

## **Superfund Update: Revisions to Risk and Dose Assessment Tools – 17302**

Stuart Walker  
US. Environmental Protection Agency, Washington, DC 20460  
Fred Dolislager  
University of Tennessee

### **ABSTRACT**

The U.S. Environmental Protection Agency (EPA) Superfund remedial program is finishing up a significant number of revisions to its guidance for the risk assessment process at radioactively contaminated Superfund sites. The six Preliminary Remediation Goal (PRG) and Dose Compliance Concentration (DCC) internet based calculators for risk and dose assessment at Superfund sites are being revised to reflect better science, revisions to existing exposure scenarios and new scenarios, and changes to match up more closely with the EPA chemical regional screening level calculator. A comprehensive set of revisions to the PRG calculator was finished in November 2014. Additional revisions to the other 5 calculators were made in. A set of further revisions are expected to be finalized prior to December 2016 and will be discussed in this abstract. There are several additional revisions that may be finished prior to WM 2017 and will be presented if finished or discussed in more general terms if still underway.

### **INTRODUCTION**

The US. EPA Superfund remedial program is finishing another round of revisions to its Preliminary Remediation Goal (PRG) calculator for risk assessments for radioactively contaminated soil, water, and air. When completed, these revisions will also be made to Dose Compliance Concentration (DCC) calculator which is used for dose assessments for radioactive contamination in soil, water, and air.

### **METHOD**

#### **Progeny Ingrowth**

The +D and +E isotopes will be removed from the selection list. The draft calculator offers three options for calculating PRGs, see Figure 1. Previous versions of this calculator employed slope factors that included progeny ingrowth for 100 years; designated "+D." The +D slope factors are no longer included in the pick list. This section describes the potential applications of the three choices.

#### **PRG output options:**

- ☒ Assume secular equilibrium throughout chain (no decay)
- ☐ Provide results for progeny throughout chain
- ☐ No progeny included

Figure 1. Screenshot of PRG options for calculating PRGs

Assume secular equilibrium throughout the chain (no decay). This is the preferred PRG calculation option and is marked as the default selection in the calculator. When a single isotope is selected, the calculator identifies all the daughters in the chain. The PRGs for each daughter are combined with the parent on a fractional basis. The fractional basis is determined by branching fractions where a progeny may decay into more than one isotope. The resulting PRG is now based on secular equilibrium of the full chain. For straight chain decay, all the progeny would be at the same activity of the parent and the PRG provided in the output would be the inverse sum of the reciprocal PRGs of the parent and all the progeny. Currently, all the soil PRG equation images are presented with a radioactive decay term to account for half-lives shorter than the exposure duration. Decay is not included in this PRG option as the assumption of secular equilibrium is that the parent is continually being renewed.

Provide results for progeny throughout chain. This option displays the PRGs calculated with half-life decay as identified in the PRG equation images. In addition to the selected isotope, all the individual progeny PRGs are displayed. This option presents the progeny so that when screening environmental data against PRGs, the risk assessor can identify any isotopes for which he has no data.

No progeny included. This option displays PRGs, with half-life decay as identified in the PRG equation images, for only the selected isotopes. No progeny PRGs are displayed or contribution combined into the PRG for the selected isotope.

### **Produce**

The current PRG and DCC calculators include exposures from fruits and vegetables in both the farmer and residential scenarios. This will be revised to now include 24 specific subcategories of produce. The produce intake rates are derived from 24 individual produce items, found in the 2011 Exposure Factors Handbook, that contribute to the overall produce ingestion PRG. Mass loading factors (MLFs) were also improved, from a single MLF that was applied to all produce, to 24 individual MLFs that correspond with the 24 individual produce items that make up the new produce intake rates. The user will also be able to choose between fresh weight intake rates which may be more appropriate for some sensitive subgroups that consume the entire produce, or pick intake rates that assume cooking and preparation more typical for the U.S. population. See Figure 2 for a screenshot of the choices in the PRG calculator.

Select Produce Items to Include	
<input checked="" type="checkbox"/> Toggle All <input checked="" type="checkbox"/> Apples <input checked="" type="checkbox"/> Asparagus <input checked="" type="checkbox"/> Beets <input checked="" type="checkbox"/> Berries <input checked="" type="checkbox"/> Broccoli <input checked="" type="checkbox"/> Cabbage <input checked="" type="checkbox"/> Carrots <input type="checkbox"/> Cereal Grains <input checked="" type="checkbox"/> Citrus Fruits <input checked="" type="checkbox"/> Corn <input checked="" type="checkbox"/> Cucumbers <input checked="" type="checkbox"/> Lettuce	<input checked="" type="checkbox"/> Lima Beans <input checked="" type="checkbox"/> Okra <input checked="" type="checkbox"/> Onions <input checked="" type="checkbox"/> Peaches <input checked="" type="checkbox"/> Pears <input checked="" type="checkbox"/> Peas <input checked="" type="checkbox"/> Potatoes <input checked="" type="checkbox"/> Pumpkin <input type="checkbox"/> Rice <input checked="" type="checkbox"/> Snap Beans <input checked="" type="checkbox"/> Strawberries <input checked="" type="checkbox"/> Tomatoes Toggle intake rates: <input checked="" type="radio"/> Fresh weight <input type="radio"/> Cooked weight
Apples	
<input type="text" value="1"/> $CF_{res-apple}$ (contaminated apple fraction) unitless <input type="text" value="667520"/> $IFAP_{res-adj}$ (age-adjusted apple ingestion factor) g <input type="text" value="73.7"/> $IRAP_{res-a}$ (apple ingestion rate – resident adult) g/day	<input type="text" value="72.2"/> $IRAP_{res-c}$ (apple ingestion rate – resident child) g/day <input type="text" value="0.000160"/> $MLF_{apple}$ (apple mass loading factor) unitless
Asparagus	
<input type="text" value="1"/> $CF_{res-asparagus}$ (contaminated asparagus fraction) unitless <input type="text" value="300300"/> $IFAS_{res-adj}$ (age-adjusted asparagus ingestion factor) g <input type="text" value="39.3"/> $IRAS_{res-a}$ (asparagus ingestion rate – resident adult) g/day	<input type="text" value="12.0"/> $IRAS_{res-c}$ (asparagus ingestion rate – resident child) g/day <input type="text" value="0.0000790"/> $MLF_{asparagus}$ (asparagus mass loading factor) unitless

Figure 2 Screenshot of all Produce choices and details on Apples and Asparagus

The user will be able to select four climate zones (temperate, subtropical, tropical, humid) and up to seven soil types (e.g., default, sand, loam, clay, organic, coral sand, other) depending upon the climate zone to use a more appropriate soil to plant transfer factor from IAEA when available. See Figure 3 below.

Parameters Common to all Produce Routes	
<a href="#">Produce Consumption – direct</a>	
<input type="text" value="20"/> ED <sub>res-a</sub> (exposure duration – resident adult) yr	<input type="text" value="1.0E-6"/> TR (target cancer risk) unitless
<input type="text" value="6"/> ED <sub>res-c</sub> (exposure duration – resident child) yr	Select a climate zone <input type="button" value="Climate zone"/>
<input type="text" value="350"/> EF <sub>res-a</sub> (exposure frequency – resident adult) day/yr	<input type="button" value="Soil type"/>
<input type="text" value="350"/> EF <sub>res-c</sub> (exposure frequency – resident child) day/yr	

Figure 3 Climate zone and Soil type toggle buttons

In the PRG results, in addition to the Produce PRG, users can also select to see the PRG for each produce category. This will enable users to quickly determine which produce categories are driving the Produce PRG, and determine if developing site-specific information which categories they should focus on. Below in Figure 4 see PRG results including each default produce category.

Default Resident PRGs for Soil					
Isotope	Ingestion PRG (pCi/g)	Inhalation PRG (pCi/g)	External Exposure PRG (pCi/g)	Produce Consumption PRG (pCi/g)	Total PRG (pCi/g)
*Secular Equilibrium PRG for Cs-137	2.10E+01	7.51E+04	4.56E-02	9.04E-02	3.03E-02

  

Default Resident Produce Output for Soil							
Isotope	Apple Consumption PRG (pCi/g)	Asparagus Consumption PRG (pCi/g)	Beet Consumption PRG (pCi/g)	Berry Consumption PRG (pCi/g)	Broccoli Consumption PRG (pCi/g)	Cabbage Consumption PRG (pCi/g)	Carrot Consumption PRG (pCi/g)
*Secular Equilibrium PRG for Cs-137	1.49E-01	6.74E-01	3.87E-01	2.52E-02	2.07E-01	1.51E+00	3.50E-01

  

Citrus fruit Consumption PRG (pCi/g)	Corn Consumption PRG (pCi/g)	Cucumber Consumption PRG (pCi/g)	Lettuce Consumption PRG (pCi/g)	Lima beans Consumption PRG (pCi/g)	Okra Consumption PRG (pCi/g)	Onion Consumption PRG (pCi/g)	Peaches Consumption PRG (pCi/g)
5.73E-01	5.80E-01	4.95E-01	7.45E-01	4.10E-01	1.75E-01	1.30E-01	2.32E-01

  

Pears Consumption PRG (pCi/g)	Peas Consumption PRG (pCi/g)	Potatoes Consumption PRG (pCi/g)	Pumpkin Consumption PRG (pCi/g)	Snap beans Consumption PRG (pCi/g)	Strawberries Consumption PRG (pCi/g)	Tomatoes Consumption PRG (pCi/g)
1.12E-01	4.73E-01	2.11E+00	4.32E-01	7.31E-01	3.75E-02	5.27E-01

Figure 4 PRG run results overall and for each Produce Category

### Farm Animals

In the farmer scenario for the PRG and DCC calculators, the previous 5 animal products will have an additional 4 animal products (Goat Milk, Mutton Milk, Goat Meat, and Mutton) that users may select as appropriate for their site-specific risk/dose assessment. The user will also be able to choose between fresh weight intake rates which may be more appropriate for some sensitive subgroups that

consume the entire animal product, or pick intake rates that assume cooking and preparation more typical for the U.S. population. See Figure 5 below.

Select Animal Products to Include	
<input checked="" type="checkbox"/> Toggle All <input checked="" type="checkbox"/> <b>Beef</b> <input checked="" type="checkbox"/> Eggs and Poultry <input checked="" type="checkbox"/> Fish <input type="checkbox"/> Goat <input type="checkbox"/> Goat Milk	<input checked="" type="checkbox"/> Dairy <input type="checkbox"/> Mutton <input type="checkbox"/> Sheep Milk <input checked="" type="checkbox"/> Swine Toggle intake rates: <input checked="" type="radio"/> Fresh weight <input type="radio"/> Cooked weight
Beef	
<a href="#">Beef Consumption – back calculated to soil</a> <a href="#">Beef Consumption – back calculated to soil and water</a> <a href="#">Beef Consumption – back calculated to water</a> <a href="#">Beef Consumption – direct</a>	
<input type="text" value="1"/> $CF_{far-beef}$ (beef contaminated fraction) unitless <input type="text" value="2098950"/> $IFB_{far-adj}$ (age-adjusted beef ingestion factor) g <input type="text" value="165.3"/> $IRB_{far-a}$ (beef ingestion rate – farmer adult) g/day <input type="text" value="62.8"/> $IRB_{far-c}$ (beef ingestion rate – farmer child) g/day <input type="text" value="1"/> $f_{p-beef}$ (animal on-site fraction) unitless	<input type="text" value="1"/> $f_{s-beef}$ (fraction of year animal on site) unitless <input type="text" value="11.77"/> $Q_{p-beef}$ (beef fodder intake rate) kg/day <input type="text" value="0.5"/> $Q_{s-beef}$ (beef soil intake rate) kg/day <input type="text" value="53"/> $Q_{w-beef}$ (beef water intake rate) L/day

Figure 5 Animal Product choices and details on Beef

In the farmer scenario, when poultry is selected, the user will be able to specify which type of poultry (chicken, duck, turkey, or goose) which will affect the fodder, water, and soil ingestion intake rates for the farm animal. See Figure 6 below on how to change poultry type.

Eggs and Poultry	
<a href="#">Egg Consumption – back calculated to soil</a> <a href="#">Egg Consumption – back calculated to soil and water</a> <a href="#">Egg Consumption – back calculated to water</a> <a href="#">Egg Consumption – direct</a> <a href="#">Poultry Consumption – back calculated to soil</a> <a href="#">Poultry Consumption – back calculated to soil and water</a> <a href="#">Poultry Consumption – back calculated to water</a> <a href="#">Poultry Consumption – direct</a>	
<input type="text" value="1"/> $CF_{far-egg}$ (egg contaminated fraction) unitless <input type="text" value="1"/> $CF_{far-poultry}$ (poultry contaminated fraction unitless) <input type="text" value="775810"/> $IFE_{far-adj}$ (age-adjusted egg ingestion factor) g <input type="text" value="1376550"/> $IFP_{far-adj}$ (age-adjusted poultry ingestion factor) g <input type="text" value="59.6"/> $IRE_{far-a}$ (egg ingestion rate – farmer adult) g/day <input type="text" value="31.7"/> $IRE_{far-c}$ (egg ingestion rate – farmer child) g/day <input type="text" value="107.4"/> $IRP_{far-a}$ (poultry ingestion rate – farmer adult) g/day	<input type="text" value="46.9"/> $IRP_{far-c}$ (poultry ingestion rate – farmer child) g/day <input type="text" value="1"/> $f_{p-poultry}$ (animal on-site fraction) unitless <input type="text" value="1"/> $f_{s-poultry}$ (fraction of year animal on site) unitless <input type="text" value="0.2"/> $Q_{p-poultry}$ (poultry fodder intake rate) kg/day <input type="text" value="0.022"/> $Q_{s-poultry}$ (poultry soil intake rate) kg/day <input type="text" value="0.4"/> $Q_{w-poultry}$ (poultry water intake rate) L/day Toggle poultry type: <input checked="" type="radio"/> Chicken <input type="radio"/> Duck <input type="radio"/> Turkey <input type="radio"/> Goose
<b>NOTES:</b> 1. Changing poultry type changes the intake variables $Q_{s-poultry}$ , $Q_{p-poultry}$ , and $Q_{w-poultry}$ , which affect both the poultry and egg PRGs.	

Figure 6 Toggle buttons for Poultry

### Gamma Shielding Factor from Clean Soil while inside Buildings

In the resident, farmer, and indoor worker soil external exposure equations, a new variable has will be added ( $GSF_b$ ) to account for the gamma shielding provided by a concrete slab beneath a building. See Figure 7 below.

Select site area	▼ Site area for ACF
Select a cover layer	▼ Cover layer thickness for $GSF_o$
Select a cover layer	▼ Cover layer thickness for $GSF_b$

Figure 7 Toggle buttons for Cover layer thickness

### **Status**

The produce and animal product revisions, and the new GSF, are already incorporated into a draft revised PRG calculator and are expected to be finalized by December 2016. Two additional changes that are explained below are likely to be incorporated and finalized prior to WM 2017. All of these changes would subsequently be incorporated into the DCC calculator. The revisions to progeny ingrowth would be made to all six PRG and DCC calculators.

### **Trench Adjustments for External Exposure**

An analysis is complete to adjust external exposures for workers in trenches. These adjustment factors will be for the PRG and DCC construction worker scenarios when receptors are assumed to be in trenches for activities such as excavating soil for constructing buildings or laying down or repair utilities. This analysis includes several trench sizes (e.g., depths, lengths, and width) to adjust external slope factors in the PRG and DCC calculators for different types of construction and utility trenches for worker scenarios.

### **Gamma Shielding Factor from Different Building Types**

Another analysis recently completed was to of gamma shielding factors (GSFs) for several common building materials and thickness from contaminated soil underlying the structure and in the yard. This analysis will provide potential GSFs to adjust external slope factors in the PRG and DCC calculators for different building types.

### **Results and Discussion**

The changes to the Superfund PRG and DCC models will facilitate the risk assessment process at radioactively contaminated Superfund sites by improving the scientific basis and user flexibility to address site-specific concerns for the model runs while not significantly increasing complexity for the users.