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April 17, 2023 DRC-2023-003415 CD-2023-085

Mr. Doug Hansen, Director
Division of Waste Management and Radiation Control
P.O. Box 144880
Salt Lake City, UT 84114-4880

Subject: Responses to Federal Cell Facility Application Request for Information – DRC-2023-002667

Dear Mr. Hansen:

Energy*Solutions* hereby responds to the Utah Division of Waste Management and Radiation Control's April 7, 2023 Request for Information (RFI) on our Federal Cell Facility Application.[1] A response is provided for each request using the Director's assigned reference number. A revised copy of Appendix AB, *Clive Operational Period RESRAD Analysis* and associated references reflecting responses to the Director's request are attached. This revised Appendix is not subject to the Permanent Claim of Business Confidentiality previously asserted.[2]

Appendix AB: Operational Period Modeling

AB-1: A preliminary review of the Federal Cell License application indicates the RESRAD input files for Appendix AB, OPERATIONAL PERIOD MODELING, of the license application were not located. These electronic files are needed to verify and interpret the results of the modeling. Please provide the electronic files or indicate where they are in the application:

RESRAD model input files that serve as the basis for projection of occupational exposures during operation of the proposed Federal Cell Facility are included in subfolder entitled, *RESRAD Model Files* in the enclosed Appendix AB, *Clive Operational Period RESRAD Analysis* of the Federal Cell Facility Radioactive Material License Application. The RESRAD files represent two operational scenarios for the Federal Cell Facility (one considering releases based on isotopic distribution coefficient (K_d) and one assuming a 1% annual release fraction (files

[1] Hansen, D.J. "Federal Cell Facility Application Request for Information." via DRC-2023-002667 from the Utah Division of Waste Management and Radiation Control to Vern Rogers of Energy*Solutions*, April 7, 2023.

[2] Rogers, V.C. "Radioactive Material License Application for a Federal Cell Facility Submitted under Permanent Claim of Business Confidentiality." (CD-2022-142), Letter from Energy*Solutions* to Doug Hansen of Utah's Division of Waste Management and Radiation Control, August 4, 2022

with the R1 name designation). The RESRAD model files added to Appendix AB include:

1) SumaryReport.txt
2) RadonFlux.txt
3) OP_PERIOD.ROF
4) SumaryReport R1.txt
5) RadonFlux R1.txt
6) OP_PERIOD R1.ROF

If you have further questions regarding the response to the director's request of DRC-2023-002667 and revision of Appendix AB to the Federal Cell Facility Radioactive Material License Application, please contact me at (801) 649-2000.

Sincerely,

Vern C. Rogers
Director, Regulatory Affairs

enclosure

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

APPENDIX AB

CLIVE OPERATIONAL PERIOD RESRAD ANALYSIS

Analyses in the Appendix AB includes:

- Clive Operational Period RESRAD Analysis.
- RESRAD Model Files Folder

Operational Period Modeling of Depleted Uranium Radionuclide Concentrations in Groundwater, Pond Water, Pond Biota, and Air, and Modeling of Radon Ground Surface Flux

A screening calculation of potential radionuclide concentrations in the groundwater, surface water, biota, and air pathways is conducted for the Federal Cell Facility using the waste inventory and other applicable parameters from the Depleted Uranium (DU) PA v2.0. The modeling is performed using RESRAD-OFFSITE version 4.0. Parameter values are tabulated below.

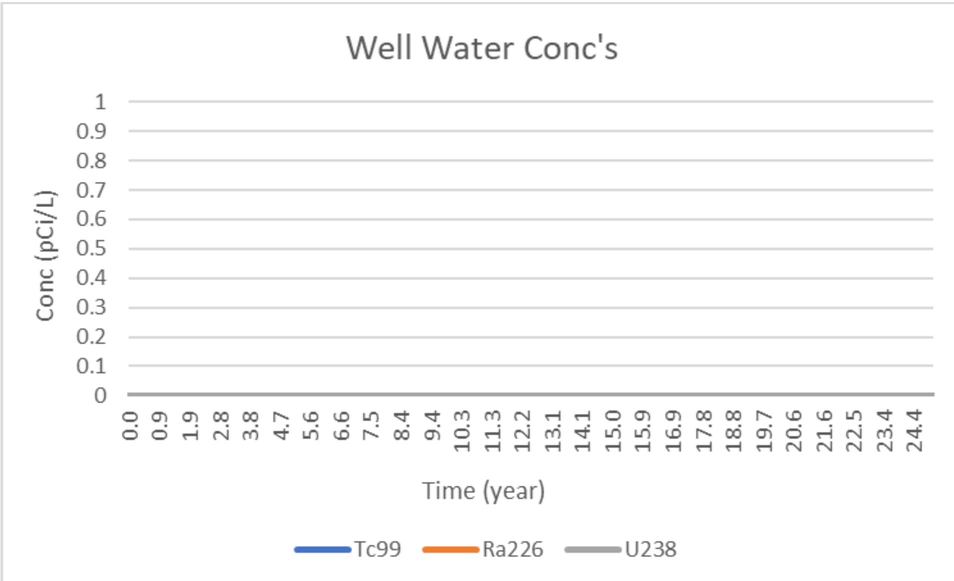
The operational period model assumes that the well is located 90 ft from the edge of the contaminated zone (CZ), and applies DU PA model K_d values as well as physical characteristics for the vadose and saturated zones.

The availability of soluble radionuclides over time for leaching to groundwater is modeled as a first-order process with a user-specified rate of 0.01 per year, such that 1% of the available radionuclide mass is leached from the CZ annually. This leach rate was applied to soluble radionuclides to account for the DU being containerized when placed in the disposal cell, then having CLSM poured over and around it within a relatively short period of time. Because concentrations in the CZ affect releases to the atmosphere and to surface runoff, the value of the leach rate also affects these pathways. The assumption of a 0.01 /yr leach rate results in delayed leaching to groundwater and higher CZ soil concentrations of I-129, Tc-99 and uranium isotopes over time than would be the case were their leach rates calculated using the K_d values for these more-soluble radionuclides. For all other radionuclides, assuming a 0.01 /yr leach rate would result in unrealistically high leaching from the CZ followed by strong retardation in the vadose and saturated zone. Therefore, a more-protective estimate of their mobilization from the CZ is achieved using K_d-derived leach rates.

Results Summary

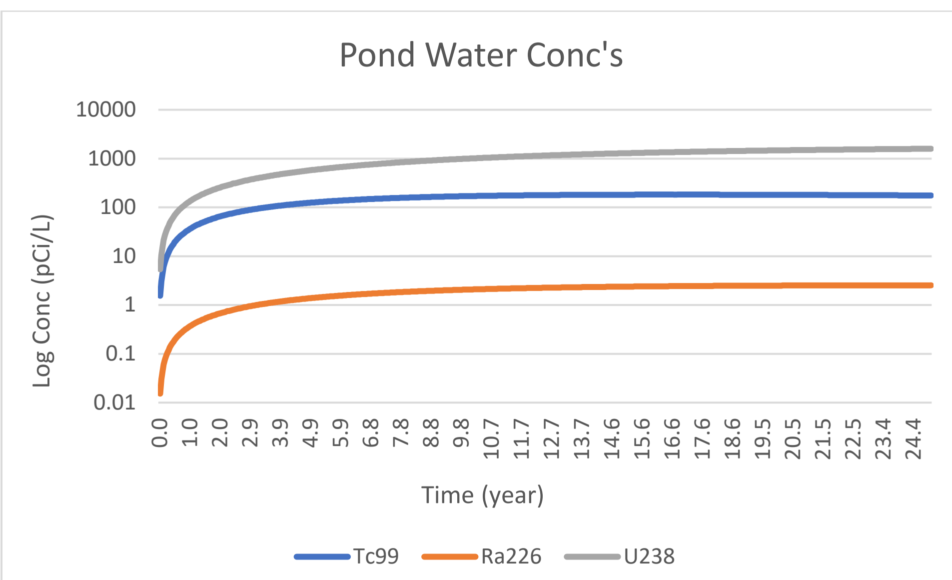
The results of the operational period screening of radionuclide concentrations in groundwater, retention pond surface water, retention pond biota, and particulates in air above the CZ is summarized in the following paragraphs. Additionally, the results of screening calculations of radon flux are presented. Quantitative modeling results for each medium is provided as concentration time-series for three of the 16 radionuclides comprising the DU inventory (Tc-99, Ra-226, and U-238). These radionuclides were selected for display in the time series for the following reasons: Tc-99 is the only radionuclide that reaches the groundwater well within the operational period; Ra-226 controls the radon surface flux results; and U-238 has the highest concentrations among all DU inventory radionuclides.

Groundwater. The only radionuclide reaching groundwater within 50 years of operations is Tc-99, which arrives at about model year 35. So, within an assumed 20-year operating period there is no breakthrough to groundwater. At model year 40, Tc-99 groundwater well concentrations are approximately 0.006 pCi/L.

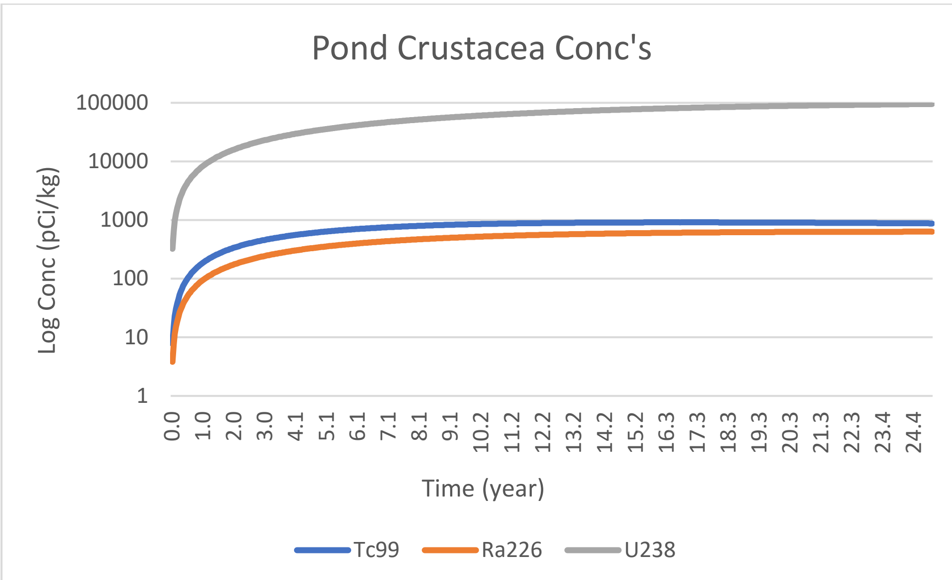


Pond Water.

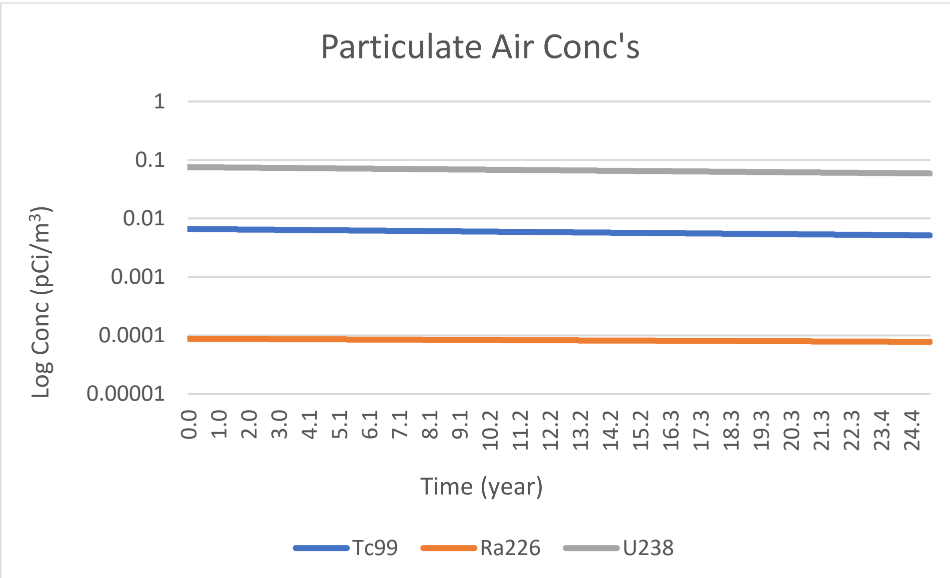
Radionuclide transport to the retention pond through CZ erosion by runoff and atmospheric deposition is tracked through modeled water concentrations, which are in equilibrium with pond sediments having an assumed active partitioning layer of 5 cm thickness. Pond water concentrations of radionuclides increase quickly and then level off over time before gradually falling. Tc-99 reaches 90% of its maximum pond water value by model year 9, and Ra-226 pond concentrations reach 90% of their maximum value by model year 12. For uranium isotopes, 90% of peak pond water concentrations occur within model year 20.



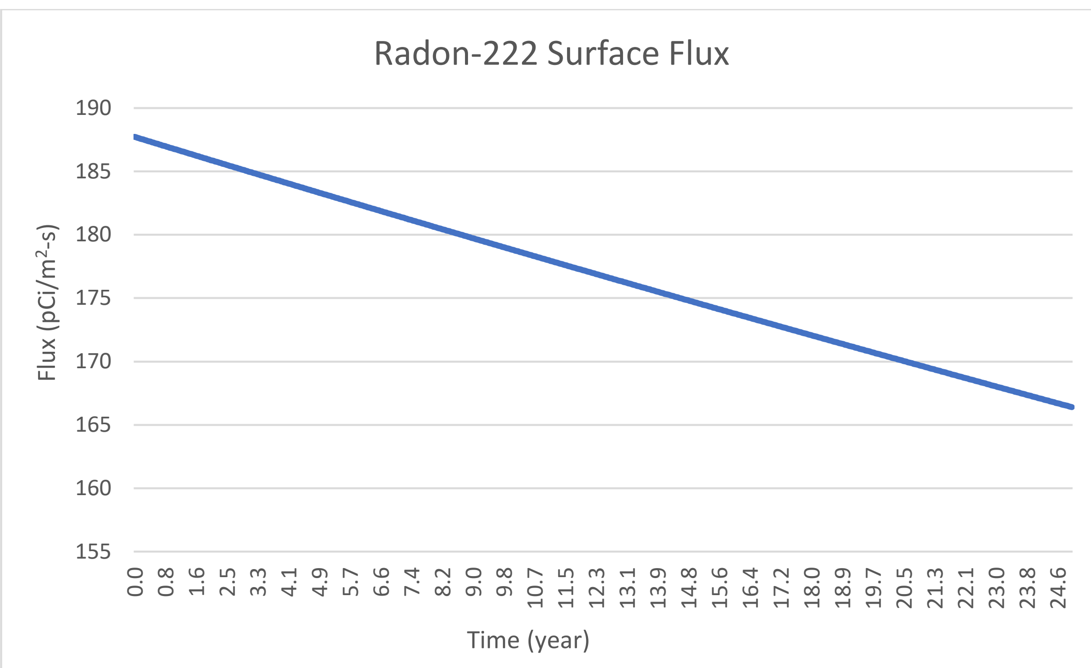
<u>Pond Biota</u>. RESRAD-OFFSITE includes modeling of radionuclide uptake into fish and crustacea inhabiting a surface water body. The stormwater retention body is assumed to host small invertebrates, which are represented by crustacea in the RESRAD model. Crustacea tissue concentrations are modeled in RESRAD based on element-specific partitioning among three media: pond water, pond sediment, and crustacean tissue. Over a 20-year modeling period, tissue concentrations of Ra-226 and Tc-99 reach approximately 6 and 9 pCi/g, respectively. Tissue concentrations of U-238 are about tenfold higher, reaching close to 90 pCi/g by model year 20.



Particulates in Air. Concentrations of radionuclides above the assumed soil source term of the CZ are modeled using default RESRAD-OFFSITE particulate resuspension and atmospheric mixing assumptions. Air concentrations are directly proportional to the virtual soil concentrations of these radionuclides. The modeled air concentrations decrease over time because a lesser amount of soluble radionuclide is released to the CZ over time with the first-order leaching rate, and residual concentrations of less-soluble radionuclides decrease more slowly over time due to their lower rate of leaching.



Radon Flux. Radon-222 flux to the atmosphere, like particulate air concentrations, also decreases with time over the operational period. The initial ground surface flux of approximately 190 pCi/m^2-s decreases to about 170 pCi/m^2-s at model year 20. The rate at which Rn-222 flux decreases with time is approximately proportional to the decrease in the concentration of its parent (Ra-226) in the CZ.



RESRAD-OFFSITE v4.0 Clive Operational Period Model Parameter Values

Parameter Description	Units	Value	Reference	Notes
Preliminary Inputs				
Radionuclide release	–	–		Exponential release over time (proportional to inventory) with a user-specified first-order leach rate of 0.01 /yr for soluble radionuclides I-129, Tc-99, uranium isotopes. K_d-derived leach rates are internally calculated by RESRAD for all other radionuclides.
Number of unsaturated zones	unitless	2		A 1-ft clay liner atop the native UZ
Active Exposure Pathways				
Set Pathways				Aquatic Foods, Drinking Water, and Radon activated
Distribution Coefficients				
Contaminated Zone; Unsat Zone 2 (Unit 3)	ml/g			Deterministic values for Unit 3 (sand) taken from Clive DU PA Model v2.01.
Unsat Zone 1 (clay liner)	ml/g			Deterministic values for clay taken from Clive DU PA Model v2.01.
Saturated Zone	ml/g			Deterministic values for clay taken from Clive DU PA Model v2.01.
Suspended and bottom surface water body sediments	ml/g			Deterministic values for silt taken from Clive DU PA Model v2.01.
Site Layout				
Bearing of x-axis (clockwise from N)	degrees	90	CAW Final Drawing 10014, C01, Rev. 2	Orientation of Class A West embankment is approximately in line with N-S axis.
X dimension of primary contamination	m	30.48		Assumed open area for DU placement
Y dimension of primary contamination	m	30.48		Assumed open area for DU placement

Parameter Description	Units	Value	Reference	Notes
X,Y coordinates: fruit, grain, non-leafy and leafy vegetables, pasture, grain, dwelling	m			Not applicable. Only groundwater and surface water pathways are of interest.
X coordinates: surface water body (small, large)	m	-20.51, 50.99		Southwest pond area (55,000 ft^2 [5110 m^2]), 71.5 m length centered on y-axis midpoint of cont. zone
Y coordinates: surface water body (small, large)	m	100, 171.5		Southwest pond area (55,000 ft^2 [5110 m^2]), 71.5 m length
Site Properties				
Precipitation	m/yr	0.2138		100-year daily records of precipitation generated by HELP.
Rainfall and runoff factor	unitless	160	RESRAD default	A measure of the energy of the rainfall; used to calculate erosion rate and surface soil concentrations. (RESRAD-OFFSITE internally-calculated erosion rate is 1.0E-05 m/yr)
Contaminated Zone Physical/Hydrological Parameters				
Length parallel to aquifer	m	30.48		Square site of 10,000 ft^2 area, assumed to have one axis parallel to flow direction.
Depth of soil mixing layer	m	0.15	RESRAD default	Well below assumed 1-m thickness of the CZ.
Deposition velocity of dust	m/s	0.001	RESRAD default	Not applicable. Transport of contamination to an offsite location is not modeled.
Irrigation	m/yr	0		No irrigation on a disposal cell is assumed.
Evapotranspiration coefficient	unitless	0.8	RESRAD default	Set at minimum value such that volumetric recharge rate through the CZ is not less than the GW flow rate of 35.76 m^3/yr beneath the CZ (a RESRAD requirement for the code to run).

Parameter Description	Units	Value	Reference	Notes
Runoff coefficient	unitless	0.1		RESRAD v6 Manual Table E.1; tight impervious clay. Treat CZ as clay liner in this respect.
Rainfall and runoff factor	unitless	160	RESRAD default	A measure of the energy of the rainfall; used to calculate erosion rate and surface soil concentrations.
Slope-length-steepness factor	unitless	0.4	RESRAD default	Accounts for the effect of terrain on erosion; used to calculate erosion rate and surface soil concentrations.
Cover and management factor	unitless	0.003	RESRAD default	Accounts for the effects of land use (forest, pasture), vegetation (type and height), and management practices (mulching, crop rotation) to calculate erosion rate and surface soil concentrations.
Support practice factor	unitless	1	RESRAD default	Accounts for conservation practices to manage erosion; used to calculate erosion rate and surface soil concentrations.
Thickness of contaminated zone	m	1		Approximate DU container height
Thickness of clean cover	m	0		
Soil erodibility factor of contaminated zone	ton/ac	0.349		Varied from RESRAD default of 0.4 to produce erosion rate of 1E-05 m/yr.
Total porosity of contaminated zone	unitless	0.4	RESRAD default	
Effective porosity of contaminated zone	unitless	0.4	RESRAD default	
Dry bulk density of contaminated zone	g/cm^3	1.5	RESRAD default	
Contaminated zone field capacity	unitless	0.3	RESRAD default	
Contaminated zone b parameter	unitless	5.3	RESRAD default	
Contaminated zone hydraulic conductivity	m/yr	10	RESRAD default	
Contaminated zone longitudinal dispersivity	m	0.05	RESRAD default	
Fraction of eroded radionuclides deposited in the surface water body		1	RESRAD default	Consistent with site CSM for evaluating groundwater and surface water impacts.

Parameter Description	Units	Value	Reference	Notes
Unsaturated Zone Hydrology				
Number of unsaturated zone strata	unitless	2		Stratum 1 is the 1-ft clay liner, below which the unsaturated zone (stratum 2) is primarily Unit 3 materials.
Clay liner unsaturated zone thickness	m	0.3048		Assumed 1-ft clay liner.
Clay liner unsaturated zone hydraulic conductivity	m/yr	0.315		Clay liner has maximum design permeability of 1E-06 cm/s
Clay liner unsaturated zone b parameter	unitless	11		RESRAD v6 Manual Table E.2; clay.
Zone 3 unsaturated zone thickness	m	3.93		Calculated from CAS embankment measurements as the mean value of Zone 3 thickness. Mean Zone 3 thickness computed by interpolating data from the 4 corners of the embankment. Thickness at each corner calculated as the elevation of the bottom of the clay liner minus the water table elevation.
Zone 3 unsaturated zone dry bulk soil density	g/cm^3	1.61	Bingham Environmental 1991; Appendix B	Calculated as particle density × (1 - total porosity). A particle density of 2.65 g/cm3 was assumed based on the higher of values calculated by Colorado State University Porous Media Laboratory from two Unit 3 borehole cores.
Zone 3 unsaturated zone total porosity	unitless	0.393		Based on the saturated moisture content of Zone 3. Estimate calculated with Monte Carlo methods using data from two Unit 3 borehole cores.
Zone 3 unsaturated zone effective porosity	unitless	0.393		Effective and total porosity assumed to be identical.
Zone 3 unsaturated zone field capacity	unitless	0.232		Based on Unit 3 soil texture of 45% sand, 39% silt, and 15% clay (Appdx 10.5, Unsaturated Zone Modeling). Field capacity from Table 4 of Schroeder et al, (1994a); HELP soil class 8 (loam).

Parameter Description	Units	Value	Reference	Notes
Zone 3 unsaturated zone hydraulic conductivity	m/yr	227		Associated with silty loam soil texture (Yu et al 2001; Table E.2).
Zone 3 unsaturated zone b parameter	unitless	5.3	RESRAD default	
Zone 3 unsaturated zone longitudinal dispersivity	m	0.14		Higher values of longitudinal dispersivity result in shorter radionuclide transport times. Longitudinal dispersivity is a function of the length of the flow path (Gelhar et al, 1992). The ratio of dispersivity to unsaturated zone thickness for the RESRAD-OFFSITE default values is 0.025. This is less than a value of 0.036 based on linear regression of the data shown in Figure 1 of Gelhar et al (1992). The higher ratio of 0.036 was protectively applied to calculate dispersivity as 0.036 × 3.93 m.
Saturated Zone Hydrology				
Thickness of the saturated zone	m	4.94	Envirocare 2000; Envirocare 2004	Calculated as the mean of a normal distribution from measurements at wells GW-19B, GW-27D, GW-25, and GW-1.
Dry bulk density of saturated zone	g/cm^3	1.57	Whetstone 2000; Section 7.1.2	
Saturated zone total porosity	unitless	0.29	Whetstone 2000; Section 7.1.3	
Saturated zone effective porosity	unitless	0.29		Effective and total porosity assumed to be identical.
Saturated zone hydraulic conductivity	m/yr	237.5	Whetstone 2011	
Saturated zone hydraulic gradient	unitless	0.001	Whetstone 2011	
Depth of aquifer contributing to well	m	4.94		Corresponds to the screened interval of the well. Assumed to be equal to the aquifer thickness.

Parameter Description	Units	Value	Reference	Notes
Saturated zone longitudinal dispersivity	m	0.99		Higher values of longitudinal dispersivity result in shorter radionuclide transport times. Longitudinal dispersivity is a function of the length of the flow path (Gelhar et al, 1992). The ratio of dispersivity to groundwater flow path length (distance to the well) for the RESRAD default values is 0.030. This is less than a value of 0.036 based on linear regression of the data shown in Figure 1 of Gelhar et al (1992). The higher ratio of 0.036 was protectively applied to calculate dispersivity as 0.036 × 27.4 m (90 ft).
Saturated zone horizontal lateral dispersivity	m	0.001		RESRAD default is 0.4, smaller values of lateral dispersivity are conservative because dilution in the aquifer is minimized.
Saturated zone vertical lateral dispersivity	m	0.001		RESRAD default is 0.02, smaller values of lateral dispersivity are conservative because dilution in the aquifer is minimized.
Water Use				
Human consumption rate	L/yr	730		2 L/day. UAC R317-6-2.
Number of humans consuming	unitless	2		RESRAD default is 4; lower water use corresponds to minimal required pumping rate and less dilution of contamination in well water (Yu et al 2007).
Use indoors of dwelling	L/day	100		RESRAD default is 225; lower water use corresponds to minimal required pumping rate and less dilution of contamination in well water (Yu et al 2007).
Irrigation applied to fruit, grain, vegetables, pasture, livestock feed and dwelling	m/yr			Not applicable. Pathways limited to groundwater and surface water.

Parameter Description	Units	Value	Reference	Notes
Well pumping rate	m^3/yr	75		RESRAD default is 5100. Minimum water need calculated in RESRAD-OFFSITE is 74.5 m^3/yr. Smaller values minimize radionuclide dilution and are more protective.
Occupancy				
Fraction of time spent on primary contamination (outdoors)		1		Specified for evaluation of radon air concentrations.
Groundwater Transport				
Distance parallel to aquifer flow from downgradient edge of contamination to well	m	27.4		A 90 ft distance is defined in the license application.
Distance perpendicular to aquifer flow from center of contamination to well	m	0		The well is assumed to be located in the center of the groundwater flow path from the embankment.
Distance parallel to aquifer flow from downgradient edge of contamination to surface water body	m	–		Not relevant; no connectivity specified between aquifer and pond.
Distance perpendicular to aquifer flow from center of contamination to surface water body	m	–		Not relevant; no connectivity specified between aquifer and pond.
Convergence criterion	unitless	0.001	RESRAD default	RESRAD default is 0.001.
Number of saturated zone sub zones (to model dispersion of progeny)	unitless	1	RESRAD default	
Number of partially saturated zone sub zones (to model dispersion of progeny)	unitless	1	RESRAD default	
Surface Water Body				
Volume of surface water body	m^3	8328	Energy*Solutions* 2020 annual groundwater report	2.2M gallons on July 2020
Potential evaporation	m/yr	0		Maintains constant water volume

Parameter Description	Units	Value	Reference	Notes
Stream outflow as a fraction of total outflow		1.		Internally calculated by RESRAD using inflow ratio
Thickness of sediment layer in partitioning equilibrium with water	m	0.05	RESRAD default	
Size of catchment area	m^2	10,500		Internally calculated by RESRAD; x- and y-coordinates specified such that watershed is about twice the size of the pond.
Sediment delivery ratio		1.		Internally calculated by RESRAD using size of catchment area.
Fraction of deposited radionuclides reaching surface water body		1		Deposited quantity of radionuclides reaching catchment approximated by atmospheric release.