CHALLENGES AND REWARDS OF DERIVING SITE-SPECIFIC DERIVED CONCENTRATION GUIDELINE LEVELS (DCGLs)

H.T. Downey, J.W. Lively, N. Walter
MACTEC

ABSTRACT

The Nuclear Regulatory Commission (NRC) has established screening values for common radionuclides in surface soils that may be used to demonstrate compliance with the requirements for license termination. Depending upon the radionuclide and level of residual radioactivity, these values may be satisfactory or site-specific values can be derived using computer modeling with the RESidual RADioactivity (RESRAD) code. RESRAD allows for pathway modeling of radionuclides through the environment and calculates potential doses to individuals in various exposure scenarios. The challenge of deriving site-specific derived concentration guideline levels (DCGLs) is to establish parameters in RESRAD that are realistic and acceptable to the regulatory agencies. The benefits of deriving site-specific DCGLs are: the dose (risk) resulting from any residual radioactivity is more representative of the actual conditions at the site; generally less remediation is needed; Final Status Surveys (FSS) will require fewer samples; and the potential dose from any location of elevated measurement can be easily calculated. All of these benefits result in a more realistic DCGL without reducing the protection of the public and an overall cost savings for the project. An example of this process is a former nuclear fuel manufacturing site in the northeast that is undergoing decommissioning and recently had Site-specific surface soil DCGLs for enriched uranium and byproduct radionuclides approved by the NRC. These DCGLs were derived at 20.6 Bq/g (557 pCi/g) total uranium and 0.18 Bq/g (5 pCi/g) Co-60, which represent a potential dose of 0.19 mSv (19 mrem) per year from the resident farmer scenario. During the process of deriving DCGLs it became apparent from the regulatory agencies that specific RESRAD parameters would require detailed technical justification in order to use a less conservative value than the default. This process took several iterations of review cycles with the NRC and State agency in order to reach consensus on the parameters and scenarios used in RESRAD. This paper provides insight to the regulatory review process of DCGLs, the supporting detail needed to allow for the use of site-specific values for RESRAD parameters, the process to reduce the byproduct radionuclides from a potential list of twenty-two to only one constituent (Co-60), and which parameters to focus on for future derivations of site-specific DCGLs.

INTRODUCTION

A DCGL is a site-specific concentration determined to be protective of the health of individuals that might be exposed in the future to the residual radioactivity that might be left in place on the Site. The DCGLs have been calculated to meet requirements set by the U.S. Nuclear Regulatory Commission (NRC). To release this property from regulatory control and terminate the Site’s radioactive materials license, the risks to human health associated with potential exposure to radioactivity originating at the Site must be evaluated and demonstrated to be within acceptable limits. To comply with NRC criteria for Site release, the residual radioactivity at the Site must not contribute an annual radiation dose in excess of the NRC criteria and must be reduced to concentrations that are as low as reasonably achievable (ALARA) taking into account existing socio, political, and economic factors.

The Nuclear Regulatory Commission (NRC) has established screening values for common radionuclides in surface soils that may be used to demonstrate compliance with the requirements for license termination. In some cases it may be advantageous to derive site-specific using computer modeling with the RESidual RADioactivity (RESRAD) code. RESRAD allows for pathway modeling of radionuclides through the environment and calculates potential doses to individuals in various exposure scenarios. The challenge of deriving site-specific derived concentration guideline levels (DCGLs) is to select parameters in RESRAD that are realistic and acceptable to the regulatory agencies. The benefits of deriving site-specific DCGLs are: the dose (risk) resulting from any residual radioactivity is more representative of the actual conditions at the site; generally less remediation is needed; Final Status Surveys (FSS) will require fewer samples; and the potential dose from any location of elevated measurement can be easily calculated. All of these benefits result in a more realistic DCGL without reducing the protection of the public and offer an overall cost savings for the project.

An example of this process is a former nuclear fuel manufacturing site in the northeast that is undergoing decommissioning and recently had Site-specific surface soil DCGLs for enriched uranium and byproduct radionuclides approved by the NRC. The Site consists of approximately 500-acres and was formerly used to perform design, engineering support, and manufacturing of uranium fuel components for both commercial and government reactors. Lesser functions supported at this Site included thermo-hydraulic testing of non-irradiated nuclear reactor plant components, radiographic assay and testing of materials, and servicing of radiologically contaminated reactor plant components. Because of these past activities, enriched uranium (principally) and reactor byproduct materials (minimally) may have been released to the soils at the site via incidental particle transport mechanisms and by approved discharges via industrial waste discharge lines.

During the process of deriving DCGLs it became apparent from the regulatory agencies that specific RESRAD parameters would require detailed technical justification in order to use a less conservative value than the default. This process took several iterations of review cycles with the NRC and State agency in order to reach consensus on the parameters and scenarios used in RESRAD. This paper provides insight to the regulatory review process of DCGLs and the supporting detail needed to allow for the use of site-specific values for RESRAD parameters. In addition, this paper also describes the process to evaluate and technically justify the use of total uranium instead of the three individual radionuclides (U-234, U-235, and U-238) for the uranium profile, and the process to evaluate and technically justify the use of Co-60 instead of potentially twenty-two radionuclides for the byproduct profile.

Dose Modeling

Site-specific DCGLs were derived with the approach of making as many parameters as possible site-specific. After evaluating the sensitivity of various site parameters on the final DCGL, only a few parameters were significant for this site and so many parameters were changed back to the default value to ease regulatory review and acceptance. In particular, there were two parameters of concern with the NRC with the end result being that one was changed back to default and the other was technically justified for use in deriving the DCGLs. Dose modeling with RESRAD was performed for six different potential future exposure scenarios:

- An occupational worker employed at a facility located at the Site (most likely);
- A commercial truck farmer;
- A construction worker participating in a construction or excavation project at the Site;
- A recreational visitor using open park-like space (jogging, biking, etc.) at the Site;
- A residential occupant in a suburban residential setting; and
- A residential occupant in a resident farm setting (least likely).

The resident farmer scenario, while thought to be improbable, is evaluated as a gauge of the extent of potential annual dose that might be accrued by a receptor in the event that more likely projected and anticipated future land uses prove inaccurate. The resident farmer scenario is essentially a screening level analysis with most of the exposure parameters used in the modeling conservatively set to default values. The resident farmer receptor is assumed to live on the site, consume produce grown on the site, derive his drinking and irrigation water from potentially contaminated sources onsite, and to raise livestock onsite to supply the annual dietary intake of milk and meat products. In this capacity, the residential farming exposure scenario serves as a measure of the upper range of the uncertainty in the assumption of future Site land use.

Uncertainty in scenarios is the result of our lack of absolute knowledge about the future uses of the Site. It is important to recognize that the outlook evaluation time criterion (1000 years) is not intended to predict future scenarios for the next 1000 years, but to evaluate the continued protectiveness of a given DCGL for 1000 years into the future given the reasonable and plausible future uses of the Site in today's social and economic conditions.

Factors affecting the mechanisms for, and intensity of, human exposure must be identified, and appropriate values must be defined. Many of these factors are highly dependent upon Site-specific conditions (e.g., wind velocity), while others are more related to fundamental physical properties independent of the specific Site location (e.g., mass loading for inhalation). Many other factors are dependent upon the availability and projected activities of receptors (e.g., hours per day at the Site). To accurately determine the values to be used for many of these factors that become input parameters to the computer modeling codes, the risk assessor must first envision and characterize the plausible future exposure scenarios that a potential receptor may encounter. Among the advantages that RESRAD brings to a radiological dose or risk assessment is its ability to derive values for exposure parameters based on built-in fate and transport computations using well-defined site-specific data. It is also able to integrate dose and risk projections over time taking into account transient conditions over that period.

Regulatory Review

Several rounds of RESRAD modeling and regulatory review were needed with the NRC and State agency in order to establish the final version of acceptable parameters. In the end, each agency requested additional information or technical justification on different parameters. The NRC focused on two parameters: building shielding factor (SHF1) and distribution coefficient (K_d). On the other hand, the State agency requested the following conditions for dose-modeling of the Site-specific DCGLs:

- DCGL may not give the average member of the critical group greater than 19 millirem/year total effective dose equivalent, plus As Low As Reasonably Achievable (ALARA).
- The liquid intake for all receptors must be at least 2.0 liters total per day with a minimum of 0.4 liters per day of milk and 1.0 liter per day of water.
- Resident farmer scenario
- Input parameters other than the RESRAD default require a specific written proposal with the appropriate technical analyses.

Building Shielding Factor (SHF1)

The first parameter that the NRC questioned was the building shielding factor (SHF1). This parameter represents the attenuation of direct gamma radiation exposure to individuals while inside a building on Site as compared to being outside directly over the soil (source). The concept is that during the period of time a receptor is indoors, there is a reduced (attenuated) gamma radiation field due to the shielding effect of the materials used to construct the structure the receptor is occupying. The default value in RESRAD is designed to account for numerous types of buildings/structures that are typical across the entire United States. Due to regional weather conditions across the United States, building construction codes and approved building methods vary significantly. As this Site is located in the northeast, the climate is such that due to the cold winter weather, footings for buildings must be deep in order to be below the frost line. This typically results in residential buildings with a basement as opposed to a slab, which would allow for a greater reduction in direct exposure due to the reduced source underneath the building due to excavation and greater shielding from the concrete foundation walls/floor. A Site-specific SHF1 was derived using the Microshield® code to evaluate the potential reduction in direct exposure from various types of buildings that might be present on the Site.

In order to model this scenario in MicroShield®, two cases were used; one to evaluate the dose to a receptor from residual radioactivity in soil directly underneath the footprint of the building, and another to evaluate the dose to the receptor from residual radioactivity in soil outside the building. The total dose is the sum of the two cases (dose originating from beneath the building and dose originating from outside the building). The Site-specific SHF1 considered variations in thickness of concrete slab, thickness of compacted soil, and wall material and thickness. Direct exposure was calculated for numerous combinations of the materials/thickness and compared to the direct exposure with no shielding present. The results of this modeling were a central tendency of 0.05 with a range from 0.01 to 0.20.

The NRC accepted a more sophisticated approach to determining SHF1, however they indicated that it needed to account for all types of buildings that could be present in the future, including homes with crawl spaces and mobile homes. Although these other types of buildings are not common construction types in the region, they provide very little or no shielding from the flooring material as compared to the other construction types. The effect of including these construction types was estimated to change the distribution of SHF1 values such that the central tendency would be closer to 0.11, which more than doubles the proposed value. An additional complication was discovered in the MicroShield® modeling with respect to the geometries used (limitation of the code) that increased the uncertainty of the modeling results. Even though this value would be more favorable than the default RESRAD value (0.27), the potential increase in DCGLs did not seem to be compensated by the effort required to technically justify a site-specific value. Therefore the default RESRAD value for SHF1 was used in the final version of the DCGLs.

Distribution Coefficient (K_d)

Distribution coefficients (K_d) describe the partitioning of soluble concentrations of radionuclides introduced to a soil column between solid (soil) and liquid phases. It is a key parameter influencing the migration of radioactivity from surface soils to groundwater. Distribution coefficients for a given chemical species (e.g., uranium) can vary over many orders of magnitude depending on the soil type, pH, redox potential, and presence of other ions.

Two site-specific sampling programs have been undertaken at the Site to assess the site-specific K_d for uranium (Wang 1996, ENSR 2001). The results of these studies indicated that K_d values were much higher for surface soils and decreased to low values around 3 meters below ground surface (bgs). As most of the residual radioactivity that would remain following decommissioning would be in the surface soils, the initial site-specific K_d value was derived from only the surface soil values. The NRC indicated that the lower K_d values should not be ignored since they could account for significant changes in the water-related pathways. The approach to resolve this issue was to create three different distributions of K_d values based on depth.

These three different distributions are used to represent the uranium K_d parameter. One distribution, based on measured desorption K_d in contaminated surface soils is used for the "contaminated layer" in the RESRAD model. A second distribution, based on measured adsorption K_d in soils lying within the top 2 meters bgs is used for "unsaturated layer #1" in the RESRAD model. A third distribution, based on measured adsorption K_d in soils lying more than 3 meters bgs is used for both the "unsaturated layer #2" and "saturated layer" in the RESRAD model. Figure 1 graphically illustrates the conceptual Site model of these layers that the K_d parameters represent.

The first layer distribution was based upon 11 K_d values from the two reports that evaluated site-specific K_d values. In the study performed by Wang, eight surface soil samples from various locations were tested for desorption K_d (transfer of radioactivity from soil to water). The results ranged from 1,760 to 22,800 ml/g with an average of 8,591 ml/g. In the study performed by ENSR, three soil samples were tested for desorption K_d. The desorption K_d samples were from different locations across the Site and the results ranged from 1,700 to 20,000 ml/g with an average of 8,922 ml/g.

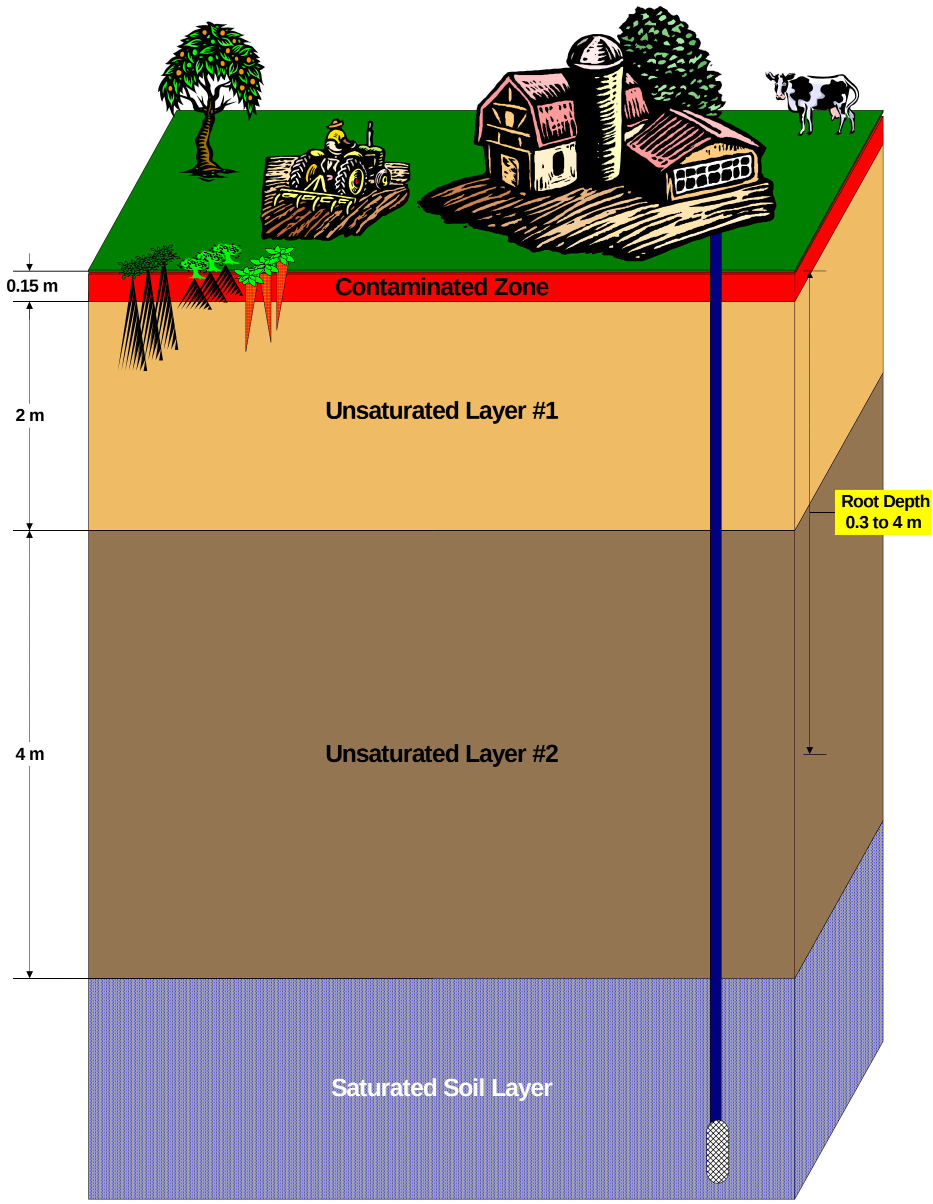

Fig. 1. Conceptual site model depicting the K_d layers

Comparing the two studies reveals that the desorption K_d values are comparable since the range and mean for both sets are essentially identical and therefore can be considered one population. This provides data from 11 locations and can be considered a reasonable approximation for the Site. The desorption K_d values are summarized in Table I and are applicable for the contaminated layer in RESRAD. K_d for the contaminated layer has a central tendency of 8,700 ml/g with a range of approximately 1,700 to 40,000 ml/g.

Table I. Uranium K_d Values for Surface Soil (Contaminated) Layer

Source	**Uranium Distribution Coefficient (K_d), ml/g**		
	U-234	**U-235**	**U-238**
ENSR 2001	20000	20000	10000
ENSR 2001	8000	7000	8000
ENSR 2001	3000	2600	1700
Wang 1996	4360		5680
Wang 1996	2220		2720
Wang 1996	8290	8650	18100
Wang 1996	20500	22800	22500
Wang 1996	14600	10800	11600
Wang 1996	5170	5480	11600
Wang 1996	2060	2380	2590
Wang 1996	1760	1920	3230
Minimum	1.700 ml/g		
Average	8.687 ml/g		
Maximum	22.800 ml/g		

The site-specific K_d studies suggest the need to use two distinct values for K_d in the underlying unsaturated soils depending upon the depth of the soil below the ground surface. This is because measured K_d values for uranium isotopes in near surface soils are markedly different from those measured in deeper subsurface soils. The demarcation point below which the uranium K_d appears to change markedly is approximately 2 meters below ground surface (bgs). Consequently, the underlying unsaturated layer at the site has been subdivided into two unsaturated layers. The uranium K_d for the uppermost layer (unsaturated layer #1) is derived from adsorption K_d measurements made on samples collected from 0 to 2 meters bgs. Uranium adsorption K_d measurements made on samples collected from deeper than 2 meters are used to derive the probabilistic K_d distribution used for unsaturated layer #2.

The adsorption K_d values (transfer of radioactivity from water to soil) were only evaluated in the ENSR study (ENSR 2001). Table II contains measured adsorption K_d values from soils between 0 to 2 meters bgs. Based on the Site-specific data available, uranium K_d values in unsaturated zone #1 have been described in RESRAD with a lognormal-N distribution having a central tendency of 3,300 ml/g and a range of approximately 3,000 to 3,600.

Table II. Uranium K_d Values for Unsaturated Layer #1

Depth (m)	Uranium Distribution Coefficient (K_d), ml/g		
	U-234	U-235	U-238
0 - 0.15	3600	3400	3500
1.5 - 2	3100	3200	3000
Minimum	3,000 ml/g		
Average	3,300 ml/g		
Maximum	3,600 ml/g		

Table III contains measured adsorption K_d values from soil samples collected from depths 3 meters and greater bgs. Based on the Site-specific data available, the uranium K_d value in

Unsaturated zone #2 has been described in RESRAD with a lognormal-N distribution having a central tendency of 125 ml/g (the RESRAD default) and a range of approximately 6 to 2,500 ml/g.

Table III. Uranium K_d Values Unsaturated Layer #2

Depth (m)	Uranium Distribution Coefficient (K_d), ml/g		
	U-234	U-235	U-238
3	7	8	7
4.6 – 4.9	450	470	440
5.5 - 6	10	13	8.6
Minimum 7 ml/g			
Average 157 ml/g			
Maximum 470 ml/g			

The uranium K_d in the Saturated Layer is the same RESRAD default probabilistic distribution (lognormal-N) used for Unsaturated layer #2. It is conservatively assumed that the near surface, water-bearing zone produces a sufficient quantity of drinking quality water to support all water demands that might be placed upon it and that the water would be extracted thru onsite wells placed at the down gradient edge of the source term.

This approach to creating layers based upon the K_d distributions utilizing all the site-specific K_d values was accepted by the regulatory agencies and incorporated into the final version of dose modeling with RESRAD.

Uranium Profile

To determine the consequence of various enrichments upon the soil DCGL, a series of RESRAD calculations were performed. The source term was adjusted iteratively with uranium isotopic ratios associated with enrichments from 0.1% to 95%. The total uranium activity was held constant. The result, graphically presented in Figure 2, shows that for a constant total uranium activity in soil, the lower enrichments produce nearly equivalent but slightly greater dose than higher enrichments. Uranium enrichments ranging from 3.5% to 95% produce a virtually flat (<15% variance) dose response allows for the use of a single uranium in soil DCGL without regard to the enrichment. To ensure that the uranium in soil DCGL will be derived to be protective of the annual dose limits without regard to enrichment, the DCGL was derived conservatively assuming that the uranium isotopes are present in ratios associated with 3.5% EU. This approach was accepted by the regulatory agencies and incorporated into the final version of dose modeling with RESRAD.

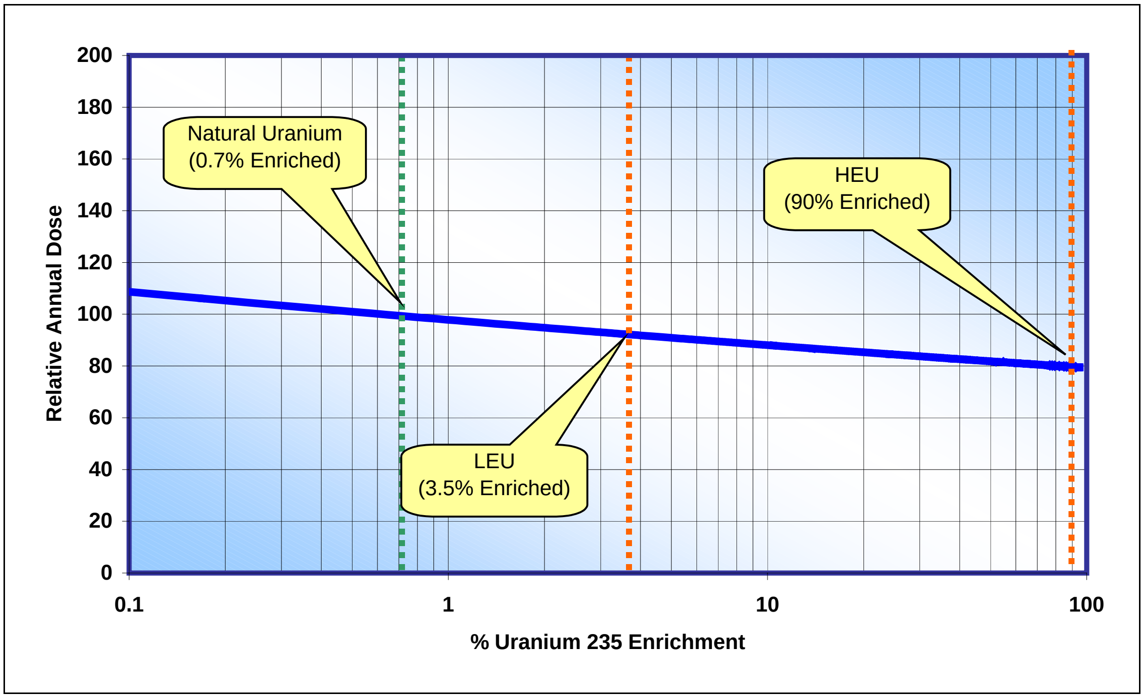

Fig. 2. Effect of Uranium enrichment on projected future dose

Byproduct Profile

The process to determine the appropriate byproduct radionuclide profile to be used in the byproduct source term in deriving soil DCGLs for the Site entails several steps. First, the potentially enormous number of byproduct radionuclides must be narrowed down to just those present at the Site. Next, the relative proportions of these radionuclides needs to be established. Finally, this site-specific mixture is evaluated to ascertain which radionuclides are most important in terms of their ability to produce dose and thus affect the DCGL. To accomplish this, a sensitivity analysis utilizing RESRAD was devised to assess the relative effectiveness of each byproduct radionuclide detected at the site to produce dose. This process provides assurance that the byproduct source term used in the derivation of the soil DCGL is representative of the byproduct radionuclides present at the site and appropriately conservative for its intended use in the derivation of the site-specific soil DCGLs.

The byproduct radionuclide profile was derived from three distinct data sources containing site-specific data. These data were normalized using the ratio of individual radionuclides (including "hard-to-detect" radionuclides) to Co-60. The maximum ratio for each radionuclide was selected from each data set and then these maximum values were compared with maximum ratios from each of the other data sets to select the overall maximum ratio for each radionuclide. The overall maximum ratios were utilized to create an ultra conservative input mixture for RESRAD in order to perform a sensitivity analysis on the dose produced by each radionuclide in the mixture. The resident farmer scenario was used to perform the sensitivity analysis.

The result of the RESRAD run is summarized in Table IV. The maximum dose occurs at time equals zero years . The results show that the primary dose producing radionuclides are Co-60

(86.6%), Cs-137 (7.0%), Cs-134 (2.7%), and Mn-54 (2.3%). The rest of the radionuclides individually produce less than 1% of the total annual dose equivalent. The sensitivity analysis reveals that only four of the twenty-two radionuclides are potent enough in terms of their dose-producing potential to contribute even as much as 1% of the total annual dose to a resident farm receptor. Only Co-60 is capable of producing as much as 10% of the total annual dose to a resident farm receptor. No isotope other than Co-60 contributes a dose approaching even 1 mrem/yr at any time in the 1000-year outlook. After approximately 10 years, the potential dose contribution from byproduct materials has been reduced to only a few millirem per year primarily through radioactive decay of Co-60. Additional evaluation of the results shows that only the external (penetrating) gamma radiation pathway produces any significant dose.

Table IV. RESRAD Input and Results - Byproduct Radionuclide Profile

Radionuclide	RESRAD Input		RESRAD Results		Dose Fraction
	Bq/g	pCi/g	mSv/y	mrem/y	
Ag-110m	0.00035	0.0095	0.00007	0.00703	0.0002
Am-241	0.00383	0.1035	0.00022	0.02190	0.0005
C-14	0.00018	0.0050	0.00002	0.00204	0.0000
Cm-243	0.00085	0.0230	0.00011	0.01064	0.0002
Cm-244	0.00085	0.0230	0.00002	0.00244	0.0001
Cm-245	0.00424	0.1145	0.00046	0.04569	0.0010
Cm-246	0.00424	0.1145	0.00023	0.02266	0.0005
Co-57	0.00388	0.1050	0.00020	0.02023	0.0005
Co-60	0.18498	5.0000	0.38640	38.64000	0.8660
Cs-134	0.01010	0.2730	0.01222	1.22200	0.0274
Cs-137	0.05886	1.5910	0.03128	3.12800	0.0701
Fe-55	0.36228	9.7925	0.00004	0.00371	0.0001
H-3	1.14791	31.0280	0.00020	0.02033	0.0005
Mn-54	0.02074	0.5605	0.01038	1.03800	0.0233
Ni-63	0.04308	1.1645	0.00003	0.00259	0.0001
Pu-238	0.00141	0.0380	0.00007	0.00679	0.0002
Pu-239	0.00886	0.2395	0.00047	0.04745	0.0011
Pu-240	0.00886	0.2395	0.00047	0.04743	0.0011
Pu-241	0.16082	4.3470	0.00017	0.01703	0.0004
Sb-125	0.01273	0.3440	0.00040	0.03965	0.0009
Sr-90	0.00906	0.2450	0.00264	0.26350	0.0059
Zn-65	0.00126	0.0340	0.00008	0.00832	0.0002

At the time the DCGLs were being derived, guidance contained in the NRC's NMSS Decommissioning Standard Review Plan, NUREG-1727 (NRC 2000) for development of the site-specific DCGLs, acknowledged that a number of radionuclides might be present in the source term found at a site, yet "almost all of the dose would come from just one or two of the nuclides." This is clearly the case with the byproduct radionuclide profile as evidenced by the results of the sensitivity analysis. The NRC's decommissioning guidance suggests that in such cases, "the presence of nuclides that likely contribute less than 10% of the total effective dose equivalent may be ignored."

Considering that the sensitivity analysis confirms that only Co-60 is capable of producing contribute as much as 10% of the total effective dose equivalent, the isotope mixture used to derive the site-specific soil DCGL corresponding to the byproduct source term includes only Co-60. This approach was accepted by the regulatory agencies and incorporated into the final version of dose modeling with RESRAD.

More recent guidance from the NRC was issued since these DCGLs were derived and approved. Consolidated NMSS Decommissioning Guidance, NUREG-1757 Volume 2 (NRC 2003) provides a section titled "INSIGNIFICANT RADIONUCLIDES AND EXPOSURE PATHWAYS". Here insignificant is defined as no greater than 10% of the dose criteria and this is an aggregate limit. Furthermore, the dose from the insignificant radionuclides must be accounted for in demonstrating compliance with the dose criteria. This guidance would not change the approach that was used to derive the byproduct DCGL and the rest of the guidance does not apply until after Final Status Surveys are performed.

RESRAD Results

Once all the RESRAD parameters and regulatory issues had been addressed, a final dose modeling session was performed with RESRAD. Most of the parameters were the default value as previously discussed. As an example, a list of the modified RESRAD input parameters for the resident farmer scenario is provided in Table V.

Table V. Modified RESRAD Input Parameters – Resident Farmer Scenario

Parameter	Parameter
Area of Contaminated Zone [AREA]	Average Annual Wind Speed [WIND]
Cover Depth [COVER0]	Precipitation Rate [PRECIP]
Thickness of Contaminated Zone [THICK0]	Milk Consumption [DIET(3)]
Thickness of Unsaturated Zone #1[H(1)]	Drinking Water Intake [DWI]
Thickness of Unsaturated Zone #2[H(2)]	K_d (Uranium) [DCACTC, DCACTU1, DCACTU2, DCACTS]

The results of the RESRAD dose modeling are presented by scenario in Table VI. The approved DCGLs were the resident farmer scenario values of 20.6 Bq/g (557 pCi/g) total uranium and 0.18 Bq/g (5 pCi/g) Co-60, which represent a potential dose of 0.19 mSv (19 mrem) per year. An additional perspective of these DCGLs is provided in Table VII where the potential dose from all scenarios is calculated using the concentrations of the resident farmer DCGLs.

Table VI. RESRAD Dose Modeling Results by Scenario

Exposure Scenario	Average Residual Radioactivity Concentration in Soil Bq/g (pCi/g) equivalent to 0.19 mSv/y (19 mrem/y)	
	Total Uranium	**Co-60**
Occupational Worker	117.2 (3,167)	0.64 (17.3)
Construction Worker	170.9 (4,620)	0.88 (23.8)
Recreational User / Visitor	710.9 (19,216)	3.64 (98.5)
Truck Farmer	199.4 (5,390)	1.47 (39.6)
Suburban Resident	37.7 (1,020)	0.22 (5.9)
Resident Farmer	20.6 (557)	0.18 (5.0)

Table VII. Potential Dose in All Exposure Scenarios

Exposure Scenario	Potential Peak Mean Annual Dose mSv/y (mrem/y)	
	20.6 Bq/g (557 pCi/g) Total Uranium	**0.18 Bq/g (5.0 pCi/g) Co-60**
Occupational Worker	0.033 (3.3)	0.046 (4.6)
Construction Worker	0.023 (2.3)	0.04 (4.0)
Recreational User / Visitor	0.006 (0.6)	0.009 (0.9)
Truck Farmer	0.019 (1.9)	0.024 (2.4)
Suburban Resident	0.104 (10.4)	0.161 (16.1)
Resident Farmer	0.19 (19)	0.19 (19)

CONCLUSION

As shown by this example of deriving site-specific DCGLs many input parameters can affect the dose modeling, however the regulatory agencies will generally focus on any that have a significant impact as compared to the default conservatively derived values. The level of detail required in order to technically justify some changes to input parameters might not be worth the effort for the resultant change in DCGL, as shown in the case of the building shielding factor (SHF1). In other cases, having sufficient site-specific data will allow for modified input parameters that match the actual conditions at the site as was shown with the distribution coefficient (K_d) for uranium. It is also important to evaluate the potential to reduce the number of radionuclides that may need DCGLs since this will simplify and reduce costs in the FSS process. In any case, it is important to discuss the dose modeling with respect to site-specific parameters with the regulatory agencies that will be involved in the review and approval of the

DCGLs in order to develop a better understanding of the amount of technical justification warranted for the site-specific parameters.

Although the challenges involved with technical justification of site-specific parameters may be great, the rewards will be even greater. The benefit of this process is a more realistic (less conservative) DCGL without reducing the protection of the public. This translates into the potential for less remediation being needed, reduced number of FSS samples, and the ability to easily calculate the potential dose from any location of elevated measurement. From the Site presented as an example, it is anticipated that the benefits of deriving the site-specific DCGLs using the best available data will result in less remediation of surface soils, most of the site will be classified as class 3 survey units which will reduce the amount of FSS sampling, and will allow for on-site analysis of FSS samples utilizing gamma spectroscopy. In addition to a significant reduction in remediation costs, these factors will result in an overall cost savings for the project by reducing the time to perform FSS, reducing the costs of analysis of FSS samples, and reducing the time to prepare the FSS report.

REFERENCES

1. ENSR International, 2001. Uranium Distribution Coefficient (K_d) Report, Westford, MA, October 2001.

2. MACTEC, 2003. Derivation of the Site-Specific Soil DCGLs, Portland, ME, September 2003.

3. Nuclear Regulatory Commission (NRC), 2000. NMSS Decommissioning Standard Review Plan, NUREG-1727, Rev. 0, US Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards, Division of Waste Management, Washington, DC, September 2000.

4. Nuclear Regulatory Commission (NRC), 2003. Consolidated NMSS Decommissioning Guidance, NUREG-1757, Vol. 2, US Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards, Division of Waste Management, Washington, DC, September 2003.

5. Wang, Y., K. A. Orlandini, C. Yu, 1996. Estimation of Uranium and Cobalt-60 Distribution Coefficients, ANL/EAD/TM-59, Argonne National Laboratory, Environmental Assessment Division, Argonne, IL., May 1996.

6. Yu, C., et. al., 2000. RESRAD for Windows, Version 6.0, Computer Modeling Code, Developed by Argonne National Laboratory, Environmental Assessment Division, Argonne, IL under joint sponsorship by the U.S. Department of Energy and the U.S. Nuclear Regulatory Commission, August 2000.