Development of Radiological Inventory Distributions for the West Valley Probabilistic Performance Assessment (PPA) Model

NEPTUNE AND COMPANY

These slides present work in progress. The material and content are subject to change.

Purpose

- Define inventory to be used as input to the West Valley PPA Model from existing data sources
  - Radiological and chemical wastes, other contamination, and residuals
- Structured parallel to the PPA Model
  - Waste Management Areas (12) – each may have zero, one, or multiple Facilities; zero to many Decision Units per WMA
  - Facility (34) – a modeling construct; each has its own contaminant transport and risk exposure calculations
  - Decision Unit (426) – each Decision Unit (DU) needs to have an inventory assigned
    - Inventory is assigned at the WMA and/or Facility level for those having no DUs; additional residual inventory is assigned to each Facility

WMAs

WMA 11 and 12 not shown.

Facilities

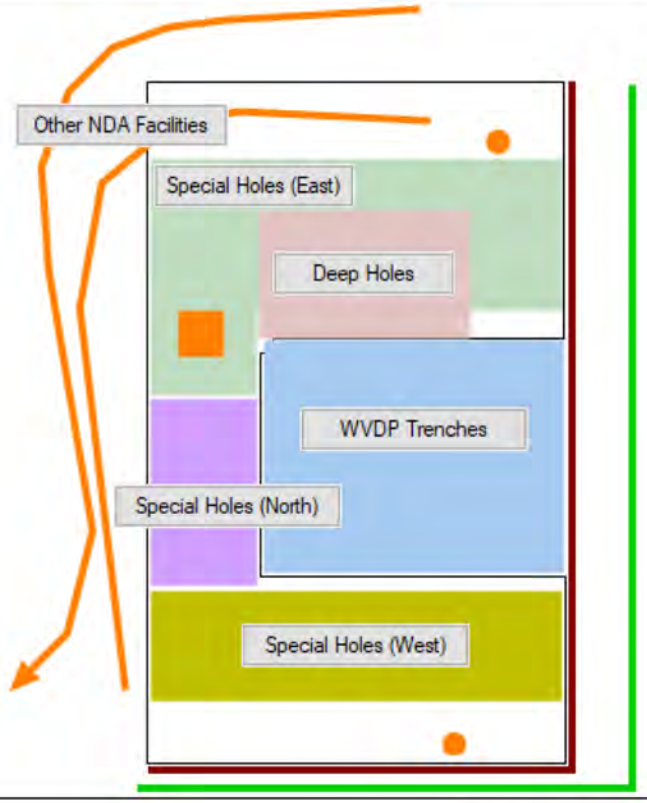
Selection of WMA 7 Closure Options

Instructions
- Select the closure option to be modeled using the drop-down box.
- For the Close-in-Place option, additional engineered controls may be selected, and individual Decision Units may be

Select closure options:

Close-In-Place (with engineered cover)

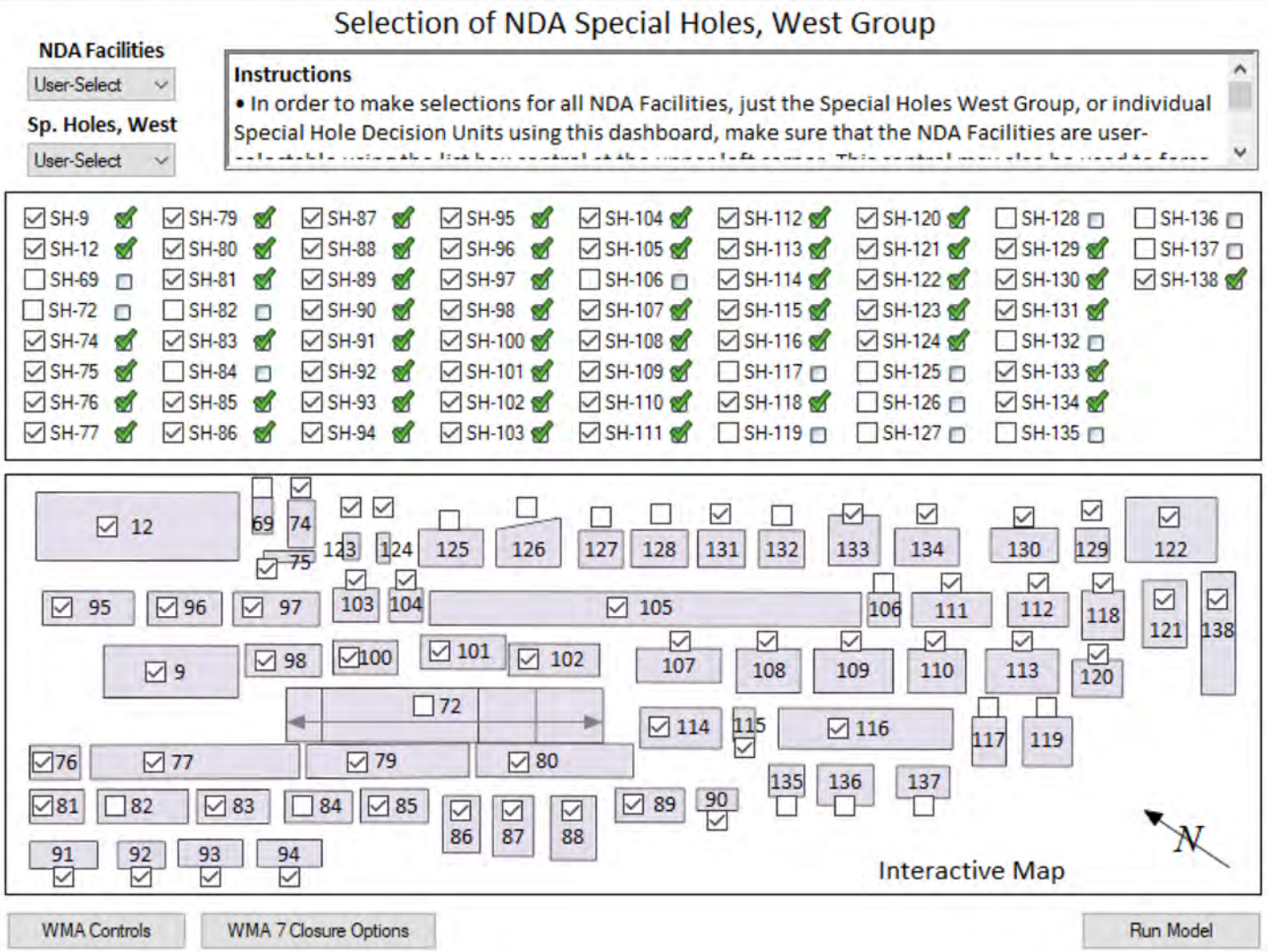
- No Action: All contamination remains in place. The existing geomembrane coverand slurry wall remain in place.
  - existing slurry wall
- Close-in-Place: Some or all contamination remains in place, as selected on the NDA Decision Units dashboards. The Close-in-Place cover would be constructed, and additional engineered controls may also be selected.
  - ☑ Upgradient French drain
  - ☐ Grout Interceptor Trench
  - ☑ Grout Decision Units > 6 m (20 ft)
- Complete removal: All NDA Holes, Trenches, and associated contamination are removed from WMA 7, and are replaced with clean backfill and a simple soil cover. Residual contamination remains in the ULT below the excavation.



WMA Controls

Run Model

Decision Units

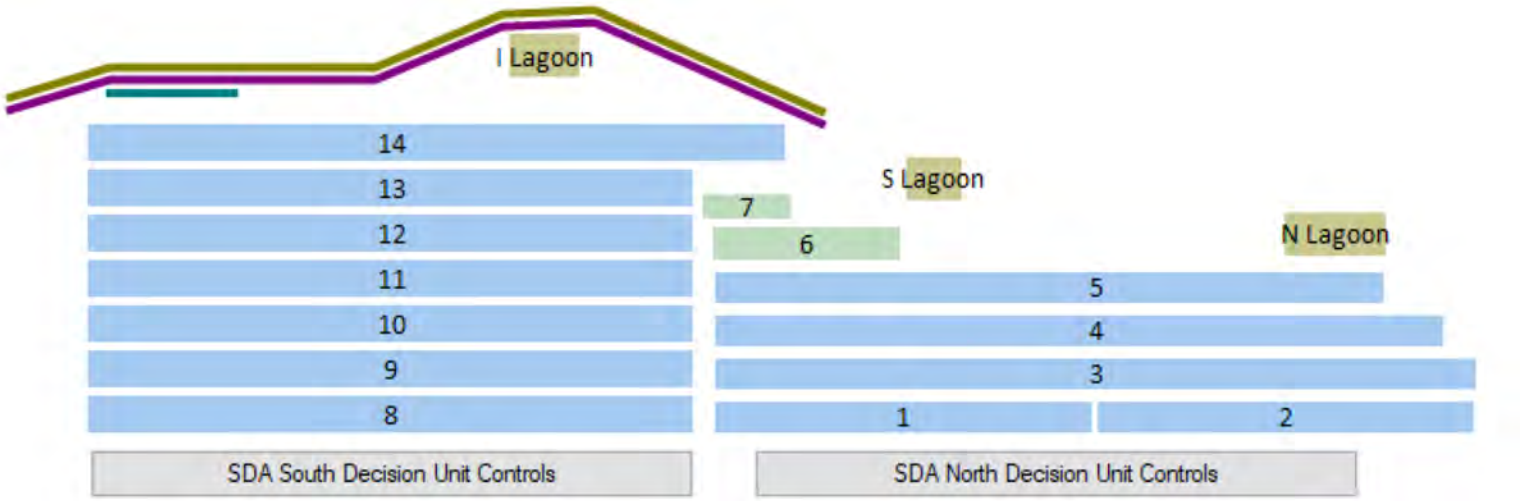


Distribution Development

- Probability distributions have been developed for DUs for the following categories
- SDA disposed waste (WMA 8)
- NDA disposed waste (WMA 7)
- Waste Tank Farm (WTF – WMA 3)
- Residual Inventory (all other WMAs except 11 and 12)

SDA Disposed Waste – WMA 8

We developed a probability distribution for the mass of each radionuclide in each 50 foot trench section at the time of disposal.



Methods Overview

Activity of waste in each SDA shipment at time of disposal

- *apply one of 33 waste profiles (URS 2002*)*
- *include add-in radionuclides*

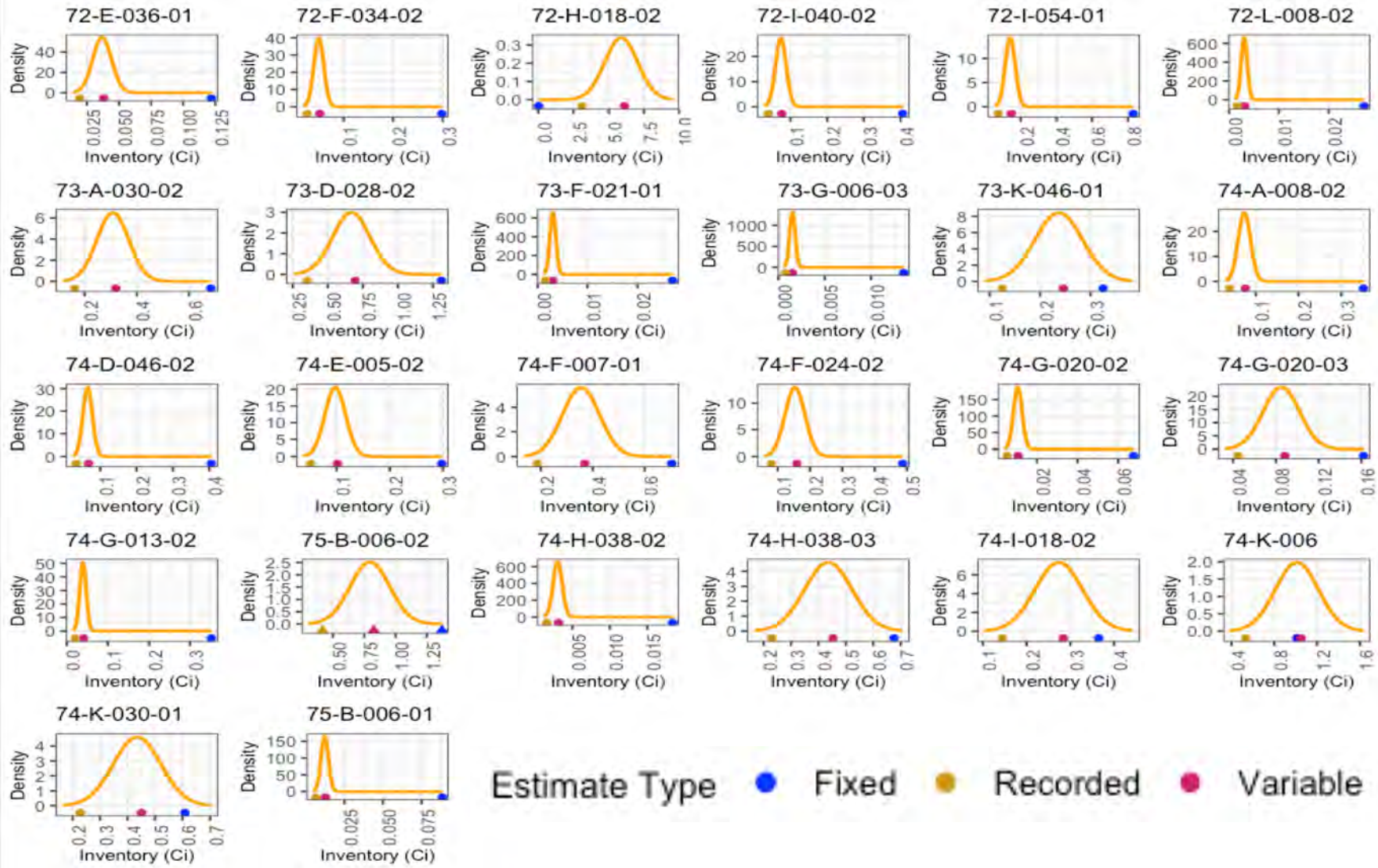
Radionuclide inventory of each SDA shipment

- *sum radionuclide inventories over all shipments in each trench section*

Radionuclide inventory in a trench section at time of disposal

**URS, 2002. SDA Radiological Characterization Report, prepared for West Valley Nuclear Services Company Inc., URS Corporation, Orchard Park NY, 2002*

Activity Distributions for SDA Shipments



Radionuclide Fractions

Table 2-8. Isotope Production Waste Profiles

	Secondary Profile				
	Large Tritium	Small Tritium	Reactor Targets	Reactor Trash	Sealed Sources
Type	Active	Active	Active	Active	Dummy
Density [a]	1.03	0.88	1.70	0.60	2.00
Nuclide	Concentration (Ci/m^3)				
H-3	2.45E+02	3.58E+02	1.09E-02	1.51E-06	n/a
C-14	2.15E-01	0	1.17E-05	1.62E-09	n/a
S-35	1.06E+00	0	0	0	n/a
Cr-51	0	0	3.64E+00	0	n/a
Mn-54	0	0	2.63E+00	0	n/a
Fe-55	0	0	1.60E+01	0	n/a
Fe-59	0	0	5.05E-01	0	n/a
Co-58	0	0	6.06E+00	0	n/a
Co-60	0	0	0	5.63E-04	n/a
Ni-63	0	0	2.46E-01	0	n/a
Sr-89	0	0	1.97E+01	0	n/a
Sr-90	0	0	2.35E+00	2.70E-04	n/a
Y-91	0	0	3.11E+01	0	n/a
Zr-93	0	0	0	7.88E-04	n/a
Zr-95	0	0	3.08E+01	1.58E-03	n/a
Nb-95	0	0	5.54E+01	4.25E-03	n/a
Mo-99	0	0	0	4.17E-04	n/a
Tc-99	0	0	8.48E-05	1.18E-08	n/a
Ru-103	0	0	5.52E+00	1.19E-03	n/a
Ru-106	0	0	2.42E+00	0	n/a
Ag-110m	0	0	0	6.03E-03	n/a
In-113m	0	0	0	7.12E-04	n/a
Sn-113	0	0	0	7.12E-04	n/a
Sb-124	0	0	0	7.38E-05	n/a
I-125	0	0	0	4.04E-02	n/a
I-129	0	0	7.04E-07	9.77E-11	n/a
Cs-135	0	0	8.48E-05	1.18E-08	n/a
Cs-137	0	0	1.54E+00	2.70E-04	n/a
Ba-140	0	0	0	3.42E-03	n/a
La-140	0	0	0	4.29E-03	n/a
Ce-141	0	0	7.44E+00	0	n/a
Ce-144	0	0	5.09E+01	0	n/a
Pm-147	0	0	8.70E+00	0	n/a
U-235	0	0	4.70E-04	3.00E-05	n/a
U-238	0	0	5.48E-06	1.67E-07	n/a
Np-237	0	0	1.03E-13	3.31E-17	n/a
Pu-238	0	0	3.81E-05	1.22E-08	n/a
Pu-239	0	0	1.07E-05	3.44E-09	n/a
Pu-241	0	0	1.37E-03	4.40E-07	n/a
Pu-242	0	0	1.85E-08	5.94E-12	n/a
Am-241	0	0	2.12E-06	6.80E-10	n/a
Am-243	0	0	2.43E-07	7.77E-11	n/a
Cm-242	0	0	2.27E-04	7.29E-08	n/a
Cm-243	0	0	5.57E-08	1.79E-11	n/a
Cm-244	0	0	3.20E-05	1.03E-08	n/a
Total	2.47E+02	3.58E+02	2.45E+02	6.50E-02	n/a

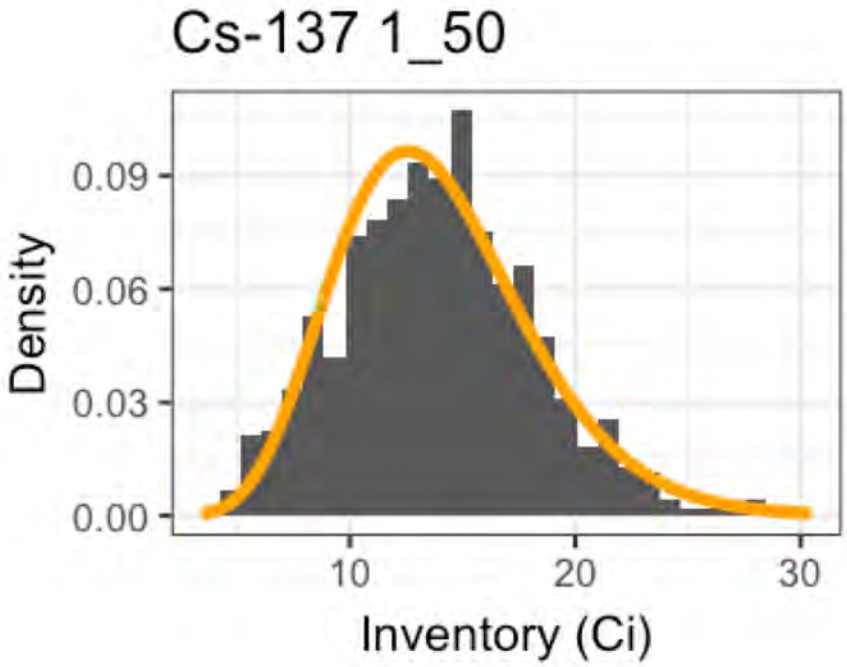
[a] Units are g/cm^3.

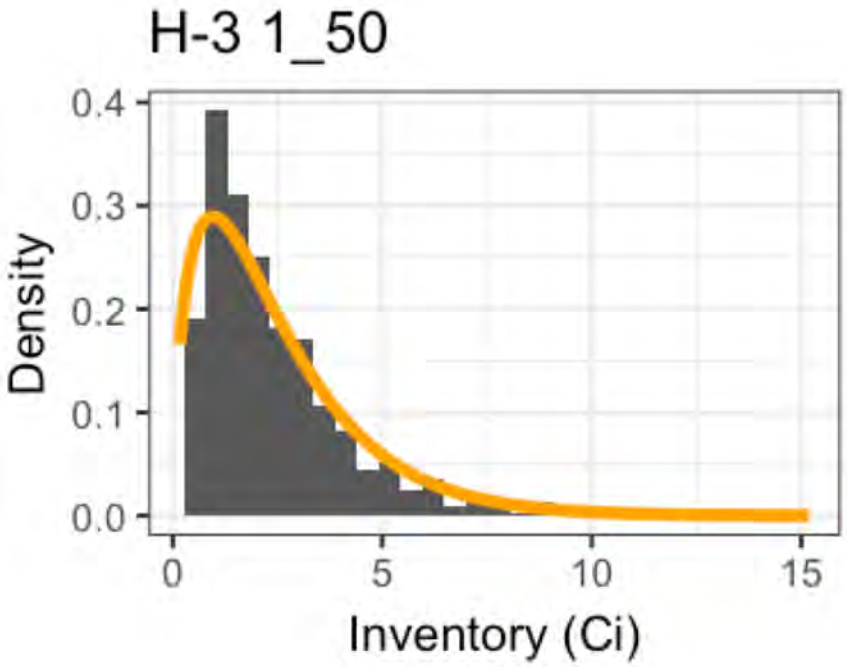
Example

SHIPMENT NO.	CUSTOMER	DATE RECD.	H&S REP.	CUBIC FEET	DATE BURIED	LOCATION BURIED	CONTAINER TYPE	CURIES PER LOAD	SNM, DECOS SPEC. HAND
75-C-021	Hittman Nuclear & Dev. Corp.	3/10/75	GB.	425 00	3/11/75	14-M-560'	concrete vault	4.596	Spec. Hand.
75-C-022	Hittman Nuclear & Dev. Corp	3/10/75	GB.	425 00	3/11/75	14-M-560'	concrete vault	4.956	Spec. Hand.
75-C-023	Hittman Nuclear & Dev. Corp	3/10/75	GB.	425 00	3/11/75	14-M-560'	concrete vault	4.956	Spec. Hand.
75-C-024	Hittman Nuclear & Dev. Corp	3/11/75	GB.	425 00	3/11/75	14-M-560'	concrete vault	36.000	Spec. Hand.
75-C-025	Hittman Nuclear & Dev. Corp	3/11/75	GB	425 00	3/11/75	14-M-560'	concrete vault	3.600	Spec. Hand.
75-C-026	Hittman Nuclear & Dev. Corp.	3/11/75	GB	425 00	3/11/75	14-M-560'	concrete vault	4.956	Spec. Hand
75-C-027	Hittman Nuclear & Dev. Corp	3/11/75	GB.	467 65	3/11/75	14-M-535'	paper liners & drums	.397	

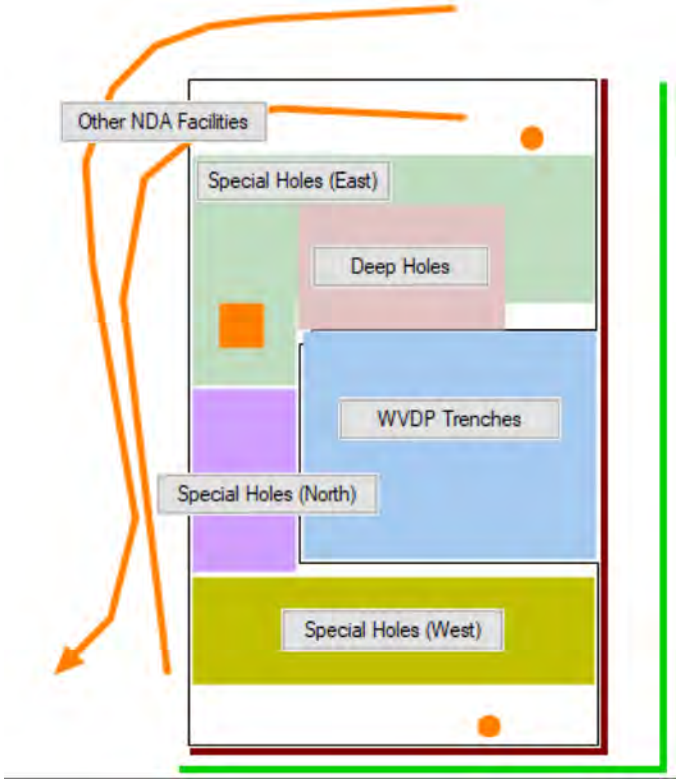
SHIPNUM	ACCT	SOURCE	TRENCH	DIST_SECT	VOLUME	WP	DOSRAT_MR	REC_MCURIE
75-C-021	HITTMAN	Millstone Power Station	14	550	425	BWR	5	4596
75-C-022	HITTMAN	Millstone Power Station	14	550	425	BWR	3	4956
75-C-023	HITTMAN	Millstone Power Station	14	550	425	BWR	25	4956
75-C-024	HITTMAN	Millstone Power Station	14	550	425	BWR	5	3600
75-C-025	HITTMAN	Millstone Power Station	14	550	425	BWR	5	3600
75-C-026	HITTMAN	Millstone Power Station	14	550	425	BWR	10	4956
75-C-027	HITTMAN	Nine Mile Point	14	500	467.65	BWR	2000	7316

Ex: Trench 1, Segment 50-100





NDA Disposed Waste – WMA 7

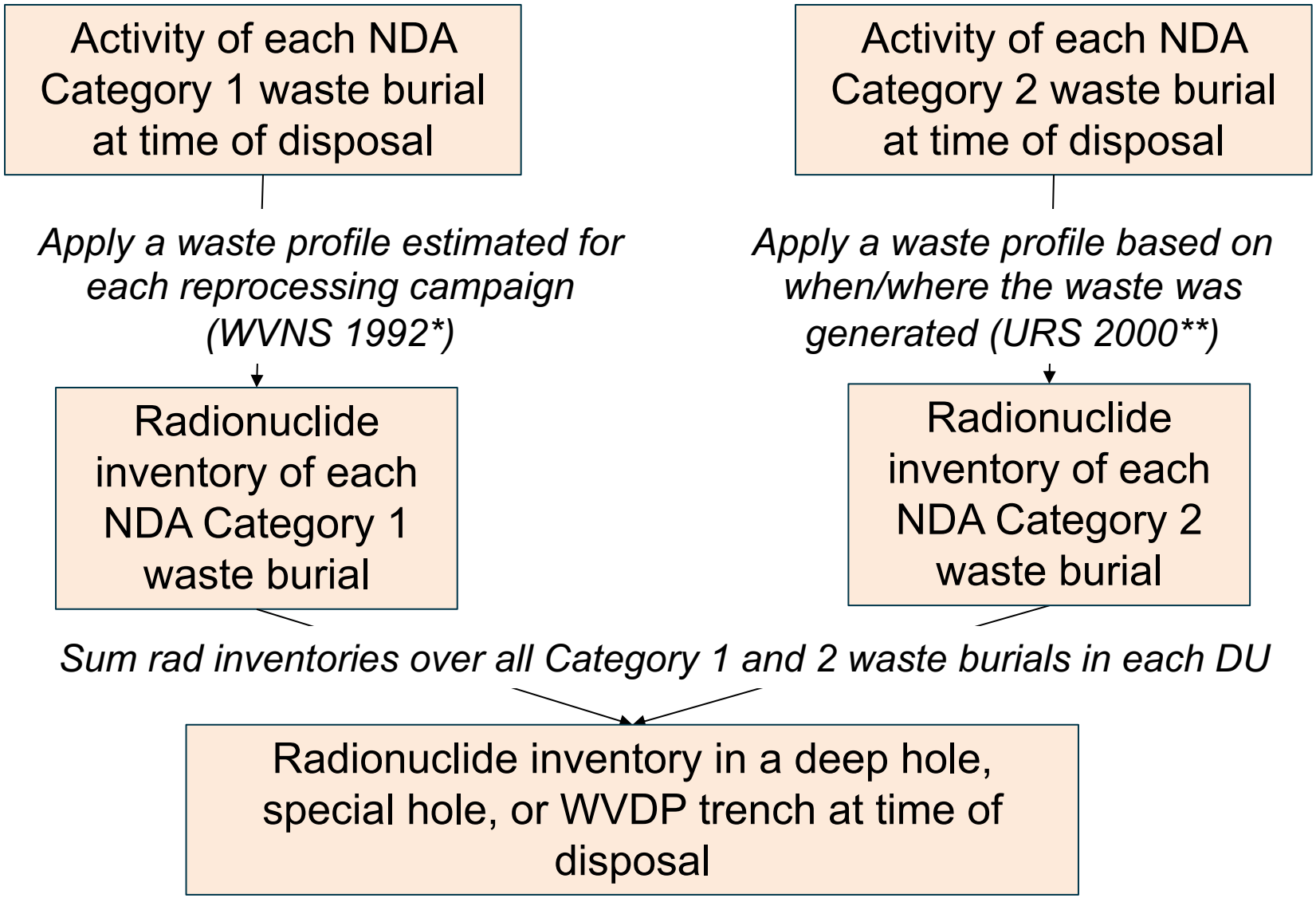


We developed a probability distribution for the mass of each radionuclide in each deep hole, special hole, or WVDP Trench at the time of disposal.

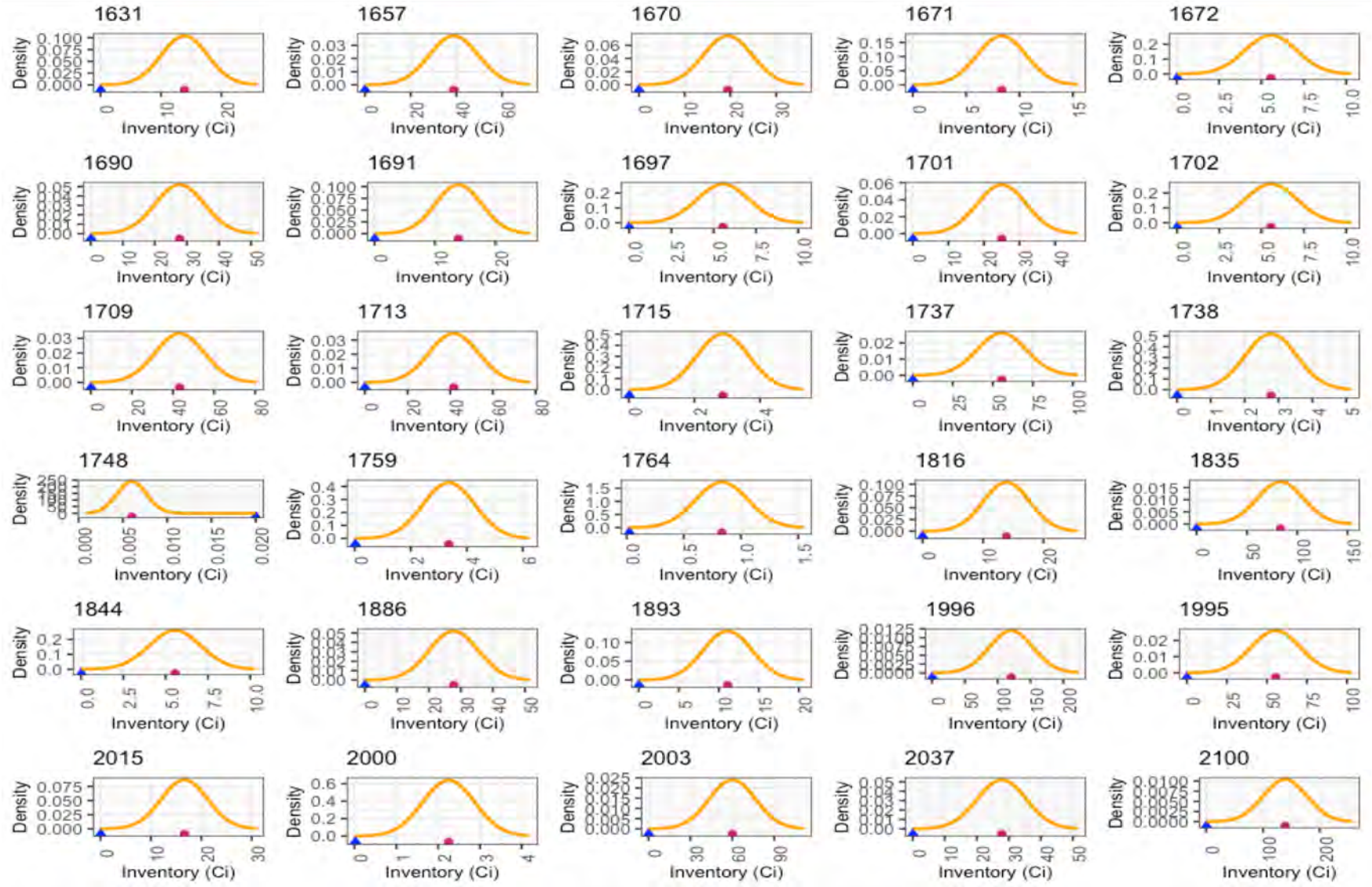
NDA Waste Types

Category 1 Waste	Category 2 Waste
• Irradiated fuel hulls • Irradiated metals from fuel assemblies	• Debris • Failed or discarded equipment • Filters • General • Ion exchange and sludge • Compact trash • Soil • Degraded extractant

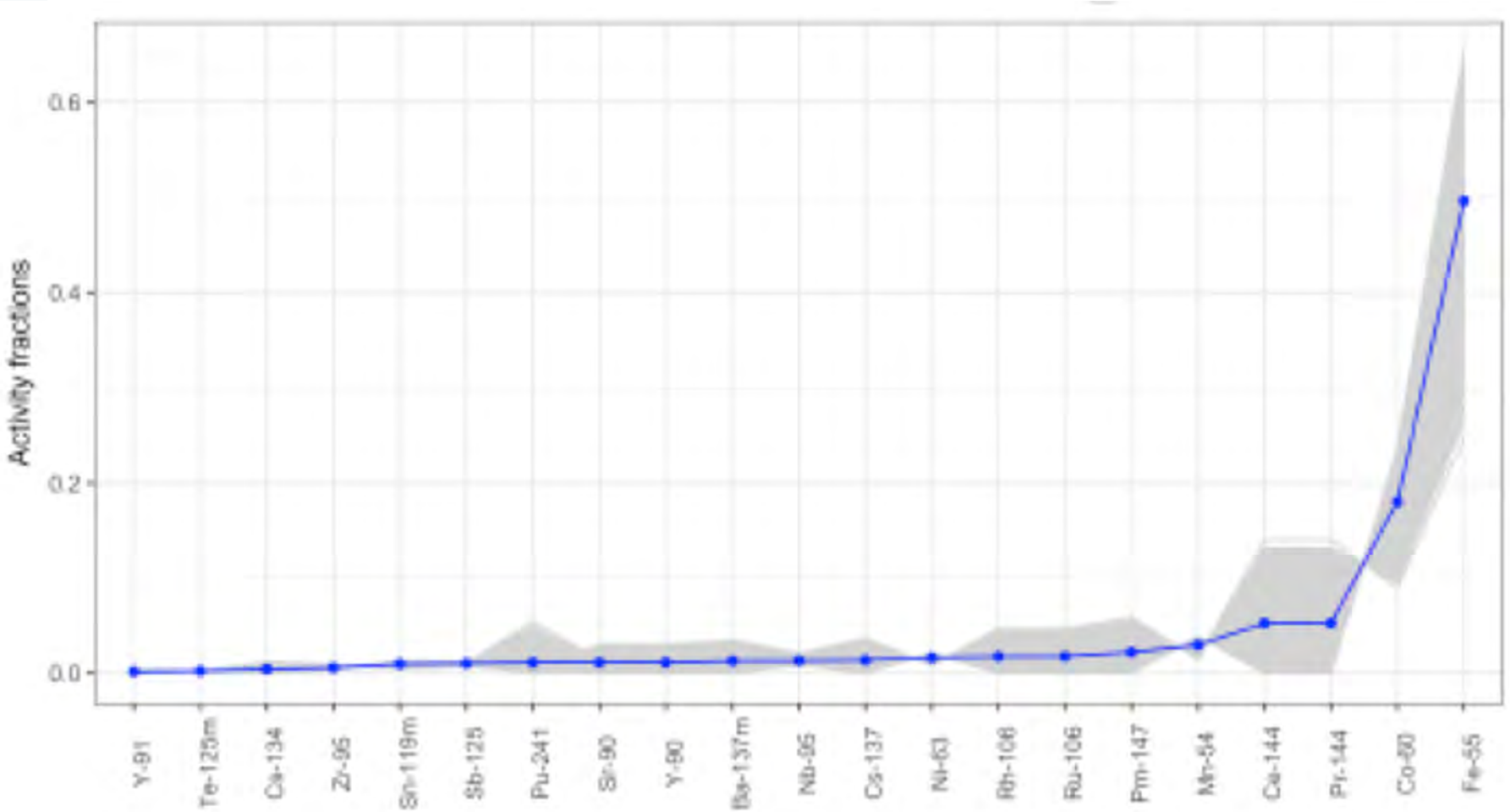
Methods Overview



Activity Distribution by Burial Record



Radionuclide Composition

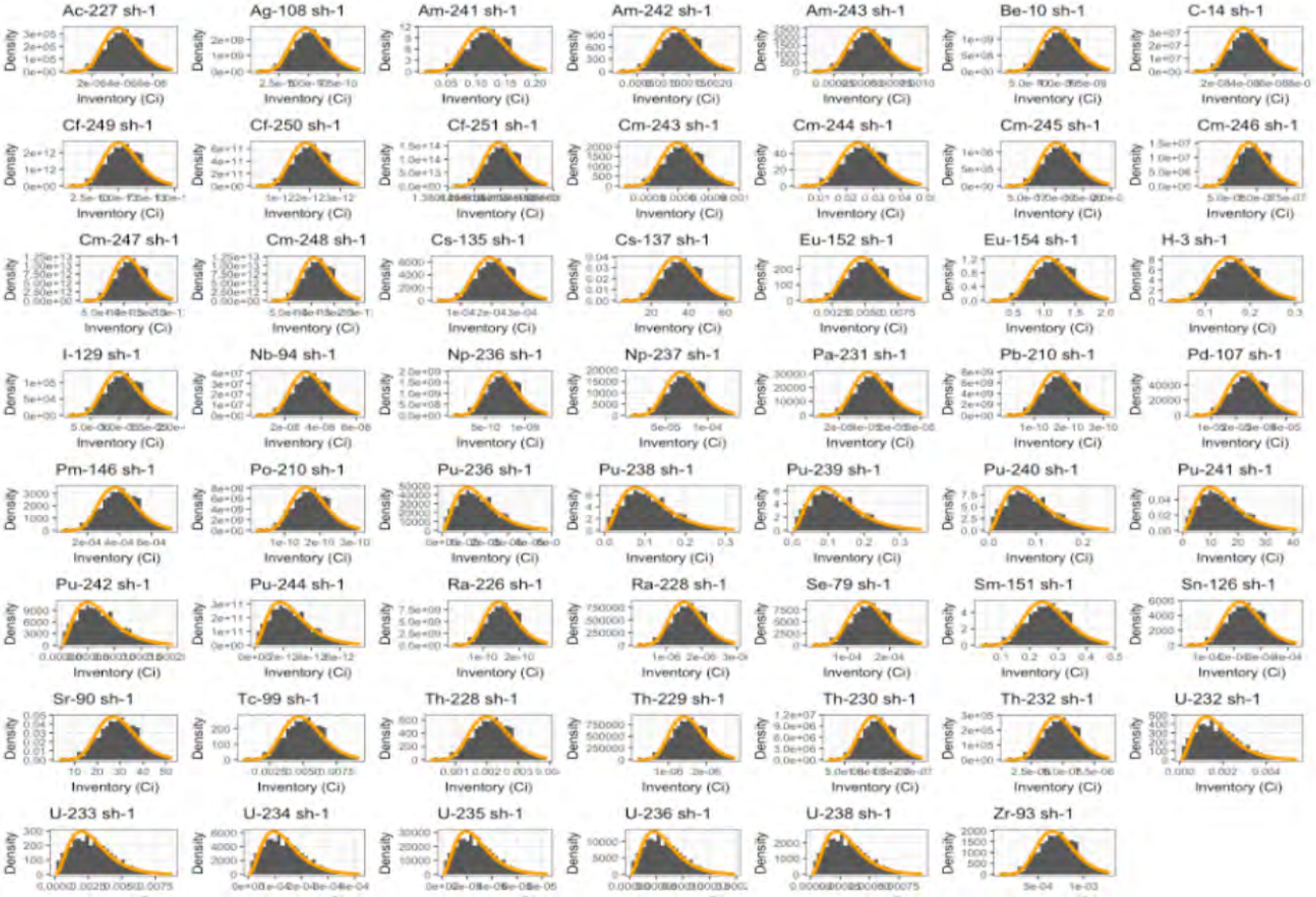


Ex: Cat 1 Waste

Number	Date Shipped	Maximum Radiation Reading R/HR	Burial Location	Drum Number Hulls Only	Cubic Feet Per Ship.		Type Activity	Contents	Steel	Wood	Concrete	Cardboard
8-001H	7-26-68	1500.0	4-6		12	0.3	Co-60	Hulls	18.000			
8-002H	7-29-68	1500.0	4-6		12	0.3	Co-60	Hulls	18.000			
8-003H	7-29-68	3.0	4-6		15	00	MFP	Filter	.	.024		
8-004H	7-30-68	1000.0	4-6		12	0.3	Co-60	Hulls	12.000			
8-005H	7-31-68	1500.0	4-6		12	0.3	Co-60	Hulls	18.000			
8-006H	8-1-68	100.0	4-6		12	0.3	Co-60	Cont+DMC Waste	1.200			
8-007H	8-2-68	1500.0	4-6		12	03	Co-60	Hulls	18.000			
8-008H	8-5-68	1500.0	4-6		12	0.3	Co-60	Hulls	18.000			
8-009H	8-6-68	1500.0	4-6		12	0.3	Co-60	Hulls	18.000			

ID	SHIPNO	BURIAL_D	ITEMS	HOLE	TYPE	VOLUMI	REC_DO	REC_CU	WASTE_CAT1	CampW
1265	68-08-001h	7/26/68	1	4-6	d	4.01	1500	6	hull	10
1266	68-08-001h	7/26/68	1	4-6	d	4.01	1500	6	hull	10
1267	68-08-001h	7/26/68	1	4-6	d	4.01	1500	6	hull	10
1269	68-08-002h	7/29/68	1	4-6	d	4.01	1500	6	hull	10
1270	68-08-002h	7/29/68	1	4-6	d	4.01	1500	6	hull	10
1271	68-08-002h	7/29/68	1	4-6	d	4.01	1500	6	hull	10

SH-1 Total Inventory

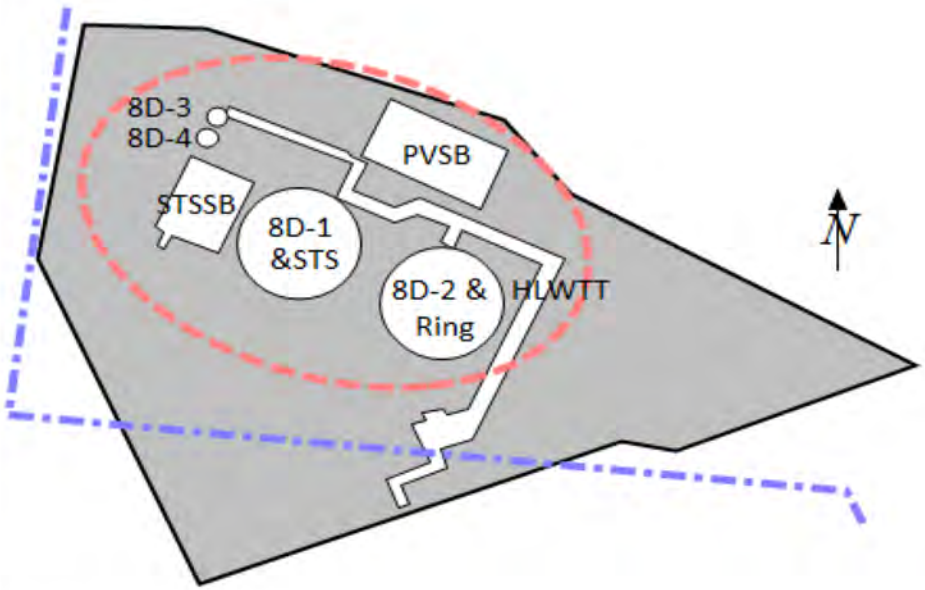


WMA 3 – Waste Tank Farm

Selection of WMA 3 Closure Options

Instructions
- Select the closure option to be modeled using the drop-down box.
- For the Close-in-Place option, additional engineered controls may be selected, and individual Decision Units may be included (remain in place) or excluded (excavated) by using the WMA 3 Decision Units dashboard.

Waste Management Area 3
Waste Tank Farm
Closure Options



Select closure options:

Close-In-Place (with engineered cover)

- No Action: All contamination remains in place. No cover is constructed, and no additional engineered controls are added.

- Close-in-Place: Some or all contamination remains in place, as selected on the WMA 3 Decision Units dashboard. The Close-in-Place cover would be constructed, and additional engineered controls may also be selected.

Select WMA 3 Decision Units

- ☑ ✔ Circumferential slurry wall
- ☑ ✔ Upgradient barrier wall
- ☑ ✔ Grout all HLW tanks

- Complete removal: All contamination and structures are removed from WMA 3, and are replaced with clean backfill and a simple soil cover. Residual contamination remains in the ULT below the excavation.

WMA Controls

Run Model

WTF Historical Data

- Historical data were used from:
  - ECS 2016: Task 1.1: Technical Memorandum—Comparison of Previous Inventories, Revision 1
  - WVNS 2005: West Valley Demonstration Project, Residual Radionuclide Inventory Estimate for the Waste Tank Farm, Supplemental Report
  - WVDP 2012: Tank 8D-4 Characterization Information Generation Evolution—2012, WVDP-554
  - WVES 2008. Transmittal of Estimated Radiological and RCRA Hazardous Inventory in Tanks 8D-3 and 8D-4

WTF Decision Units

- Probability distributions are developed for radionuclide activity (Ci) in the following 6 DUs:
  - Tank 8D-1 Supernatant Treatment System (STS)
  - Tank 8D-1 non-STS
  - Tank 8D-2 excluding the Ring
  - Tank 8D-2 Ring
  - Tank 8D-3
  - Tank 8D-4

Tank 8D-1 – Best Estimate (WVDP 2005)

Table 37: Tank 8D-1 Estimated Residual Activity (Ci) — Best Estimate Case

Radionuclide	Liquid	Sludge	Zeolite	Fixed	STS IX	STS Equip	Total
C-14	1.7e-03	4.0e-03		1.2e-04		7.6e-03	1.3e-02
Sr-90	1.3e+01	4.1e+01	2.3e+02	1.8e+02	1.2e+02	5.8e+01	6.5e+02
Tc-99	7.3e-01	4.7e-01		2.5e-02		[illegible]	[illegible]
I-129	9.2e-04	5.9e-04		3.2e-05		4.1e-03	[illegible]
Cs-137	5.1e+02	4.5e+02	1.5e+05	4.1e+03	7.8e+04	2.3e+03	[illegible]
U-232	2.3e-02	1.7e-02		9.5e-02		[illegible]	[illegible]
U-233	1.0e-02	7.2e-03		4.2e-02		4.6e-02	1.1e-01
U-234	3.9e-03	2.8e-03		1.6e-02		1.8e-02	4.0e-02
U-235	1.2e-04	9.9e-05		5.2e-04		[illegible]	[illegible]
U-238	1.1e-03	8.8e-04		4.7e-03		4.8e-03	[illegible]
Np-237	1.1e-03	1.2e-03		2.9e-03		[illegible]	[illegible]
Pu-238	2.4e-02	8.6e-02	3.1e-01	9.9e-01	1.6e-01	1.1e-01	[illegible]
Pu-239	4.2e-03	2.2e-02	8.6e-02	2.7e-01	[illegible]	[illegible]	4.4e-01
Pu-240	3.0e-03	1.6e-02	6.1e-02	1.9e-01	[illegible]	[illegible]	[illegible]
Pu-241	1.2e-01	5.0e-01	2.7e+00	7.8e+00	[illegible]	[illegible]	[illegible]
Am-241	1.2e-03	8.2e-02		2.3e-02		5.4e-03	1.1e-01
Cm-243	3.3e-06	2.3e-04		4.9e-05		1.5e-05	2.9e-04
Cm-244	1.5e-04	1.0e-02		2.2e-03		6.8e-04	1.3e-02

Tank 8D-1 STS

Tank 8D-1 STS

Includes STS

Tank 8D-1 – Conservative Case (WVDP 2005)

Table 38: Tank 8D-1 Estimated Residual Activity (Ci) — Conservative Case

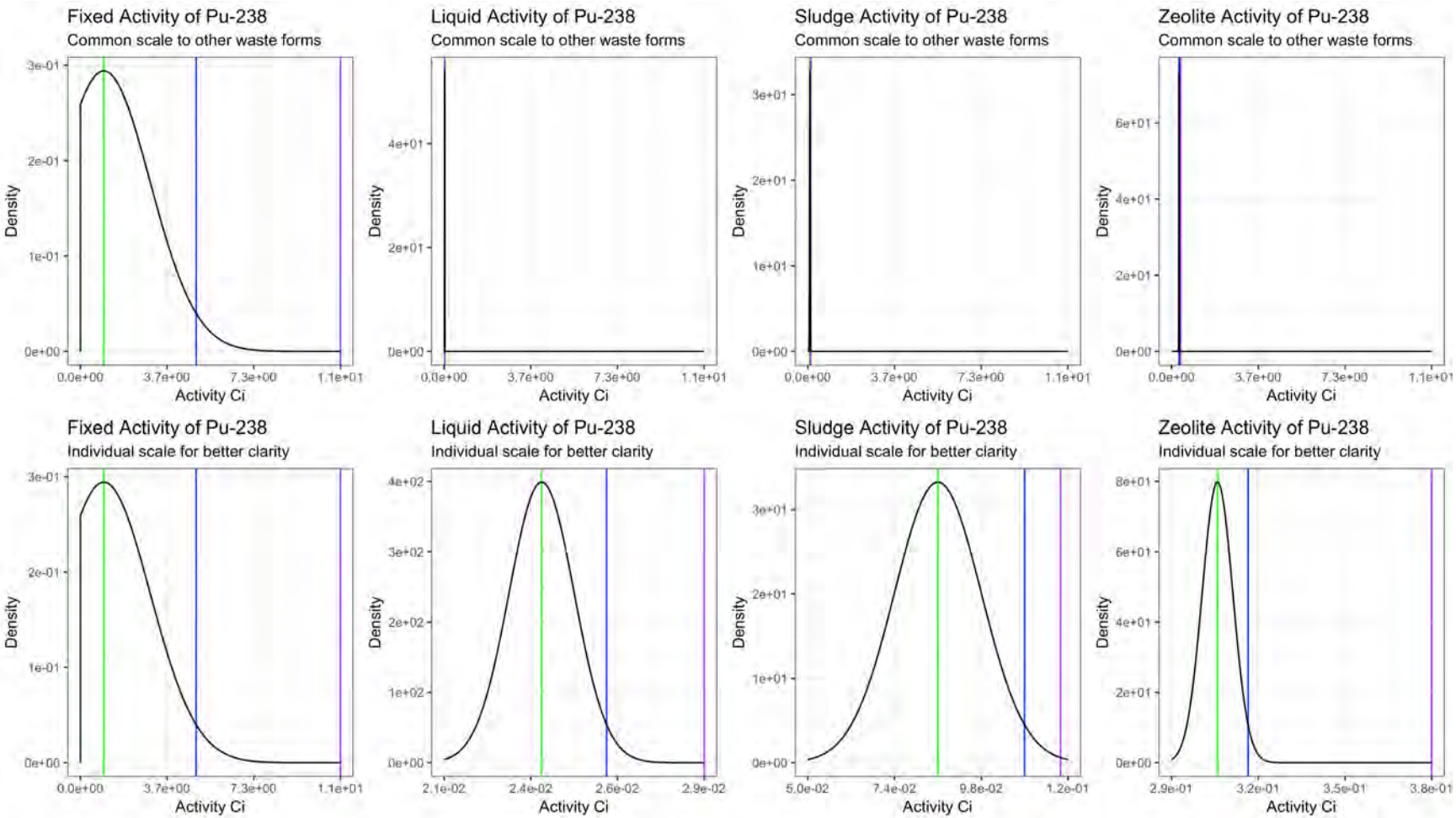
Radionuclide	Liquid	Sludge	Zeolite	Fixed	STS IX	STS Equip	Total
C-14	2.6e-03	5.2e-03		1.2e-03		1.4e-02	2.0e-02
Sr-90	1.3e+01	5.8e+01	2.4e+02	1.8e+03	1.5e+02	7.1e+01	2.3e+03
Tc-99	7.5e-01	5.4e-01		2.1e-01		4.1e+00	5.4e+00
I-129	9.5e-04	6.8e-04		2.6e-04		5.2e-03	6.8e-03
Cs-137	5.2e+02	4.6e+02	1.5e+05	5.5e+03	9.4e+04	2.8e+03	2.5e+05
U-232	2.3e-02	1.7e-02		4.5e-01		4.3e-01	9.0e-01
U-233	1.0e-02	7.2e-03		2.0e-01		5.7e-02	2.6e-01
U-234	4.0e-03	2.8e-03		7.7e-02		2.2e-02	1.0e-01
U-235	1.2e-04	1.2e-04		2.6e-03		6.8e-04	3.4e-03
U-238	1.1e-03	1.1e-03		2.4e-02		6.1e-03	3.1e-02
Np-237	1.2e-03	1.4e-03		1.5e-02		6.4e-03	2.3e-02
Pu-238	2.6e-02	1.1e-01	3.2e-01	4.9e+00	1.9e-01	1.4e-01	5.6e+00
Pu-239	4.7e-03	3.1e-02	8.8e-02	1.3e+00	5.4e-02	2.5e-02	1.5e+00
Pu-240	3.3e-03	2.2e-02	6.3e-02	9.5e-01	3.8e-02	1.8e-02	1.1e+00
Pu-241	1.3e-01	6.5e-01	2.7e+00	3.8e+01	1.7e+00	7.3e-01	4.4e+01
Am-241	1.4e-03	1.3e-01		2.9e-01		7.8e-03	3.8e-01
Cm-243	4.1e-06	4.4e-04		8.4e-04		2.3e-05	1.1e-03
Cm-244	1.9e-04	2.0e-02		3.8e-02		1.0e-03	5.0e-02

Tank 8D-1 STS

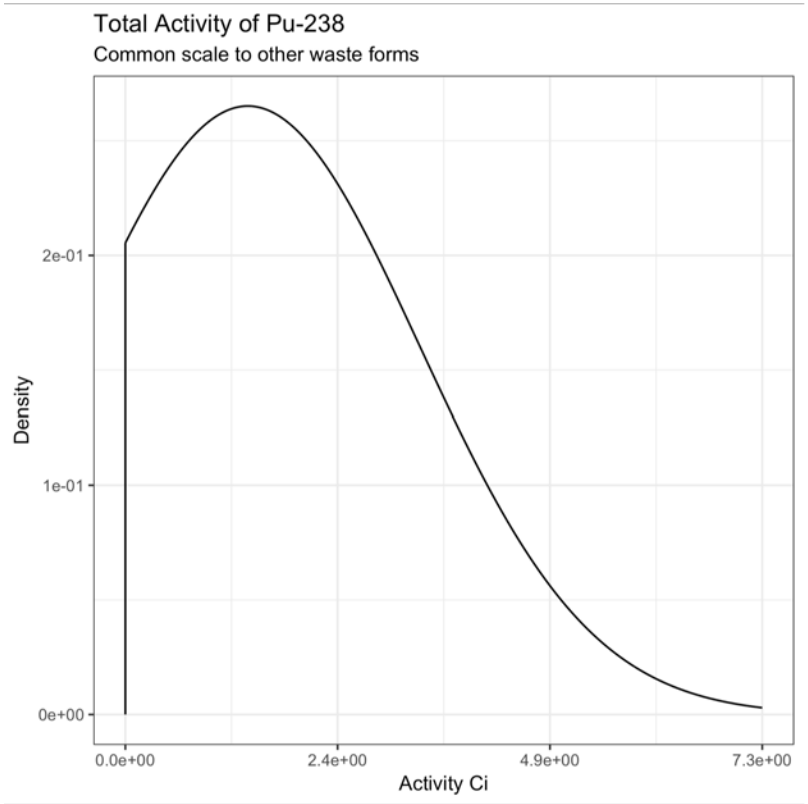
Tank 8D-1 STS

Includes STS

Distributions of Pu-238 in Tank 8D-1 non-STS



Distribution of Total Pu-238 in Tank 8D-1 non-STS



Percentile	Ci
75th	2.7×10^0
90th	3.9×10^0
95th	4.7×10^0
99th	6.0×10^0
99.9th	$7.5^b \times 10^0$

Truncated N(Mean = 1.41×10^0, SE = 1.97×10^0)

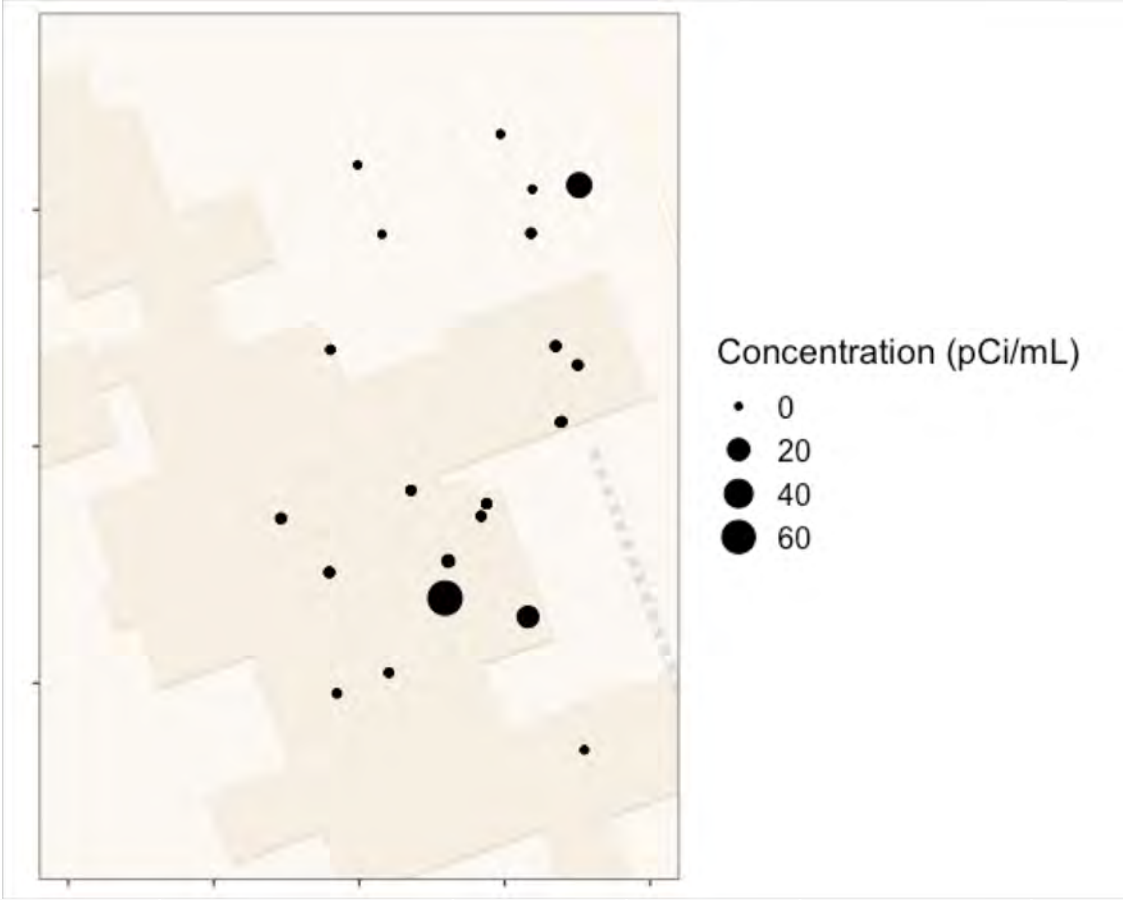
Residual Inventory

WMA 11 and 12 not shown.

Residual Inventory Distribution Development

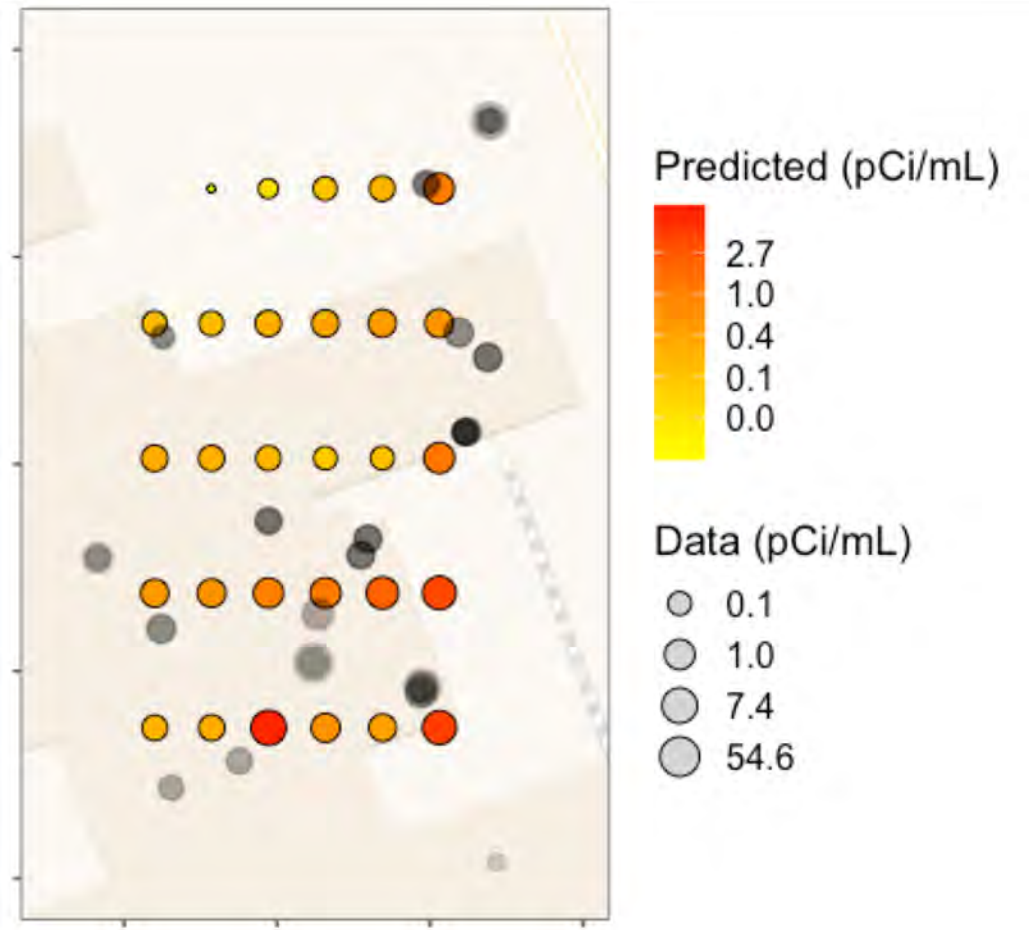
1. Subset data into DUs, and depth intervals used in the PPA model (e.g., different stratigraphic units)
2. Examine the data available for each radionuclide in each area, and choose the matrix (soil or groundwater) with the most data
3. Create a grid of points across the area of interest
4. Use spatial statistical methods to estimate values at each spatial location in the grid
5. Develop a distribution of the concentration across the interpolated points at the appropriate spatial scale

Example: Tritium Data



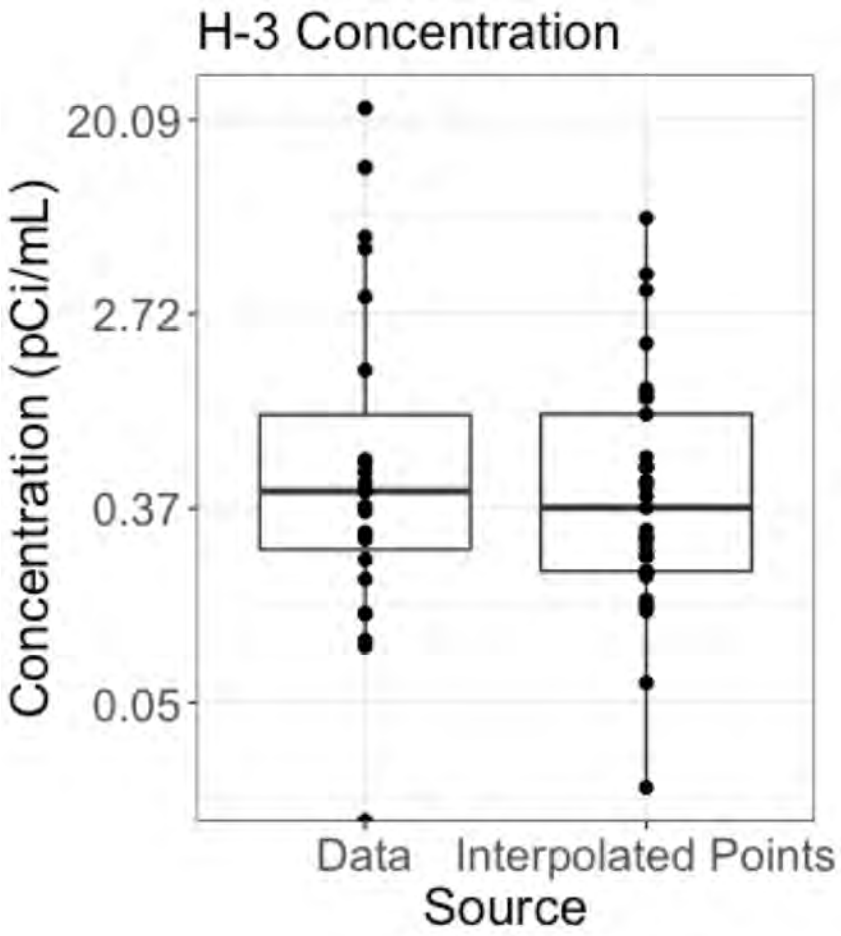
Matrix	Total Measurements	Locations	Years	Range of Values	Units
Groundwater	62	23	1994, 1998	0 - 64.48	pCi/mL
Soil	20	6	1998	0.361 - 43.4	pCi/g

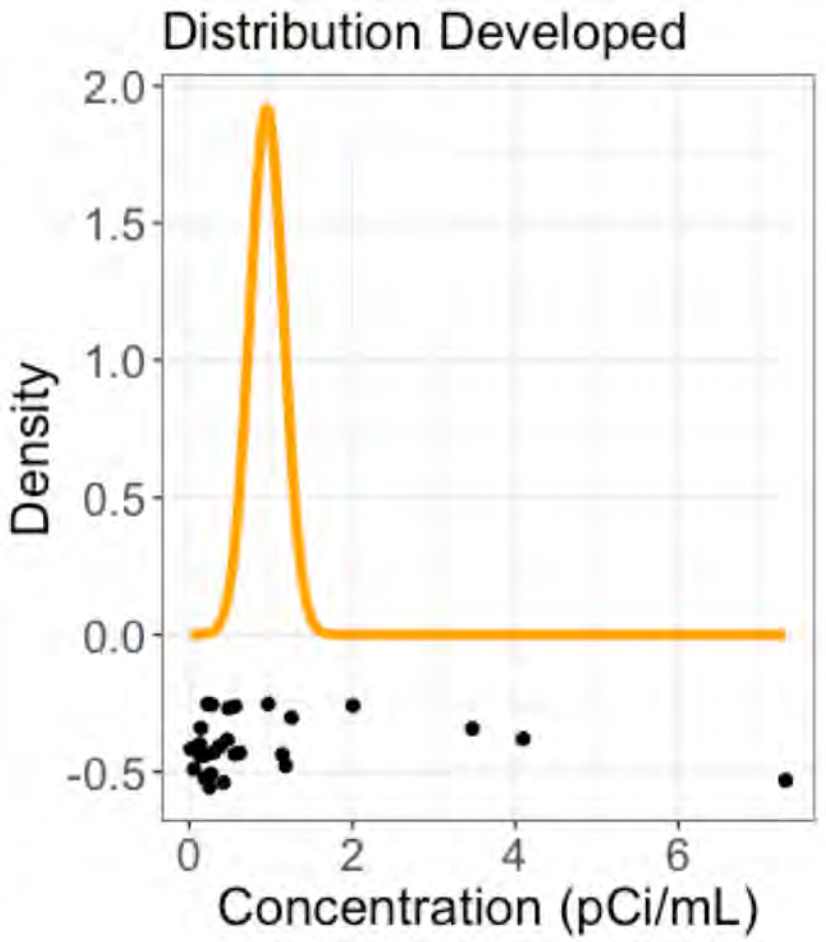
Example: Tritium Predicted Values



High predicted values should occur around higher measured concentrations

Example: Tritium Distribution





Conclusion

1. Existing inventory estimates have been used as the basis for developing distributions
2. Distributions capture uncertainty for application in probabilistic performance assessment model
3. Inventory distributions have been developed for all 426 Decision Units, with up to 66 radionuclides in each
4. Spatial statistics have been used for residual inventory distribution development