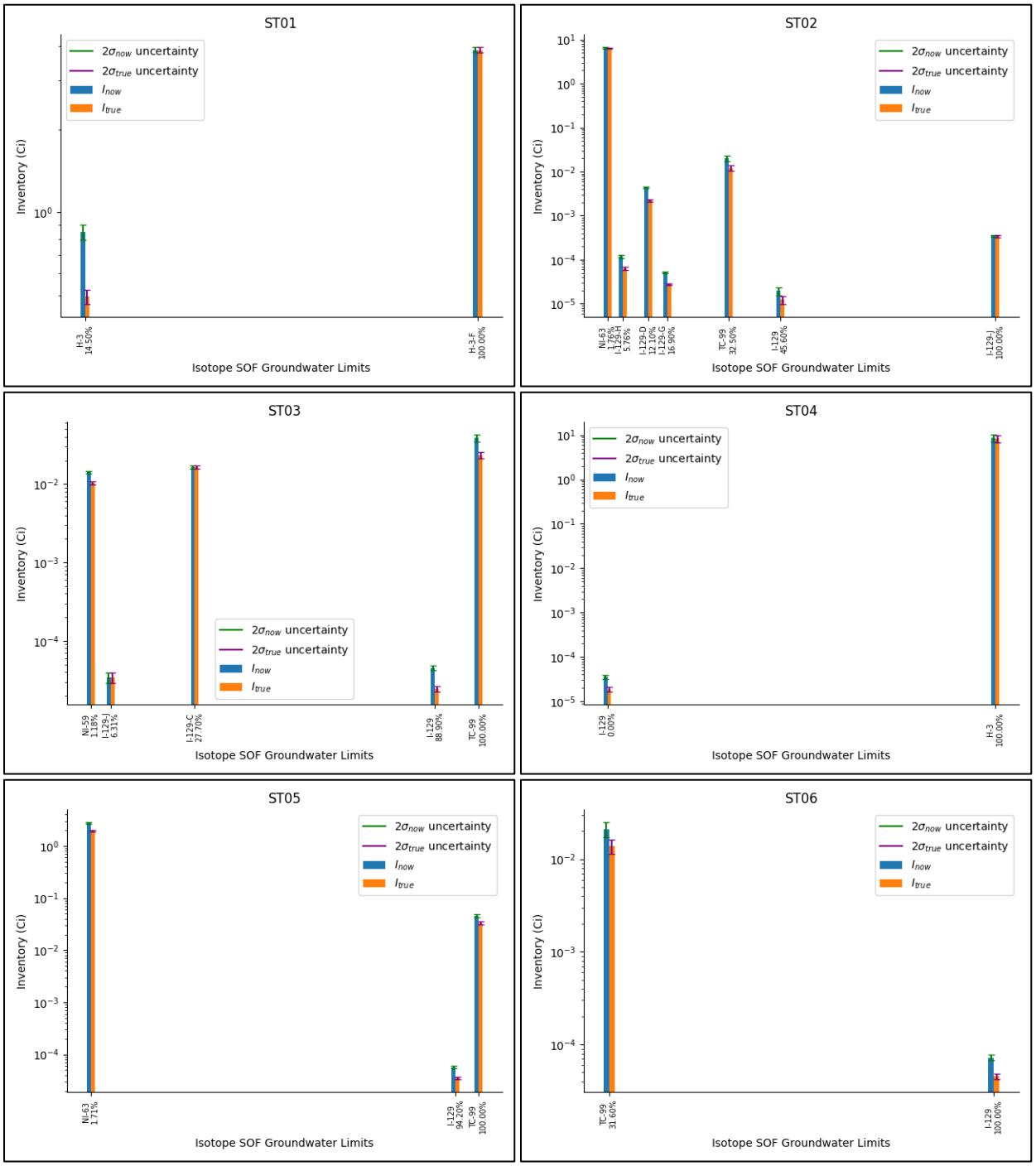


**Figure B-4. ST01 to ST06 Activities and Uncertainties**

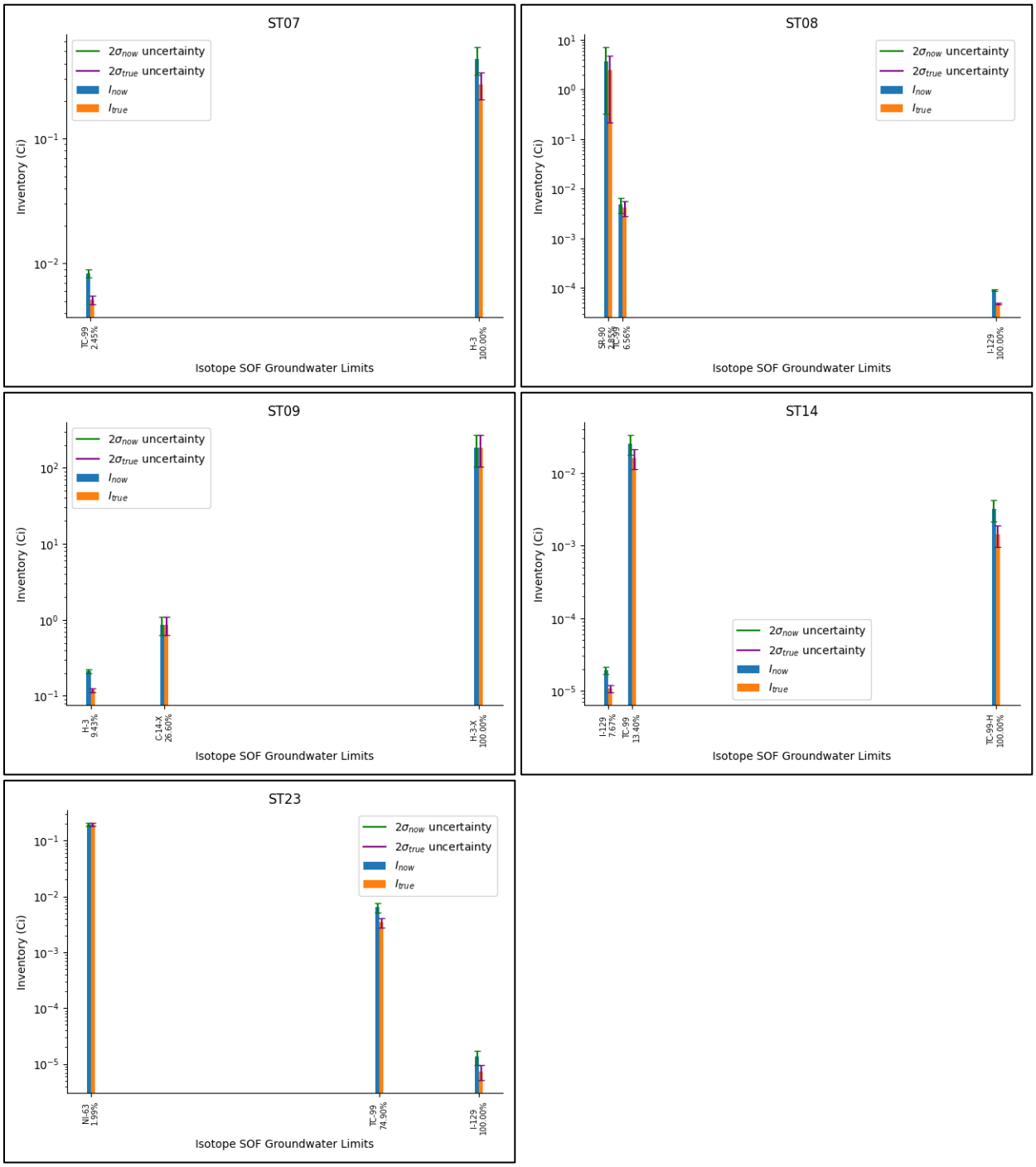


**Figure B-5. ST07 to ST23 Activities and Uncertainties**

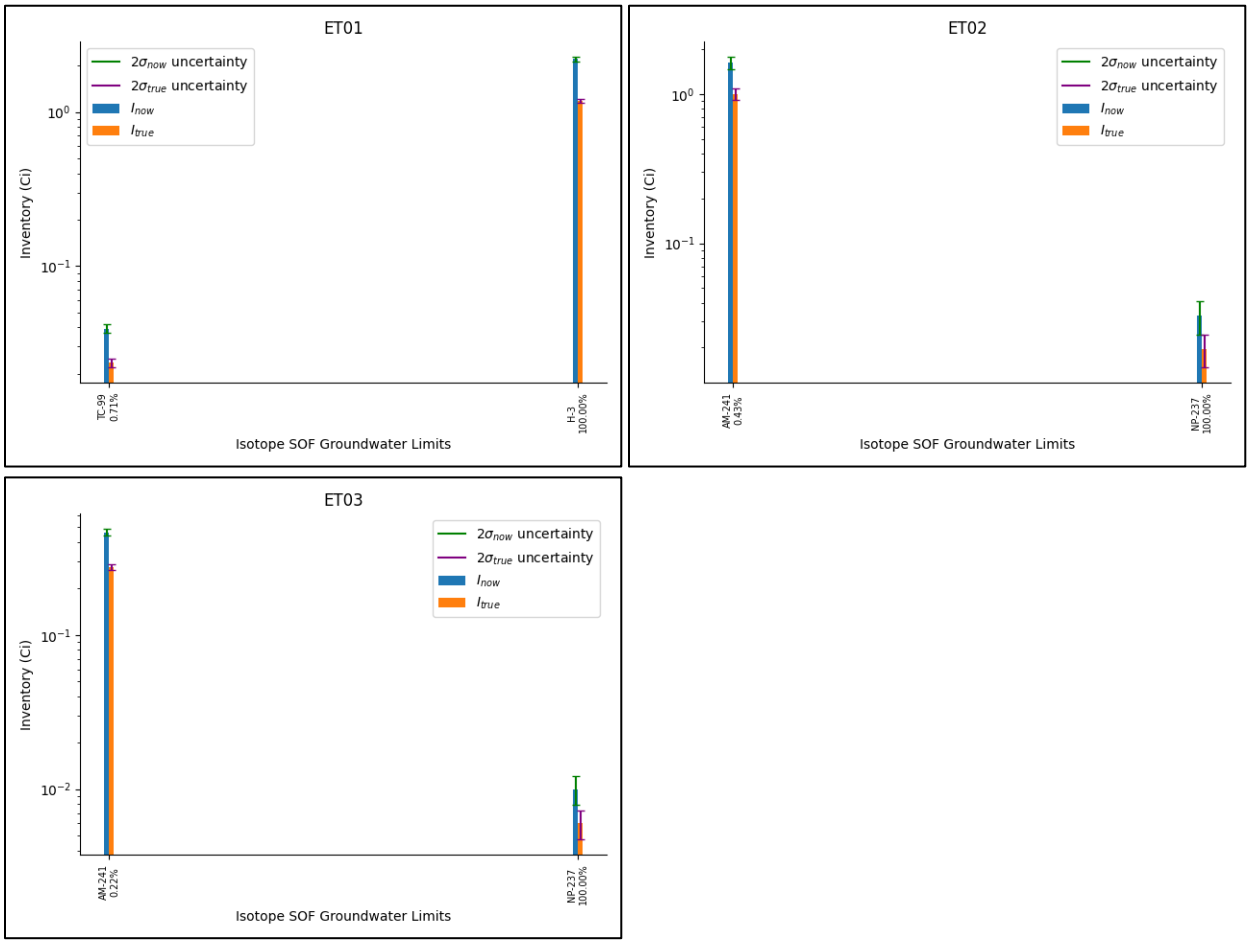


**Figure B-6. ET01 to ET03 Activities and Uncertainties**

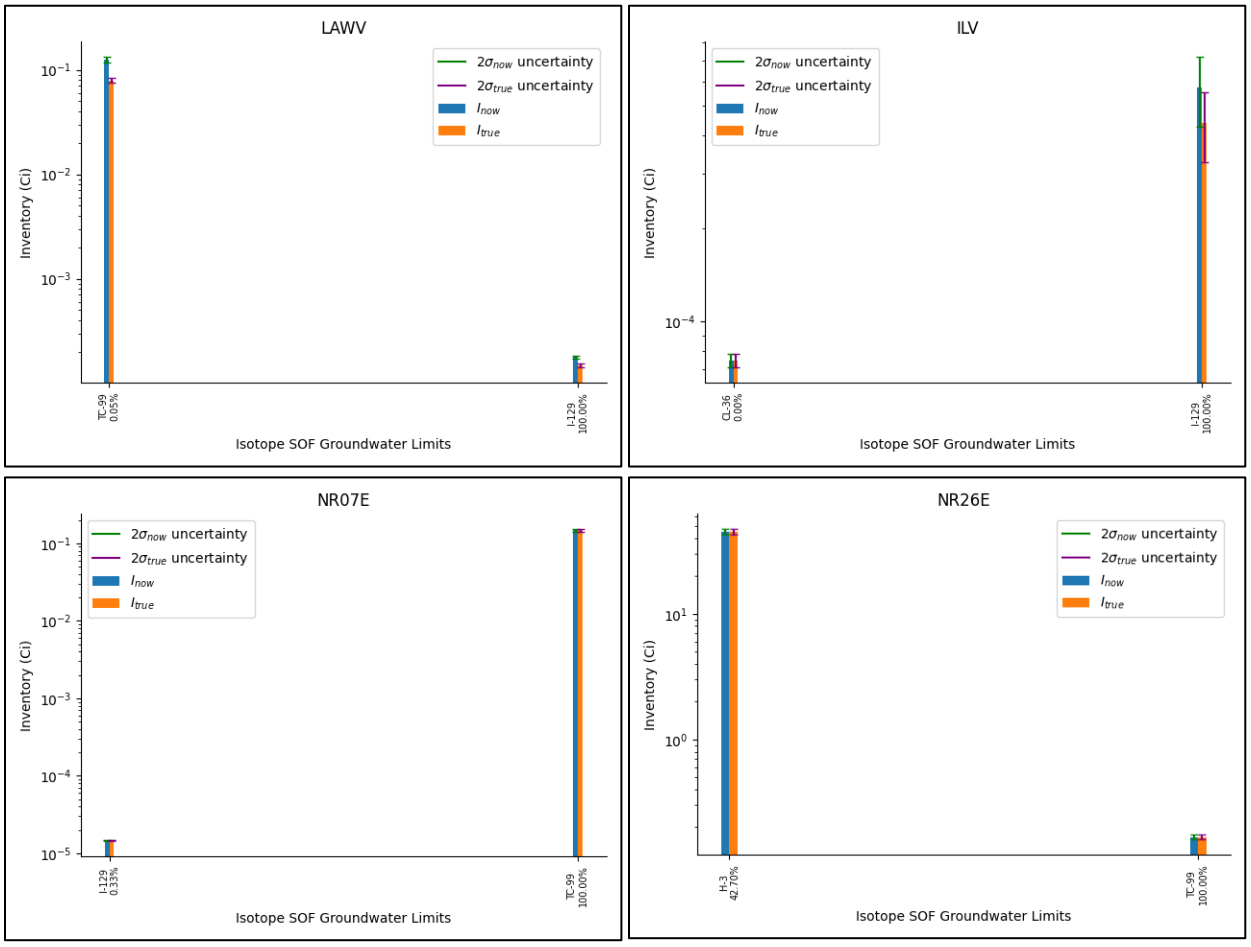


**Figure B-7. Low-Activity Waste Vault, Intermediate-Level Vault, and Naval Reactor Component Disposal Area Activities and Uncertainties**

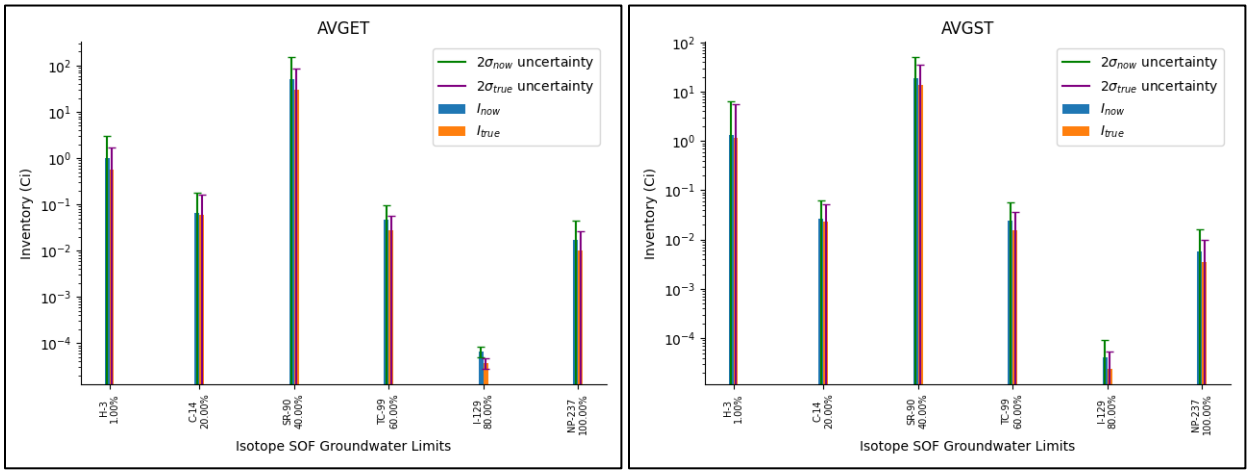


**Figure B-8. Average Engineered Trench (left) and Slit Trench (right) Activities and Uncertainties for Closure Analysis**