West Valley Demonstration Project

DOE Briefing on the Phase 1 Decommissioning Plan

Probabilistic Uncertainty Analysis and Dose Modeling Update

DOE-NRC Meeting

September 2, 2009

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for the U.S. Department of Energy

Note that the last three slides provide definitions of key technical terms and acronyms.

Objectives

(1) Describe changes to certain deterministic conceptual model input parameters and the resulting deterministic DCGL changes

(2) Provide details on the probabilistic uncertainty analysis as discussed at the 6/15/09 DOE-NRC meeting

(3) Discuss alternate scenario analysis results, including those involving offsite receptors

(4) Describe preliminary STOMP modeling results

(5) Describe plans for revising cleanup goals, considering the probabilistic uncertainty analysis results and results of the other analyses

(6) Obtain input from NRC on the modeling and actions being taken

To begin with key points

Key points

- Revised deterministic DCGLs generally slightly lower than original DCGLs for surface soil, generally slightly higher for subsurface soil, and lower for streambed sediment
- Probabilistic peak-of-the-mean DCGLs generally lower than revised deterministic DCGLs
- Of alternate exposure scenarios evaluated, one, the residential gardener for subsurface soil DCGLs, was more limiting than the base case (resident farmer scenario) for some radionuclides
- Preliminary STOMP groundwater modeling results do not provide basis for changing DCGLs
- Based on results, DOE plans to revise the cleanup goals as follows
  - Surface soil: base on peak-of-the-mean DCGLs
  - Subsurface soil: base on lower of residential gardener/resident farmer deterministic analysis DCGLs and peak-of-the-mean DCGLs
  - Streambed sediment: base on peak-of-the-mean DCGLs
  - Use the same area dose apportionment factors used in Rev 0 of the DP

Deterministic conceptual model changes

- Revised to be more consistent with DEIS dose modeling
  - NRC had commented on differences between DEIS and DP input parameters
- Also to address RAI 5C19 (contaminated plant fraction)
  - Use contaminated plant fraction of 1 for surface soil model
  - Use lower, more plausible vegetable, grain, and fruit ingestion rates
- RAI 5C12 response described revised Appendix C with parameter changes
  - RAI 5C4 response provided revised surface soil DCGLs
  - RAI 5C6 response provided revised subsurface soil DCGLs
  - RAI 5C12 response provided revised streambed sediment DCGLs

Deterministic model parameter changes (1 of 2)

Parameter	Units	Old Value	New Value	Model	Basis for change
Length parallel to aquifer flow	m	1.00E+02	1.65E+02	SS	For 0.2 dilution factor
Evapotranspiration coefficient	none	5.50E-01	7.80E-01	All	Achieve 0.26 m/y infil.
Runoff coefficient	none	6.00E-01	4.10E-01	All	Achieve 0.26 m/y infil.
Mass loading for inhalation	g/m^3	2.50E-05	1.48E-05	All	NUREG/CR-5512*
Filtration factor, inhalation	none	4.00E-01	1.00E+00	SS,SB	NUREG/CR-5512
Fruit/grain ingestion rate	kg/y	1.78E+02	1.12E+02	SS,SB	NUREG/CR-5512
Leafy vegetable ingestion rate	kg/y	2.46E+01	2.10E+01	SS,SB	NUREG/CR-5512
Milk consumption	L/y	1.01E+02	2.33E+02	SS,SB	NUREG/CR-5512
Contaminated fractions (plants, meat, and milk)	none	-1.0	1.0/1.0/1.0	SS	All from contam. source
	none	-1.0	0.05/0.01/0/01	SB	100 m^2 CZ area

Changes, mainly for consistency with DEIS, reflected in revised Appendix C provided with RAI 5C12 response.

* Calculated based on NUREG/CR-5512.

Deterministic model parameter changes (2 of 2)

Parameter	Units	Old Value	New Value	Model	Basis for change
Cm K_d (CZ, UZ, SZ)	mL/g	calculated	6760	All	NUREG/CR-5512
Sr K_d (CZ)*	mL/g	6.16	5	SS	Site specific value
Progeny K_d for Ac	mL/g	20	1740	All	NUREG/CR-5512
Progeny K_d for Pb	mL/g	100	2400	All	NUREG/CR-5512
Progeny K_d for Pa	mL/g	50	2040	All	NUREG/CR-5512
Progeny K_d for Ra	mL/g	70	3550	All	NUREG/CR-5512
Progeny K_d for Th	mL/g	60,000	5890	All	NUREG/CR-5512

Changes reflected in revised Appendix C in RAI 5C12 response.

*Changed for surface soil model only. Value remains 15 mL/g in subsurface soil and streambed sediment models

Deterministic $DCGL_W$ values – surface soil

Nuclide	New DCGL (pCi/g)	Old DCGL (pCi/g)
Am-241	4.3E+01	5.4E+01
C-14	2.0E+01	3.5E+01
Cm-243	4.1E+01	4.7E+01
Cm-244	8.2E+01	1.0E+02
Cs-137*	2.4E+01	2.9E+01
I-129	3.5E-01	6.5E-01
Np-237	9.4E-02	1.1E-01
Pu-238	5.0E+01	6.4E+01
Pu-239	4.5E+01	5.8E+01
Pu-240	4.5E+01	5.8E+01
Pu-241	1.4E+03	1.8E+03
Sr-90*	6.2E+00	9.7E+00
Tc-99	2.4E+01	3.2E+01
U-232	5.8E+00	6.3E+00
U-233	1.9E+01	2.2E+01
U-234	2.0E+01	2.3E+01
U-235	1.9E+01	1.6E+01
U-238	2.1E+01	2.4E+01

*Value reflect 30 years decay.

Changes

- New DCGLs generally lower
  - Cs-137, 83% of old value
  - Sr-90, 66% of old value
  - I-129, 54% of old value
  - U-235, 119% of old value
- Primary reasons for these results
  - Increased ingestion rate of fruit, vegetables, and grain, leafy vegetables; and milk
  - Increased inhalation parameters

Green = lower DCGL

Deterministic $DCGL_W$ values – subsurface soil

Nuclide	New DCGL (pCi/g)	Old DCGL (pCi/g)
Am-241	7.2E+03	6.4E+03
C-14	5.6E+05	4.3E+05
Cm-243	1.2E+03	1.1E+03
Cm-244	2.4E+04	2.0E+04
Cs-137*	4.4E+02	4.4E+02
I-129	6.5E+02	4.2E+02
Np-237	5.8E+01	3.7E+01
Pu-238	1.5E+04	1.2E+04
Pu-239	1.3E+04	1.1E+04
Pu-240	1.3E+04	1.1E+04
Pu-241	2.4E+05	2.2E+05
Sr-90*	4.4E+03	3.1E+03
Tc-99	1.6E+04	1.1E+04
U-232	1.1E+02	1.2E+02
U-233	2.7E+03	1.7E+03
U-234	2.8E+03	1.7E+03
U-235	9.4E+02	9.5E+02
U-238	2.9E+03	1.8E+03

*Values reflect 30 years decay.

Changes

- New DCGLs generally slightly higher
- Primary reasons for these results
  - Increased ingestion rate of fruit, vegetables, and grain, leafy vegetables; and milk
  - Increased inhalation parameters
  - Increased dilution due to lowered infiltration rate (dilution factor now 0.004 vs. previous 0.008)

Green = lower DCGL

Deterministic $DCGL_W$ values – streambed sediment

Nuclide	New DCGL (pCi/g)	Old DCGL (pCi/g)
Am-241	1.6E+04	1.6E+04
C-14	3.4E+03	3.4E+03
Cm-243	3.6E+03	3.6E+03
Cm-244	4.8E+04	4.7E+04
Cs-137*	1.3E+03	1.3E+03
I-129	3.7E+03	3.7E+03
Np-237	5.2E+02	5.4E+02
Pu-238	2.0E+04	2.0E+04
Pu-239	1.8E+04	1.8E+04
Pu-240	1.8E+04	1.8E+04
Pu-241	5.1E+05	5.2E+05
Sr-90*	9.5E+03	9.5E+03
Tc-99	2.2E+06	2.2E+06
U-232	2.6E+02	2.7E+02
U-233	5.7E+04	5.8E+04
U-234	6.0E+04	6.1E+04
U-235	2.9E+03	2.9E+03
U-238	1.2E+04	1.3E+04

*Values reflect 30 years decay.

Changes

- No significant changes
- Reason for no significant changes
  - Model parameter changes and activation of inhalation pathway had little impact (inhalation pathway not active in original model)

Green = lower DCGL

Probabilistic modeling approach (as described 6/15/09)

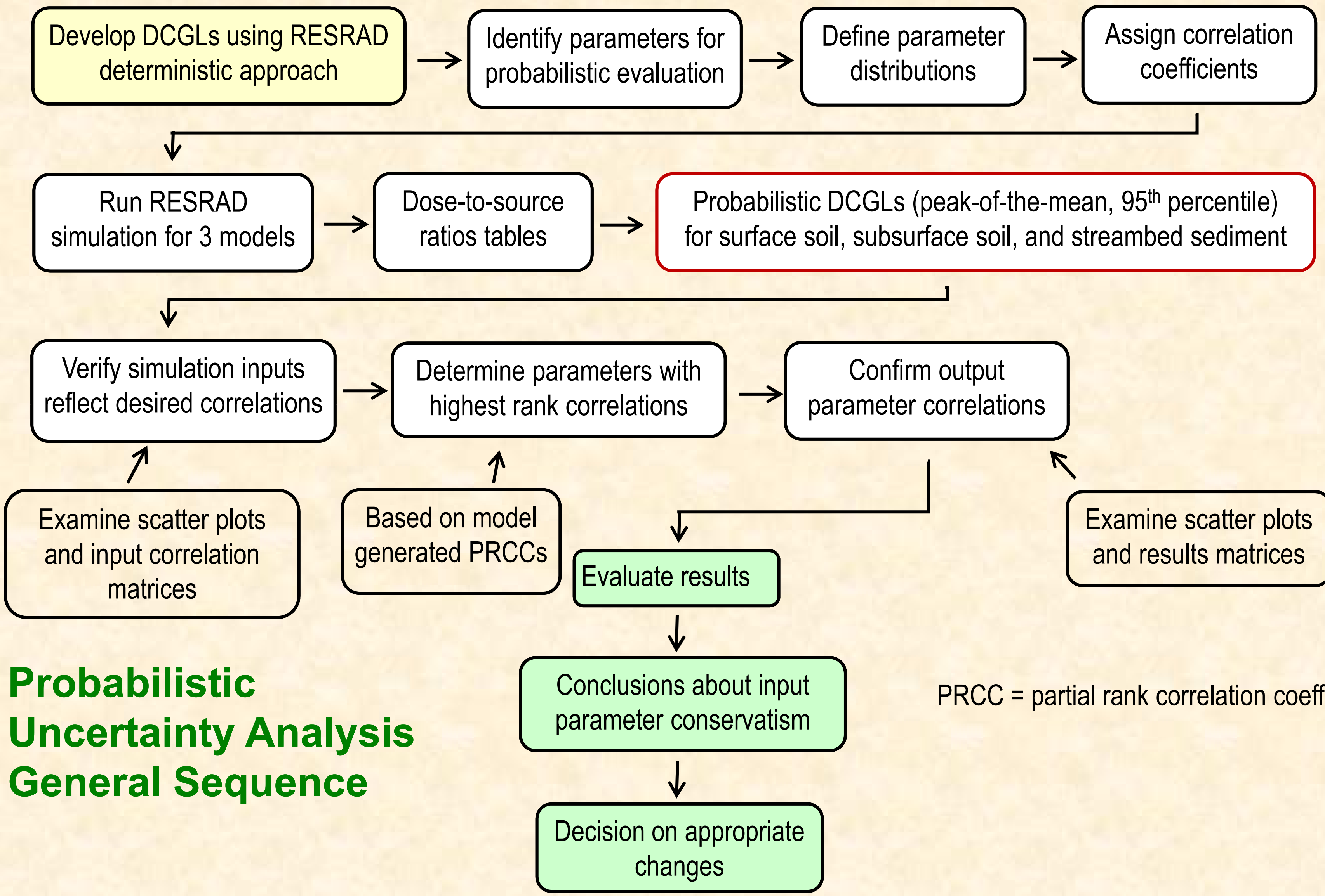
- Make use of probabilistic capabilities of RESRAD version 6.4
- Evaluate key input parameters for 3 conceptual models
  - Using ranges of parameter values with appropriate distributions
- Calculate peak-of-the-mean $DCGL_w$ values for 25 mrem/y for each of 18 radionuclides of interest
- Calculate 95th percentile $DCGL_w$ values for 25 mrem/y
- Evaluate results, draw conclusions, decide on actions
- Describe details in new Appendix E and associated Attachment 1 electronic files

Response to RAI 5C15 will provide details, including new Appendix E.

Probabilistic uncertainty analysis initiated Jan 09

- Effort initiated to resolve the open item identified in the DOE letter forwarding Rev 0 to the DP for evaluating the degree of conservatism in conceptual model key input parameters
- Other considerations in this approach
  - DOE's recent use of probabilistic dose modeling at other sites
  - The advantages of probabilistic dose modeling, such as those described in Appendix I to NUREG-1757, vol. 2
  - Citizens Task Force recommendations about probabilistic dose modeling
- Plans for this analysis were outlined and discussed at the 6/15/09 DOE-NRC meeting

WVDP Phase 1 Decommissioning Plan – Probabilistic Uncertainty Analysis



Probabilistic Uncertainty Analysis General Sequence

PRCC = partial rank correlation coefficient

Probabilistic parameter selection basis

- Based on factors such as
  - Deterministic sensitivity analysis results and primary dose drivers for each model (Section 5.2.4)
  - Availability of site-specific information
  - Preliminary model simulations
  - Discussions at 6/15/09 meeting and NRC guidance on potentially significant parameters
- Selected for evaluation
  - 12 surface soil, 7 subsurface soil, and 3 streambed sediment parameters, along with
    - K_d values for the18 principal radionuclides
    - Plant, meat, and milk biotransfer factors for the 18 principal radionuclides (fish transfer factors for the streambed sediment model)

Parameter distribution basis

- Were based on applicable guidance in NUREG/CR-6676 and NUREG/CR-6697
- One of the following distributions was used, as applicable
  - Triangular
  - Bounded normal
  - Bounded lognormal (for K_ds)
- Bounds based on available literature values and consideration of site-specific data

Selected probabilistic parameters

Parameter	Distribution	Surface	Subsurface	Sediment
Contamination zone thickness	triangular	x		
Length parallel to aquifer flow	triangular	x		
Saturated zone hydraulic conductivity	triangular	x		
Well pumping rate	bounded normal	x	x	
Irrigation rate	bounded normal	x	x	
Indoor time fraction	triangular	x	x	
Outdoor time fraction	triangular	x	x	x
Unsaturated zone hydraulic conductivity	triangular	x		
Contaminated zone hydraulic conductivity	triangular	x		x
Root depth	triangular	x	x	
Precipitation rate	bounded normal	x	x	x
External gamma shielding factor*	triangular	x	x	
Biotransfer factors (plant/meat/milk)	triangular	x	x	x**
K_d values for each zone	bounded lognormal	x	x	x

*Key gamma-emitting radionuclides (Cs-137 and U-232)

**Fish biotransfer factor in lieu of milk

Distribution coefficients values and ranges* (mL/g)

Element	RESRAD Default	Surface Soil DCGL CZ	Subsurface Soil DCGL CZ	Sediment DCGL CZ	Unsaturated Zone	Saturated Zone
Am	20	1900 (420 - 111,000)	4000 (420 - 111,000)	4000 (420 - 111,000)	1900 (420 - 111,000)	1900 (420 - 111,000)
C	0	5 (0.7 - 12)	7 (0.7 - 12)	7 (0.7 - 12)	5 (0.7 - 12)	5 (0.7 - 12)
Cm	calculated	calculated	calculated	calculated	calculated	calculated
Cs	4600	280 (48 - 4800)	480 (48 - 4800)	480 (48 - 4800)	280 (48 - 4800)	280 (48 - 4800)
I	calculated	1 (0.4 - 3.4)	2 (0.4 - 3.4)	2 (0.4 - 3.4)	1 (0.4 - 3.4)	1 (0.4 - 3.4)
Np	calculated	2.3 (0.5 - 5.2)	3 (0.5 - 5.2)	3 (0.5 - 5.2)	2.3 (0.5 - 5.2)	2.3 (0.5 - 5.2)
Pu	2000	2600 (5 - 27,900)	3000 (5 - 27,900)	3000 (5 - 27,900)	2600 (5 - 27,900)	2600 (5 - 27,900)
Sr	30	5 (1 - 32)	15 (1 - 32)	15 (1 - 32)	5 (1 - 32)	5 (1 - 32)
Tc	0	0.1 (0.01 - 4.1)	4.1 (1 - 10)	4.1 (1 - 10)	0.1 (0.01 - 4.1)	0.1 (0.01 - 4.1)
U	50	35 (15 - 350)	10 (1 - 100)	10 (1 - 100)	35 (15 - 350)	35 (15 - 350)

**Ranges used in deterministic sensitivity evaluation.*

Distribution coefficients, progeny (mL/g)

Element	RESRAD Default	Surface Soil DCGL CZ	Subsurface Soil DCGL CZ	Sediment DCGL CZ	Unsaturated Zone	Saturated Zone
Ac	20	1740	1740	1740	1740	1740
Pb	100	2400	2400	2400	2400	2400
Pa	50	2040	2040	2040	2040	2040
Ra	70	3550	3550	3550	3550	3550
Th	60,000	5890	5890	5890	5890	5890

Radionuclides of these elements are not treated as random variables because Am-241 is the only progeny of interest, as explained in the response to RAI 5C2.

Assigned correlation coefficients as planned

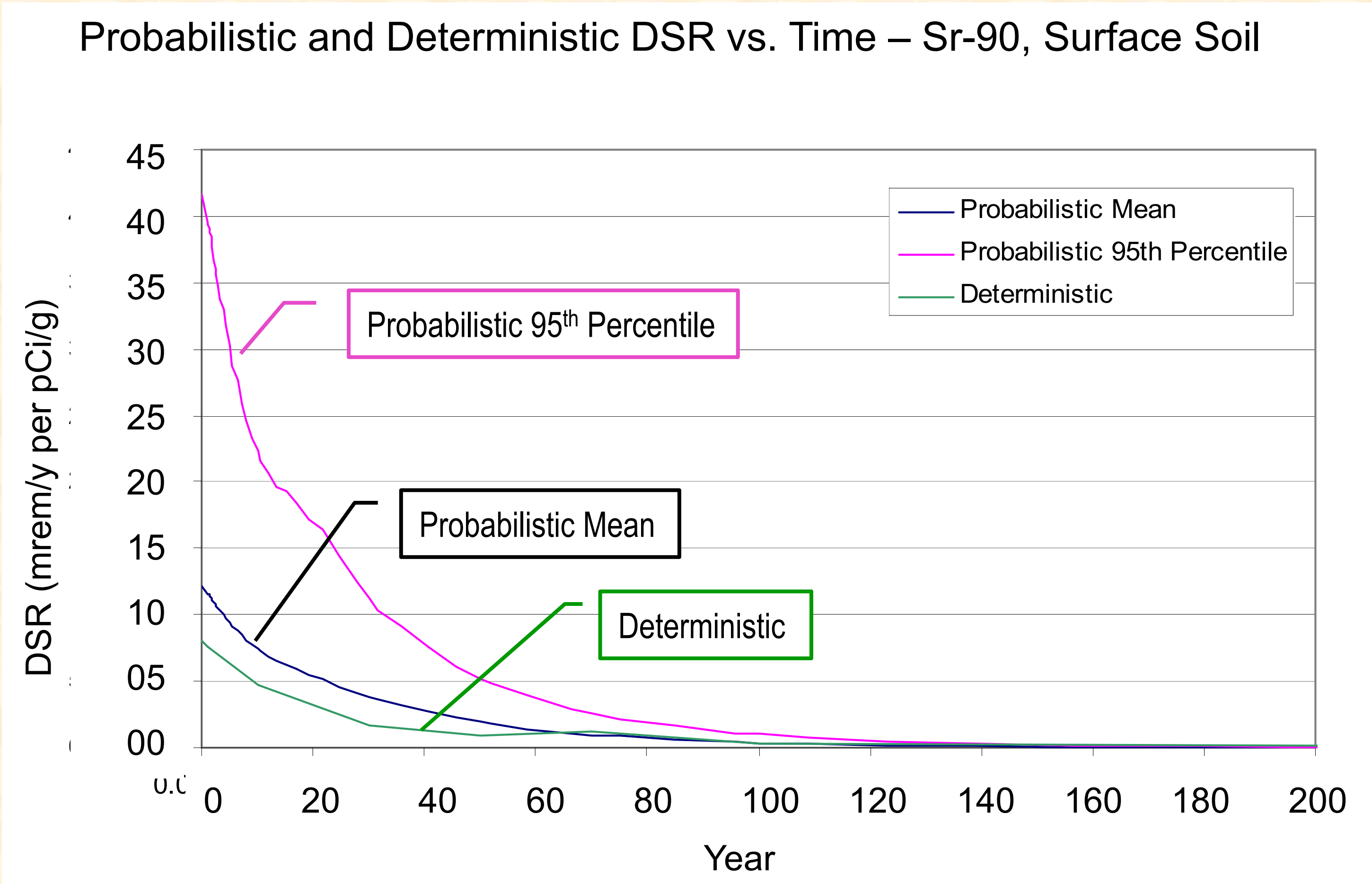
- Followed examples in NUREG/CR-6676
  - 0.95 for directly correlated parameters
  - -0.95 for inversely correlated parameters
- Used -0.87 for correlation of K_d with plant, meat, and milk transfer factors based on 1984 Oak Ridge study
- Provided details in Appendix E tables

Ran simulations and evaluated results as planned

- Produced dose-to-source ratios for each model
- Calculated peak-of-the-mean and 95th percentile DCGLs for 25 mrem/y for each model
- Examined scatter plots and input matrices to ensure inputs reflected desired correlations
- Determined parameters with the highest rank correlations by evaluating PRCCs
- Examined scatter plots to confirm output parameter correlations
- Compared probabilistic DCGLs to deterministic DCGLs

Details are in new Appendix E, which will be provided with the response to RAI 5C15

Typical results comparison (to be in Appendix E)



Time steps for results at 1 year intervals.

Surface soil results (DCGL$_W$ values in pCi/g)

Nuclide	Deterministic*	Peak-of-the-mean	95th Percentile	Difference POTM/Deter
Am-241	4.3E+01	2.9E+01	1.9E+01	-33%
C-14	2.0E+01	1.6E+01	9.8E+00	-18%
Cm-243	4.1E+01	3.5E+01	1.6E+01	-15%
Cm-244	8.2E+01	6.5E+01	2.4E+01	-21%
Cs-137**	2.4E+01	1.5E+01	8.0E+00	-37%
I-129	3.5E-01	3.3E-01	5.3E-02	-6%
Np-237	9.4E-02	2.6E-01	4.8E-02	177%
Pu-238	5.0E+01	4.0E+01	1.4E+01	-21%
Pu-239	4.5E+01	2.5E+01	4.3E+00	-44%
Pu-240	4.5E+01	2.6E+01	4.3E+00	-42%
Pu-241	1.4E+03	1.2E+03	4.2E+02	-18%
Sr-90**	6.2E+00	4.1E+00	1.2E+00	-34%
Tc-99	2.4E+01	2.1E+01	6.9E+00	-11%
U-232	5.8E+00	1.5E+00	2.3E-01	-74%
U-233	1.9E+01	8.3E+00	8.5E-01	-56%
U-234	2.0E+01	8.5E+00	9.6E-01	-57%
U-235	1.9E+01	3.5E+00	1.8E+00	-81%
U-238	2.1E+01	9.8E+00	1.1E+00	-52%

- The peak-of-the-mean probabilistic DCGLs are all less than the deterministic DCGLs, except for Np-237
- Conclusions
  - The revised deterministic surface soil model is not sufficiently conservative

Probabilistic results from Table E-9

Green = lower DCGL

*Revised deterministic DCGLs (slide 7).
**Value reflects 30 years decay.

Subsurface soil results (DCGL$_W$ values in pCi/g)

Nuclide	Deterministic*	Peak-of-the-mean	95th Percentile	Difference POTM/Deter
Am-241	7.2E+03	6.8E+03	4.3E+03	-5%
C-14	5.6E+05	7.2E+05	3.6E+05	28%
Cm-243	1.2E+03	1.1E+03	9.3E+02	-3%
Cm-244	2.4E+04	2.2E+04	1.1E+04	-7%
Cs-137**	4.4E+02	3.0E+02	2.7E+02	-31%
I-129	6.5E+02	6.7E+02	2.6E+02	4%
Np-237	5.8E+01	9.3E+01	3.0E+01	62%
Pu-238	1.5E+04	1.4E+04	6.8E+03	-7%
Pu-239	1.3E+04	1.2E+04	6.1E+03	-7%
Pu-240	1.3E+04	1.2E+04	6.4E+03	-9%
Pu-241	2.4E+05	2.5E+05	1.6E+05	4%
Sr-90**	4.4E+03	3.4E+03	1.0E+03	-21%
Tc-99	1.6E+04	1.4E+04	4.4E+03	-10%
U-232	1.0E+02	7.4E+01	5.4E+01	-30%
U-233	2.7E+03	9.9E+03	3.4E+03	264%
U-234	2.8E+03	1.3E+04	3.8E+03	349%
U-235	9.4E+02	9.3E+02	7.6E+02	-1%
U-238	2.9E+03	4.6E+03	3.8E+03	57%

Probabilistic results from Table E-11

- Many of the peak-of-the-mean probabilistic DCGLs are lower than the deterministic DCGLs
  - Others are higher
- Conclusion
  - Deterministic model is reasonably conservative, but residential gardener results need to be taken into account (discussed below)

Green = lower DCGL

*Revised deterministic DCGLs (slide 8).
**Value reflects 30 years decay.

Streambed sediment results (DCGL$_W$ values in pCi/g)

Nuclide	Deterministic*	Peak-of-the-Mean	95th Percentile	Difference POTM/Deter
Am-241	1.6E+04	1.0E+04	5.2E+03	-34%
C-14	3.4E+03	1.8E+03	7.4E+02	-46%
Cm-243	3.6E+03	3.1E+03	2.1E+03	-15%
Cm-244	4.8E+04	3.8E+04	2.5E+04	-21%
Cs-137**	1.3E+03	1.0E+03	7.2E+02	-21%
I-129	3.7E+03	7.9E+02	3.5E+02	-79%
Np-237	5.2E+02	3.3E+02	1.1E+02	-37%
Pu-238	2.0E+04	1.2E+04	7.0E+03	-38%
Pu-239	1.8E+04	1.2E+04	6.1E+03	-33%
Pu-240	1.8E+04	1.2E+04	6.0E+03	-33%
Pu-241	5.1E+05	3.4E+05	1.9E+05	-33%
Sr-90**	9.5E+03	4.7E+03	1.7E+03	-50%
Tc-99	2.2E+06	6.6E+05	2.4E+05	-70%
U-232	2.6E+02	2.2E+02	1.5E+02	-15%
U-233	5.8E+04	2.2E+04	6.4E+03	-62%
U-234	6.0E+04	2.2E+04	5.9E+03	-64%
U-235	2.9E+03	2.3E+03	1.6E+03	-19%
U-238	1.3E+04	8.2E+03	4.6E+03	-34%

Green = lower DCGL

- The peak-of-the-mean probabilistic DCGLs are all lower than the deterministic DCGLs
  - Sr-90 50% lower
  - Cs-137 19% lower
- Conclusion
  - The deterministic model is not sufficiently conservative

Probabilistic results from Table E-13

*Revised deterministic DCGLs (slide 9).
**Value reflects 30 years decay.

Summary, actions on results

- Used RESRAD version 6.4 probabilistic capabilities
- Identified appropriate parameters to treat probabilistically, following NRC suggestions and considering preliminary parameter evaluations
- Established key parameter distributions following NRC guidance
- Calculated peak-of-the-mean and 95^{th} percentile DCGLs
- Evaluated results, comparing to deterministic DCGLs

Will explain how the results are to be used after discussing the results of the analysis of alternate exposure scenarios and the preliminary results of additional STOMP groundwater modeling.

Consideration of alternative exposure scenarios

- Surface soil DCGLs
  - (1) Erosion and resulting dose to onsite and offsite receptors (RAI 5C4)
- Subsurface soil DCGLs
  - (2) Acute dose to well driller in subsurface model (RAI 5C5)
  - (3) Recreationist-hiker in area of deep gullies in WMA 2 (RAI 5C6)
  - (4) Long-term erosion in WMA 2 and resulting dose to offsite receptor (RAI 5C6)
  - (5) Releases from bottom of remediated deep excavations (RAIs 5C1, 5C7, 5C9)
  - (6) Natural gas well driller (RAI 5C8)
  - (7) Residential gardener (RAI 5C18)
- Other modeling
  - (8) STOMP modeling to evaluate impacts of flow field changes on DCGLs (RAI 5C3)
- Calc packages and associated electronic files for the dose modeling are being provided with the RAI responses

Erosion impacts on onsite receptor (surface soil)

- Unchecked long-term erosion could lead to conditions where deep gullies could cut into the area of lagoons 1, 2, and 3 in WMA 2
  - Growing crops or building a home in such an area would be unlikely
- A person regularly hiking in the area would be plausible for these conditions
- This recreationist-hiker scenario would result in less dose than the base-case resident farmer scenario for various reasons
  - More dilution of residual radioactivity
  - Less outdoor time fraction
  - Less external radiation
  - Less inhalation
  - No plant ingestion
  - No meat ingestion
  - No milk ingestion
  - No drinking water ingestion
- Analysis of the recreationist-hiker scenario discussed in connection with RAI 5C6 supports these conclusions

Erosion impacts on offsite receptor (surface soil)

- Calculation performed based on DEIS erosion modeling
  - Calculated surface soil DCGLs that would produce 25 mrem/yr to a receptor on Cattaraugus Creek near confluence with Buttermilk Creek
  - Used maximum predicted erosion rates (WEPP model rates, DEIS Table F-13)
  - Receptor assumed to ingest surface water and fish, use surface water to irrigate garden, with additional pathways of direct radiation, inhalation, inadvertent soil ingestion, consumption of milk, meat, and garden vegetables
- Results

Results in RAI 5C4 response, base-case DCGLs more limiting for all nuclides

Key Nuclide	Erosion Model DCGLs (pCi/g)*	Base-Case DCGLs (pCi/g)**
C-14	1.0E+07	2.0E+01
Sr-90	7.2E+06	6.2E+00***
Tc-99	7.4E+07	2.4E+01
I-129	5.5E+05	3.5E-01
Cs-137	5.9E+05	2.4E+01***
U-238	5.2E+06	2.1E+01
Pu-239	3.8E+05	4.5E+01

*dose to offsite receptor, **new deterministic DCGLs
***with 30-yr decay

Green = lower DCGL

Acute dose to well driller (subsurface model)

- Assumed drilling worker exposed to contaminated Lavery till soil excavated from the well bottom and deposited on the ground surface near the cistern construction area, with no dilution of source material
- Exposure pathways (1) inadvertent ingestion, (2) inhalation, (3) exposure to direct radiation (with no water shielding)
- Modeled using RESRAD 6.4 in deterministic mode

Key Parameter	Units	Value	Source
Contaminated zone area	m^2	10	Assumed for 3.14 m^3 excavated source.
Contaminated zone thickness	m	0.314	Assumed for 3.14 m^3 excavated source.
Outdoor time fraction	none	0.005	Assumed for 40 hr exposure while installing cistern out of 8,760 total hours in a year.
Soil ingestion rate	g/y	175.2	Value for construction activity in warmer months. (Yu, et al. 1993, p.121).
Inhalation rate	m^3/y	13,100	Corresponds to outdoor worker moderate activity level of 1.5 m^3/hr (Yu, et al. 2000, Table 5.1-2).
Mass loading for inhalation	µg/m^3	600	Corresponds to construction activities (Yu, et al. 1993, p.116).

Acute dose to well driller results (DCGL$_W$ in pCi/g)

Nuclide	Peak Yr	DCGL	Base Case DCGL *
Am-241	0	1.7E+04	7.2E+03
C-14	0	2.3E+09	5.6E+05
Cm-243	0	1.1E+04	1.2E+03
Cm-244	0	3.3E+04	2.4E+04
Cs-137**	0	6.7E+03	4.4E+02
I-129	0	8.0E+05	6.5E+02
Np-237	0	6.6E+03	5.8E+01
Pu-238	0	2.0E+04	1.5E+04
Pu-239	0	1.9E+04	1.3E+04
Pu-240	0	1.9E+04	1.3E+04
Pu-241	55	5.5E+05	2.4E+05
Sr-90**	0	8.7E+05	4.4E+03
Tc-99	0	7.9E+07	1.6E+04
U-232	4	1.6E+03	1.1E+02
U-233	0	6.2E+04	2.7E+03
U-234	0	6.4E+04	2.8E+03
U-235	0	1.2E+04	9.4E+02
U-238	0	3.7E+04	2.9E+03

Results

- All well driller DCGLs greater than base case – the resident farmer scenario – DCGLs

Conclusions

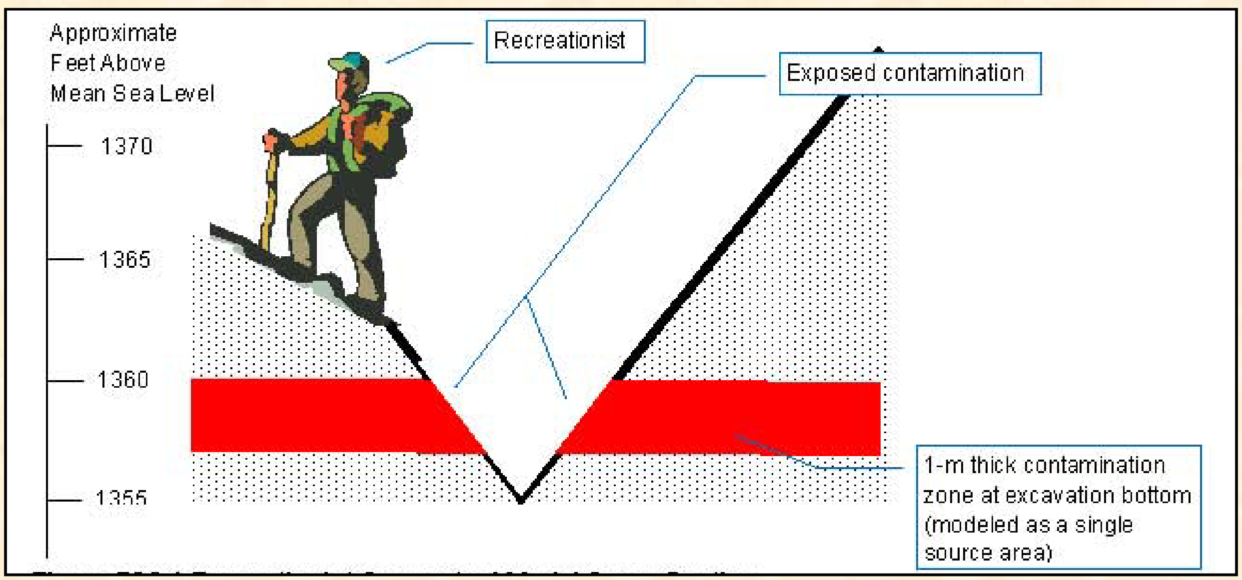
- The base case is more limiting than the cistern well driller scenario

Green = lower DCGL

*New deterministic resident farmer subsurface soil DCGLs with cistern scenario ** with 30 years decay

Recreationist-hiker at deep gullies in WMA 2

- Receptor assumed to hike in area of Lagoons 1, 2, and 3 in WMA 2 after 200 yr of unmitigated erosion exposes contamination in deep gully (based on aggressive erosion rate)
- Exposure pathways (1) inadvertent ingestion, (2) inhalation, (3) exposure to direct radiation for 28 hr/yr (112 trips to and from stream)
- Modeled using RESRAD 6.4 in deterministic mode



Recreationist-hiker analysis results (DCGL$_W$ in pCi/g)

Nuclide	Peak Yr	DCGL	Base Case DCGL *
Am-241	0	2.7E+05	7.2E+03
C-14	0	3.3E+08	5.6E+05
Cm-243	0	5.0E+04	1.2E+03
Cm-244	0	1.0E+09	2.4E+04
Cs-137**	0	9.8E+05	4.4E+02
I-129	0	1.9E+06	6.5E+02
Np-237	0	2.7E+04	5.8E+01
Pu-238	0	1.5E+06	1.5E+04
Pu-239	0	2.8E+05	1.3E+04
Pu-240	0	2.8E+05	1.3E+04
Pu-241	61	1.7E+07	2.4E+05
Sr-90**	0	1.6E+08	4.4E+03
Tc-99	0	2.2E+08	1.6E+04
U-232	7	2.8E+04	1.0E+02
U-233	0	1.3E+06	2.7E+03
U-234	0	1.4E+06	2.8E+03
U-235	0	4.2E+04	9.4E+02
U-238	0	1.9E+05	2.9E+03

*New deterministic resident farmer subsurface soil DCGLs with cistern scenario ** with 30 years decay

Results

- All recreationist-hiker DCGLs at least one order of magnitude greater than base-case – the resident farmer scenario – DCGLs

Conclusions

- The base case is more limiting than the recreationist-hiker scenario

Green = lower DCGL

Erosion impacts, offsite receptor (subsurface soil)

- Calculation performed based on DEIS erosion modeling
  - Considered erosion in WMA 2 lagoon area cuts into the bottom of the deep excavation
  - Assumed maximum predicted peak erosion rates
    - Modeled Lagoon 1 (400 m^2 in area) with large transient gully
    - Modeled Lagoon 3 (1800 m^2 in area) with large transient gully
  - Evaluated potential dose to resident farmer on Cattaraugus Creek
    - Receptor assumed to ingest surface water and fish, use surface water to irrigate garden
    - Additional pathways of direct radiation, inhalation, inadvertent soil ingestion, consumption of milk, meat, and garden vegetables
- Key results on next slide

Results for erosion impacts on offsite receptor

Lagoon 1

Key Nuclide	Erosion Model DCGLs (pCi/g)*	Base-Case DCGLs (pCi/g)**
C-14	8.4E+06	5.6E+05
Sr-90	1.2E+07	4.4E+03***
Tc-99	6.1E+07	1.6E+04
I-129	4.6E+05	6.5E+02
Cs-137	9.8E+05	4.4E+02***
U-238	4.3E+06	2.9E+03
Pu-239	3.2E+05	1.3E+04

Lagoon 3

Key Nuclide	Erosion Model DCGLs (pCi/g)*	Base-Case DCGLs (pCi/g)**
C-14	6.4E+06	5.6E+05
Sr-90	9.2E+06	4.4E+03***
Tc-99	4.7E+07	1.6E+04
I-129	3.5E+05	6.5E+02
Cs-137	7.4E+05	4.4E+02***
U-238	3.3E+06	2.9E+03
Pu-239	2.4E+05	1.3E+04

*dose to offsite receptor, **new deterministic subsurface DCGLs ***with 30-yr decay

Green = lower DCGL

Conclusions on erosion impacts

Results

- All DCGLs based on offsite receptor dose greater than base-case resident farmer scenario

Conclusions

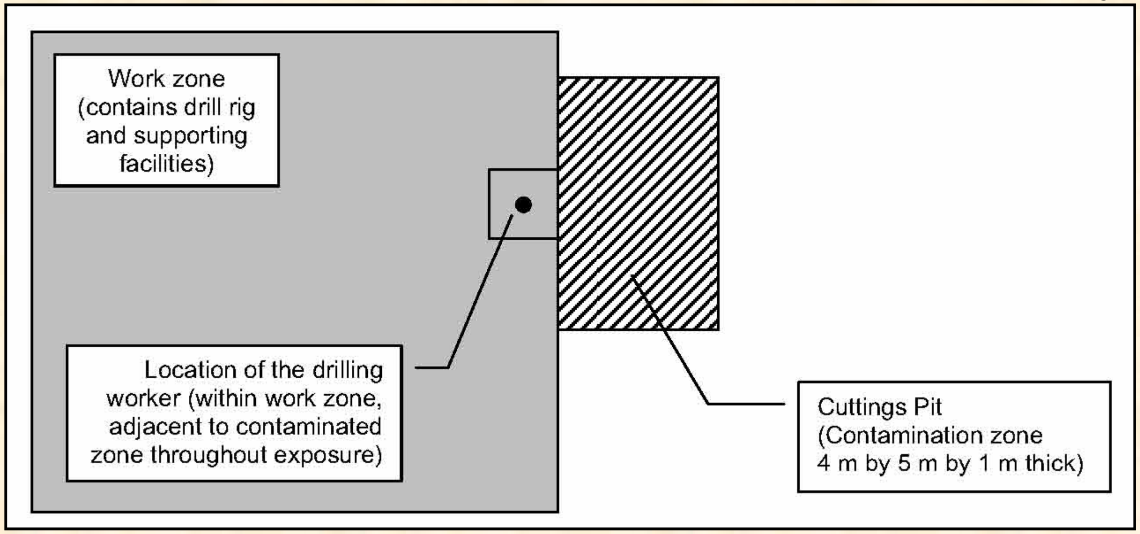
- The base case – the cistern resident farmer scenario for subsurface soil DCGLs for the deep excavations – is more limiting than an alternate scenario involving erosion impacts to an offsite receptor

Releases from bottoms of deep excavation

- STOMP model used to estimate the impacts of releases of residual contamination from the 1-m thick Lavery till layer at the bottom of the deep WMA 1 and WMA 2 excavations
- Five radionuclides are being evaluated
  - C-14, Sr-90, Tc-99, I-129, and U-238
- Preliminary flow results suggest that pumping of a well in the WMA 1 excavation area would cause a minor decrease in flow downward to the unweathered Lavery till
- Final results will be provided in the response to RAIs 5C1 and 5C9

Natural gas well driller scenario

- Assume natural gas well drilled in remediated WMA 1 excavation area
- Well 0.5-m diameter (typical), 100-m deep (conservative)
- Residual contamination at excavation bottom brought to surface and diluted with clean excavated material
- Well driller exposed 50 days for 10 hours per day, through inadvertent soil ingestion, dust inhalation, and external exposure pathways



Natural gas well driller analysis results

Nuclide	Peak Yr	DCGL	Base Case DCGL *
Am-241	0	1.4E+05	7.2E+03
C-14	0	4.9E+09	5.6E+05
Cm-243	0	1.2E+05	1.2E+03
Cm-244	0	2.6E+05	2.4E+04
Cs-137**	0	9.2E+04	4.4E+02
I-129	0	9.2E+06	6.5E+02
Np-237	0	6.6E+04	5.8E+01
Pu-238	0	1.6E+05	1.5E+04
Pu-239	0	1.5E+05	1.3E+04
Pu-240	0	1.5E+05	1.3E+04
Pu-241	56	4.5E+06	2.4E+05
Sr-90**	0	1.1E+07	4.4E+03
Tc-99	0	9.4E+08	1.6E+04
U-232	6	1.6E+04	1.0E+02
U-233	0	4.9E+05	2.7E+03
U-234	0	5.0E+05	2.8E+03
U-235	0	1.4E+05	9.4E+02
U-238	0	3.6E+05	2.9E+03

Results

- All natural gas well driller DCGLs at least one order of magnitude greater than base-case – the resident farmer scenario – DCGLs

Conclusion

- The base case is more limiting than the natural gas well driller scenario

The results are provided in the response to RAI 5C8

Green = lower DCGL

*New deterministic resident farmer subsurface soil DCGLs with cistern scenario ** with 30 years decay

Residential gardener scenario

- This model was run to address concerns over values used for pumping and irrigation rates expressed in RAI 5C18
  - For example, residential gardener scenario might be more limiting due to decreased water usage, with lower pumping rates leading to increased dose due to lower dilution factors
- Model run for both surface soil and subsurface soil using deterministic parameter values as input to RESRAD
- Surface soil model features
  - Same contaminated zone area (10,000 m^2) and thickness (1 m) as the resident farmer model, with smaller area (2,000 m^2) being used for cultivation of homegrown produce
  - Lower pumping rate (1,140 m^3/y for residential gardener vs. 5720 m^3/y for resident farmer)
  - 0.2 dilution factor with non-dispersion model
  - No consumption of meat or milk, unlike resident farmer model

Surface soil results (DCGL$_W$ values in pCi/g)

Nuclide	Peak Yr	Res. Gardener DCGL	Base Case DCGL *
Am-241	0	4.5E+01	4.3E+01
C-14	0	4.1E+01	2.0E+01
Cm-243	0	4.7E+01	4.1E+01
Cm-244	0	8.5E+01	8.2E+01
Cs-137**	0	4.1E+01	2.4E+01
I-129	0	7.3E-01	3.5E-01
Np-237	0	9.5E-02	9.4E-02
Pu-238	0	5.3E+01	5.0E+01
Pu-239	0	4.8E+01	4.5E+01
Pu-240	0	4.8E+01	4.5E+01
Pu-241	56	1.5E+03	1.4E+03
Sr-90**	0	8.4E+00	6.2E+00
Tc-99	0	2.6E+01	2.4E+01
U-232	6	8.2E+00	5.8E+00
U-233	0	2.0E+01	1.9E+01
U-234	0	2.1E+01	2.0E+01
U-235	0	2.0E+01	1.9E+01
U-238	0	2.2E+01	2.1E+01

Results

- The base-case resident farmer scenario limiting for all 18 radionuclides

Conclusions

- The base case is more limiting by a small margin than the residential gardener scenario for surface soil DCGLs

The results are provided in the response to RAI 5C18.

Green = lower DCGL

*New deterministic resident farmer surface soil DCGLs.
** with 30 years decay

Residential scenario – subsurface soil DCGLs

- Three models were run for each scenario (with differing contamination zone area/thickness combinations)

Parameters	Resident Farmer Model			Residential Gardener Model		
Model	1*	2	3	1	2	3
CZ Area (m^2)	100	300	50	100	300	50
CZ Thickness (m)	0.3	0.1	0.6	0.3	0.1	0.6
Well pump rate (m^3/y)	5720	5720	5720	1140	1140	1140
Dilution Factor (MB model)	0.004	0.013	0.002	0.023	0.068	0.011
Outdoor time fraction	0.25	0.25	0.25	0.12	0.12	0.12
Mass loading for Inhal. (g/m^3)	1.50E-05	1.50E-05	1.50E-05	4.50E-06	4.50E-06	4.50E-06
Contaminated Fraction - Plant	0.05	0.15	0.025	0.05	0.15	0.025
Contaminated Fraction - Milk	0.01	0.03	0.005	NA	NA	NA
Contaminated Fraction - Meat	0.01	0.03	0.005	NA	NA	NA

*Base case

Subsurface DCGL results (pCi/g)

Nuclide	Resident Farmer			Residential Gardener			Limiting Value	Scenario/ CZ Area
	Model 1*	Model 2	Model 3	Model 1	Model 2	Model 3		
Am-241	7.2E+03	**7.1E+03**	8.3E+03	9.8E+03	8.0E+03	1.1E+04	**7.1E+03**	Farmer – 300 m^2
C-14	5.6E+05	1.0E+06	**3.7E+05**	7.2E+05	4.5E+05	4.6E+05	**3.7E+05**	Farmer – 50 m^2
Cm-243	**1.2E+03**	1.2E+03	1.3E+03	1.6E+03	1.7E+03	1.8E+03	**1.2E+03**	Farmer – 100 m^2
Cm-244	2.4E+04	2.4E+04	2.9E+04	3.1E+04	**2.3E+04**	3.8E+04	**2.3E+04**	Gardener – 300 m^2
Cs-137(2)	**4.4E+02**	5.0E+02	4.8E+02	6.2E+02	7.1E+02	6.8E+02	**4.4E+02**	Farmer – 100 m^2
I-129	6.5E+02	2.7E+02	1.2E+03	1.3E+02	**5.2E+01**	2.5E+02	**5.2E+01**	Gardener – 300 m^2
Np-237	5.8E+01	2.3E+01	1.1E+02	1.2E+01	**4.3E+00**	2.2E+01	**4.3E+00**	Gardener – 300 m^2
Pu-238	**1.5E+04**	1.5E+04	1.8E+04	1.9E+04	**1.5E+04**	2.4E+04	**1.5E+04**	Gardener – 300 m^2**
Pu-239	**1.3E+04**	1.4E+04	1.6E+04	1.7E+04	**1.3E+04**	2.1E+04	**1.3E+04**	Gardener – 300 m^2**
Pu-240	**1.3E+04**	1.4E+04	1.6E+04	1.8E+04	**1.3E+04**	2.2E+04	**1.3E+04**	Gardener – 300 m^2**
Pu-241	**2.4E+05**	**2.4E+05**	2.8E+05	3.3E+05	2.7E+05	3.8E+05	**2.4E+05**	Farmer - 100 & 300 m^2
Sr-90(2)	4.4E+03	1.2E+04	4.4E+03	4.8E+03	**3.2E+03**	4.8E+03	**3.2E+03**	Gardener – 300 m^2
Tc-99	1.6E+04	4.8E+04	1.5E+04	1.4E+04	**1.1E+04**	1.5E+04	**1.1E+04**	Gardener – 300 m^2
U-232	**1.0E+02**	1.8E+02	**1.0E+02**	1.5E+02	2.6E+02	1.5E+02	**1.0E+02**	Farmer – 50, 100 m^2
U-233	2.7E+03	9.7E+02	5.2E+03	5.5E+02	**1.9E+02**	1.1E+03	**1.9E+02**	Gardener – 300 m^2
U-234	2.8E+03	9.9E+02	5.6E+03	5.6E+02	**2.0E+02**	1.1E+03	**2.0E+02**	Gardener – 300 m^2
U-235	9.4E+02	1.0E+03	1.0E+03	5.9E+02	**2.1E+02**	1.2E+03	**2.1E+02**	Gardener – 300 m^2
U-238	2.9E+03	1.0E+03	5.0E+03	5.9E+02	**2.1E+02**	1.2E+03	**2.1E+02**	Gardener – 300 m^2

Green = lowest DCGL

*Resident farmer model 1 is base case.
**And base-case resident farmer.

Results and conclusions

Results

- The residential gardener is limiting for most radionuclides
  - Model 2 with its contamination zone area of 300 m^2 and thickness of 0.1 m
- The base case resident farmer is limiting for Cm-243, Cs-137 and Pu-241
- The resident farmer Model 2 or Model 3 is limiting for 3 radionuclides

Conclusions

- The most appropriate subsurface soil deterministic DCGLs are those of the limiting value column
  - That is, the lowest DCGLs of the 6 model runs
  - The 6 models (with 2 exposure scenarios and 3 source area/thickness combinations) are considered to be equally plausible

The results are provided in the response to RAI 5C8

STOMP modeling of flow field changes

- This modeling was performed to determine the impact of flow field changes related to the presence of the hydraulic barriers on the hydraulic parameters used in development of DCGLs
  - That is, whether the assumed dilution factors would still be valid with the barriers in place
- The modeling used STOMP to calculate dilution factors and pressure distributions
- The results shows that
  - Hydraulic barriers would not cause significant changes in the hydraulic gradient south (i.e., upgradient) of the WMA 1 excavation
  - RESRAD dilution model can provide a reasonable representation of dilution at the well

Details will be provided in the response to RAI 5C3.

Overall results – surface soil DCGLs

Modeling	Results
Changes to deterministic model	Most DCGLs lower, Cs-137, 69% of old value, Sr-90 78%
Probabilistic uncertainty analysis	Peak-of-the-mean DCGLs generally lower than revised deterministic DCGLs
Evaluation of alternate scenarios	
Offsite dose from surface soil erosion	Less limiting than surface soil base case.
Residential gardener scenario	Less limiting than surface soil base case
STOMP modeling of flow field change impacts	Current values of RESRAD parameters are appropriate

Conclusions – surface soil cleanup goals (pCi/g)

- DOE plans to use the peak-up-the-mean probabilistic DCGLs
- The cleanup goals below reflect 90% of these values based on the limited site-wide dose assessment apportioning process described in Section 5.4.1

Nuclide	Cleanup Goal New	Cleanup Goal Old*	Nuclide	Cleanup Goal New	Cleanup Goal Old*	Nuclide	Cleanup Goal New	Cleanup Goal Old*
Am-241	2.6E+01	4.9E+01	Np-237	2.3E-01	9.6E-02	Tc-99	1.9E+01	2.9E+01
C-14	1.5E+01	3.1E+01	Pu-238	3.6E+01	5.8E+01	U-232	1.4E+00	5.6E+00
Cm-243	3.1E+01	4.2E+01	Pu-239	2.3E+01	5.2E+01	U-233	7.5E+00	2.0E+01
Cm-244	5.8E+01	9.4E+01	Pu-240	2.4E+01	5.2E+01	U-234***	7.6E+00	2.1E+01
Cs-137**	1.4E+01	2.7E+01	Pu-241	1.0E+03	1.6E+03	U-235***	3.1E+00	1.4E+01
I-129***	2.9E-01	5.8E-01	Sr-90**	3.7E+00	8.7E+00	U-238***	8.9E+00	2.2E+01

- These cleanup goals equate to 22.5 mrem/y like the previous cleanup goals

Green = lower DCGL

*From Table 5-14, Revision 0 **Values reflect 30 years decay

***Cleanup goal below NUREG-1757, v.2 Appendix H screening value

Overall results – subsurface soil DCGLs

Modeling	Results
Changes to deterministic model	Most DCGLs slightly higher than before
Probabilistic uncertainty analysis	Many peak-of-the-mean DCGLs lower, some higher than revised deterministic DCGLs
Evaluation of alternate scenarios	
WMA 2 erosion dose to offsite receptor	Less limiting than surface soil base case
Acute dose to cistern well driller	Less limiting than subsurface soil base case
Releases from bottoms of deep excavations	Preliminary results show flow downward into the ULT with the pumping well in the WMA 1 excavation
Natural gas well driller	Less limiting than subsurface soil base case
Residential gardener scenario	More limiting than base case for most nuclides
STOMP modeling of flow field change impacts	Small impact of hydraulic barriers on estimated well dilution

Subsurface soil DCGL comparison

Nuclide	Limiting Deterministic*	Peak-of-the-mean
Am-241	7.1E+03	6.8E+03
C-14	3.7E+05	7.2E+05
Cm-243	1.2E+03	1.1E+03
Cm-244	2.3E+04	2.2E+04
Cs-137**	4.4E+02	3.0E+02
I-129	5.2E+01	6.7E+02
Np-237	4.3E+00	9.3E+01
Pu-238	1.5E+04	1.4E+04
Pu-239	1.3E+04	1.2E+04
Pu-240	1.3E+04	1.2E+04
Pu-241	2.4E+05	2.5E+05
Sr-90**	3.2E+03	3.4E+03
Tc-99	1.1E+04	1.4E+04
U-232	1.0E+02	7.4E+01
U-233	1.9E+02	9.9E+03
U-234	2.0E+02	1.3E+04
U-235	2.1E+02	9.3E+02
U-238	2.1E+02	4.6E+03

Results

- The limiting deterministic DCGLs from consideration of the residential gardener scenario are bounding in most cases

Conclusions

- It would be conservative and appropriate to use the lower of the two values as the basis for the cleanup goals

Green = lower DCGL

*Limiting values from 6 model base-case (resident farmer)-residential gardener comparison on slide 41.
**Value reflects 30 years decay.

Conclusions – subsurface soil cleanup goals (pCi/g)

Note that the values below could change based on the final STOMP modeling results.

- DOE plans to use lower DCGL from the comparison on the previous slide as the basis for the cleanup goals
- The cleanup goals below reflect a 10% reduction and then a 50% further reduction in these values based on the limited site-wide dose assessment apportioning process described in DP Sections 5.3.2 and 5.4.1

Nuclide	Cleanup Goal		Nuclide	Cleanup Goal		Nuclide	Cleanup Goal	
	New	Old*		New	Old*		New	Old*
Am-241	3.1E+03	2.9E+03	Np-237	1.9E+00	1.7E+01	Tc-99	5.1E+03	5.0E+03
C-14	1.7E+05	1.9E+05	Pu-238	6.2E+03	5.5E+03	U-232	3.3E+01	5.3E+01
Cm-243	5.0E+02	5.1E+02	Pu-239	5.5E+03	5.0E+03	U-233	8.7E+01	7.5E+02
Cm-244	1.0E+04	8.8E+03	Pu-240	5.4E+03	5.0E+03	U-234	8.9E+01	7.7E+02
Cs-137**	1.4E+02	2.0E+02	Pu-241	1.1E+05	9.8E+04	U-235	9.3E+01	4.3E+02
I-129	2.4E+01	1.9E+02	Sr-90**	1.4E+03	1.4E+03	U-238	9.3E+01	8.2E+02

- These cleanup goals equate to 11.25 mrem/y like the original cleanup goals

*From Table 5-14, Revision 0 **Values reflect 30 years decay

Green = lower DCGL

Overall results – streambed sediment DCGLs

Modeling	Results
Changes to deterministic models	DCGLs essentially the same
Probabilistic uncertainty analysis	Peak-of-the-mean DCGLs are all lower than the revised deterministic DCGLs

Conclusions – streambed sediment cleanup goals (pCi/g)

- DOE plans to use the peak-of-the-mean DCGLs
- The cleanup goals below reflect a 90% reduction in these values based on the limited site-wide dose assessment apportioning process described in DP Section 5.4.1

Nuclide	Cleanup Goal New	Cleanup Goal Old*	Nuclide	Cleanup Goal New	Cleanup Goal Old*	Nuclide	Cleanup Goal New	Cleanup Goal Old*
Am-241	1.0E+03	1.6E+03	Np-237	3.2E+01	5.4E+01	Tc-99	6.6E+04	2.2E+05
C-14	1.8E+02	3.4E+02	Pu-238	1.2E+03	2.0E+03	U-232	2.2E+01	2.7E+01
Cm-243	3.1E+02	3.6E+02	Pu-239	1.2E+03	1.8E+03	U-233	2.2E+03	5.8E+03
Cm-244	3.8E+03	4.7E+03	Pu-240	1.2E+03	1.8E+03	U-234	2.2E+03	6.1E+03
Cs-137**	1.0E+02	1.3E+02	Pu-241	3.4E+04	5.2E+04	U-235	2.3E+02	2.9E+02
I-129	7.9E+01	3.7E+02	Sr-90**	4.7E+02	9.5E+02	U-238	8.2E+02	1.3E+03

- These cleanup goals equate to 2.5 mrem/y like the original cleanup goals

*From Table 5-14, Revision 0 **Values reflect 30 years decay

Green = lower DCGL

In summary

- Revised deterministic DCGLs generally slightly lower than original DCGLs for surface soil, generally slightly higher for subsurface soil, and lower for streambed sediment
- Probabilistic peak-of-the-mean DCGLs generally lower than revised deterministic DCGLs
- Of alternate exposure scenarios evaluated, one, the residential gardener for subsurface soil DCGLs, was more limiting than the base case (resident farmer) for some radionuclides
- Preliminary STOMP groundwater modeling results do not provide basis for changing DCGLs
- Based on results, DOE plans to revise the cleanup goals as follows
  - Surface soil: base on peak-of-the-mean DCGLs
  - Subsurface soil: base on lower of residential gardener/resident farmer deterministic analysis DCGLs and peak-of-the-mean DCGLs
  - Streambed sediment: base on peak-of-the-mean DCGLs
  - Use the same area dose apportionment factors used in Rev 0 of the DP

Definitions of key terms (1 of 2)

Correlation. A measure of the strength of the relationship between two variables (e.g., conceptual model input parameters) used to predict the value of one variable given the value of the other.

Correlation coefficient. Correlation coefficients (R values) are expressed on a scale from -1.0 to +1.0, with the strongest correlations being at both extremes and providing the best predictions. Negative values reflect inverse relationships. (See also **partial rank correlation coefficient**.)

Deterministic analysis. In a deterministic analysis, each input parameter is assumed to be an exactly known single value, as are the analysis results.

Lognormal distribution. In a lognormal distribution, the logarithm of the parameter has a **normal distribution**. A lognormal distribution is defined by two parameters, the logarithmic mean and its standard deviation.

Mean. The arithmetic mean as used here is the mathematical average of a set of numbers. The mean is calculated by adding a set of values and dividing the total by the number of values in the set.

Normal distribution. Probability values in a normal distribution follow a bell shaped curve centered about a mean value with the width of the "bell" described by the standard deviation. In a **bounded normal distribution**, upper and lower limits to the range are specified.

Partial rank correlation coefficient. The partial rank correlation coefficient measures the strength of the relationship between variables after any confounding influences of other variables have been removed.

Definitions of key terms (2 of 2)

Peak of the mean. The highest dose value in a plot of the estimated mean dose over time. *(NRC in NUREG 1757 Volume 2 indicates that when using probabilistic dose modeling, the peak-of-the-mean dose distribution should be used for demonstrating compliance with its License Termination Rule in 10 CFR Part 20, Subpart E.)*

Probabilistic analysis. In a probabilistic analysis, statistical distributions are defined for input parameters to account for their uncertainty, and the analysis results reflect the resulting uncertainty, e.g., a distribution of values rather than a single value. Such analyses use a random sampling method to select parameter values from a distribution. Results of the calculations appear in the form of a distribution of values.

Rank correlation coefficient. A correlation coefficient between two variables that is used for determining the relative importance of input parameters in influencing the resultant dose.

Triangular distribution. In a triangular distribution of a continuous random variable, the graph of the probability density function forms a triangle, with a range defined by minimum and maximum values and a mode value which is the most frequent (probable) value.

Uniform distribution. In a uniform distribution, each value within the range has the same probability of occurrence.

Acronyms

CZ	contamination zone
DCGL	derived concentration guideline level
$DCGL_W$	derived concentration guideline level, wide
K_d	distribution coefficient
m	meter
MB	mass balance (RESRAD groundwater model)
POTM	peak of the mean
PRCC	partial rank correlation coefficient
RAI	request for additional information
SB	subsurface soil
STOMP	Subsurface Transport Over Multiple Phases (computer model)
SS	surface soil
SZ	saturated zone
ULT	unweathered Lavery till
UZ	unsaturated zone
WEPP	Water Erosion Prediction Project (computer model)
WMA	waste management area
y	year