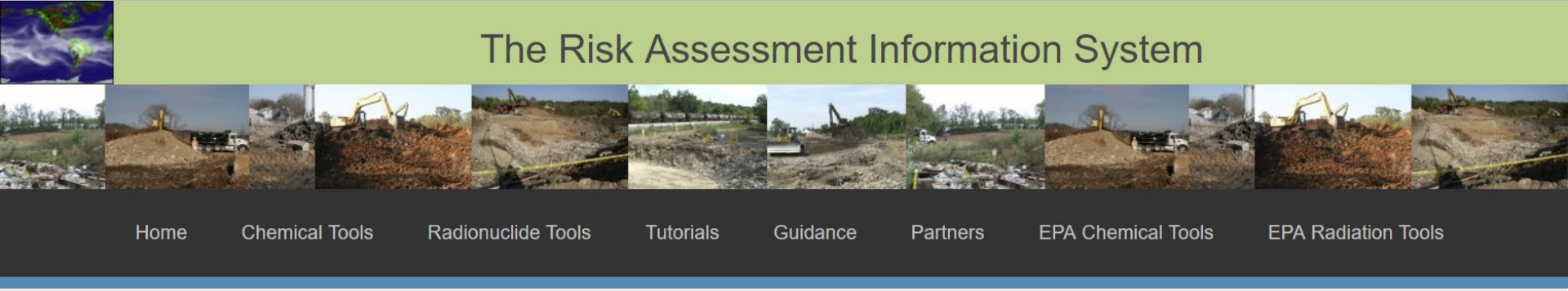
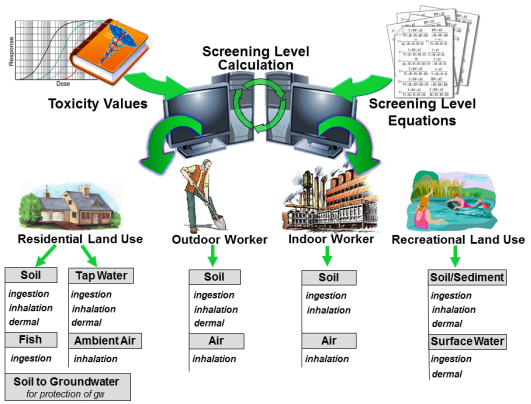


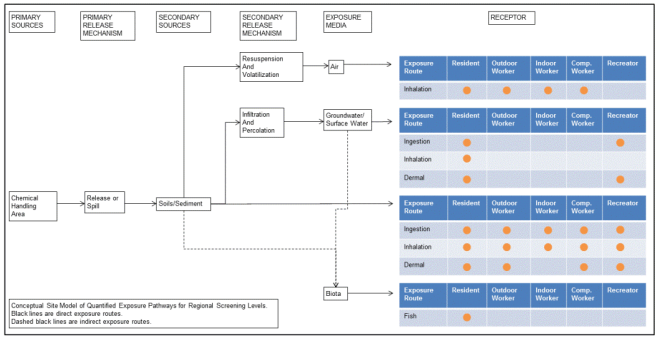
NIMBioS Risk Analysis Tutorial

Fred Dolislager, Leslie Galloway,
Debra Stewart, Katie Noto, and Karessa Manning

March 5-7, 2019

Knoxville, Tennessee





https://rais.ornl.gov/

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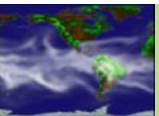
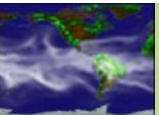


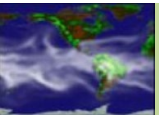
Day 1 Schedule

- 8:30 a.m. Breakfast (bagels, muffins, fruit, and coffee)
- 8:45 a.m. Welcome and Introductory Remarks
- 9:00 a.m. Regional Screening Levels Background and Supporting Documentation
- 10:00 a.m. Break
- 10:15 a.m. Regional Screening Levels Calculator
- 12:00 p.m. Lunch
- 1:00 p.m. Resume Regional Screening Levels Calculator
- 2:30 p.m. Break
- 2:45 p.m. Regional Removal Management Levels
- 3:00 p.m. Practice Exercises for RSL and RML
- 4:45 p.m. Dismiss



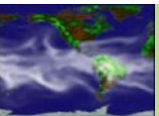
Day 1 Outline

1. Historical Perspective of RSLs
2. Understanding RSL Changes Over time (What's New)
3. Getting RSL Support (FAQ, Contact Information)
4. RSL Special Cases (Mutagens, TCE, Vinyl Chloride, Arsenic)
5. RSL Calculator
6. Resident, Worker, Construction, Recreator, Soil to Groundwater
7. Tapwater, Soil, Surface Water, Sediment, Air, Fish
8. Historical Perspective of RMLs
9. Understanding RML Changes over time (What's New)
10. Getting RML Support (FAQ, Contact Information)
11. RML Calculator
12. Focus on Resident and Worker
13. Water and Soil
14. RSL and RML Practice Sessions



RSL History

- RSL = Regional Screening Levels
- Individual tables for Regions 3, 6 and 9 with constant maintenance and differences.
- Last published region tables: Region 3 - 2004, Region 6 - 2007, Region 3 - 2006.
- Combined Headquarters (OSRTI) table in 2008 .
- Website on an ORNL-UT server for the first year.
- Subsequently moved to R3 to maintain the static pages; ORNL-UT still operates the calculator page.
- 2008 to present: What's New page provides pertinent history of the changes.
- Unified tables are shared on Region 3, 6 and 9 websites as well as other Regional websites.



What RSLs Are and Are Not

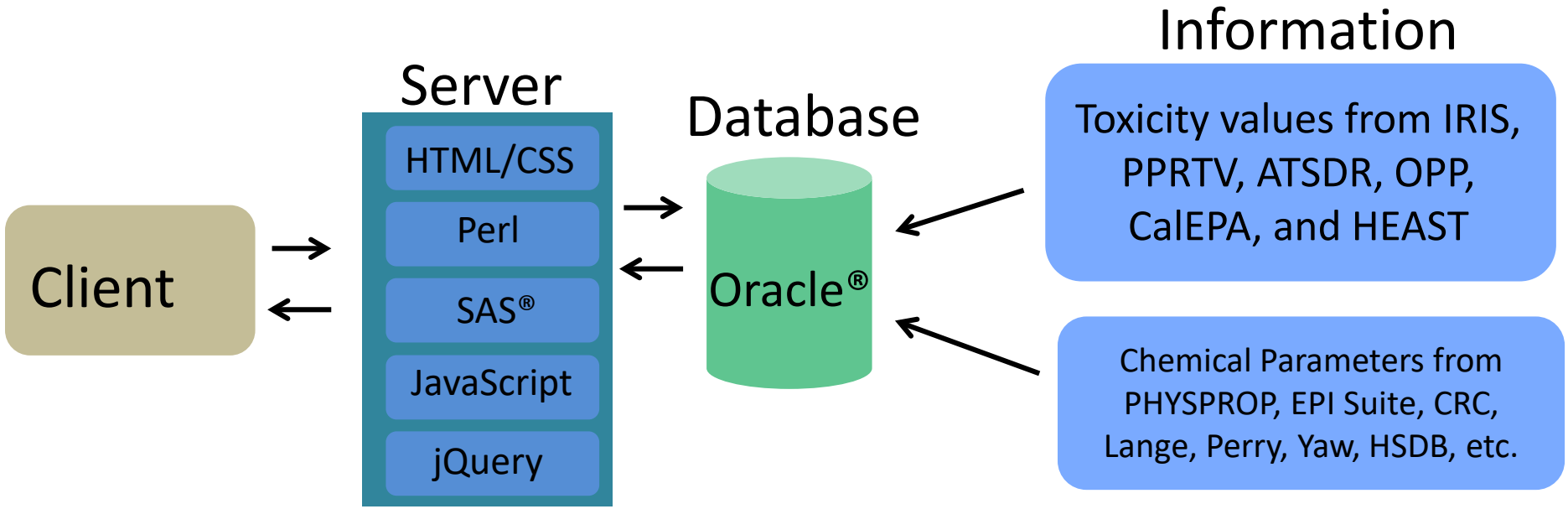
- Default Screening levels - yes
- De facto Remediation levels- maybe. Only if your PRG equations are same as RGOs.
- Site-specific screening levels – yes. Simply use the calculator to derive appropriate numbers.
- Site-specific remediation levels – yes. Simply use the calculator to derive appropriate numbers.

RSL Regulatory Basis

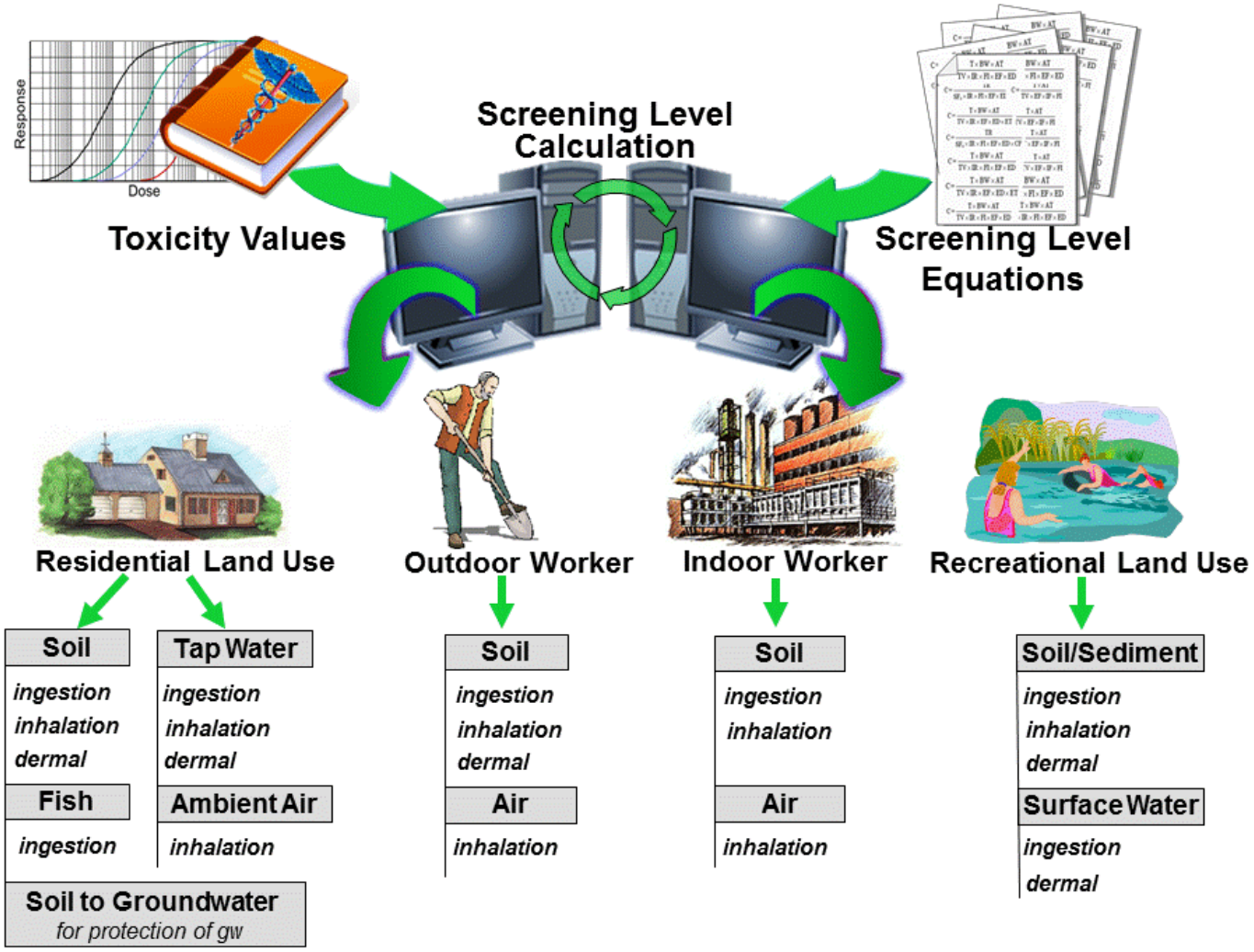
- RAGS Part A-F
- Supplemental Soil Screening Guidance and Technical Background Document
- Guidelines for Carcinogen Risk Assessment
- Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (mutagen information)

How Does it Work?

- ORACLE
- SAS
- Java script, PHP, Perl, etc.
- General hierarchy for toxicity and chemical parameters (see Section 2.3 and 2.4 of RSL for details)

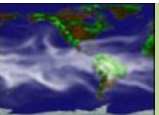


How Does it Work cont.



What is the Update Process?

- Dynamic Agenda of issues
- Conference Calls
- Toxicity Updates
- Chemical-parameter Updates
- MCL Updates
- Text updates (FAQ, What's New)
- Freeze database
- QA check of calculations
- QA tables (by hand and with computer program)
- The RSL Checklist (around 52 steps)
- Go Live



RSL Update Checklist

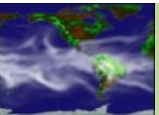
- **RSL Toxicity Database Check**
  - Cal EPA, ATSDR and IRIS databases are checked for updates; changes are made to database and verified.
  - HEAST and PPRTV updates are automatically read into database, as ORNL is hosting these databases.
  - Tier 3 toxicity values selected by the RSL Workgroup are hardcoded into database (e.g., New Jersey's oral slope factor for chromium 6).
  - Confirm that all contaminants identified as carcinogenic by a mutagenic mode of action in the OSWER cancer handbook have an M in the table and use the ADAFs. Confirm that only contaminants in the handbook (and for now also Hexavalent Chromium) have an M in the tables and use the ADAFs.
  - Exceptions are hardcoded (e.g., omission of lead RfD, some dioxins, furans, and TCE).
  - Make sure GIABS, ABS, VOC status and mutagenic status are added for new chemicals.
  - Run database search of all missing values (e.g., EPD, FA, DIA, DIW, Csat) that need to be calculated and search for new values.
  - Look for Csat of 0 and missing Csat if VOC=1. Make sure the AMBIENT STATE variable is updated.
  - Investigate the HLC, MW and VP of new chemicals to make sure that VOC status is assigned appropriately.
  - The toxicity database is "frozen" from further updates.
  - Add banner to the calculator stating that a new database in in place.
  - Run a tox compare routine, which is posted in the What's New, and verify each change, subtraction and addition of toxicity values.
  - Run the parameters compare for group to review.
  - Run the summary table compare.

RSL Update Checklist cont.

- **Chemical-Specific Parameters Check**
  - Chemical-specific parameters are added when a new chemical is added to the toxicity database.
  - Check the parameters table for chemicals without any values at all.
  - Added parameters are reviewed.

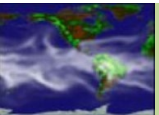
RSL Update Checklist cont.

- **RSL Review**
  - The RSLs for each chemical in the Excel QA sheet are reviewed by land use and exposure route.
  - The soil to groundwater, Diffusivity in air and water, Csat, volatilization factor, and particulate emission factor calculations are reviewed.
  - Hardcoded exceptions are reviewed for chemicals that are not listed in the QA sheet. These include all of the contaminants specifically discussed in the User's Guide (lead, manganese, vanadium, uranium, chromium, aminodinitrotoluenes, PCBs, and xylenes) as well as copper(RfD), TCE, and lead residential and industrial soil levels.
  - MCL footnotes for perchlorates and trihalomethanes are verified.
  - Make sure lead footnotes and non-RSL values are in place.
  - Make sure TCE is handled appropriately in the resident soil, air, and tapwater tables.
  - If any discrepancy is found and new tables are generated, the QA begins from the top.
  - Do all of the toxicity values have a source code to one of the 6 sources described in the user's guide or the special cases noted in the legend of the generic tables?
  - Do the supporting tables present oral, inhalation, and dermal-based screening levels (when we have the data) for both cancer and non-cancer?
  - Are the initial cancer and non-cancer RSLs no lower than the individual oral, inhalation, and dermal screening levels?
  - Is the lower of the cancer and non-cancer RSLs for each exposure media (e.g. residential soil, industrial air) carried forward into the summary table?
  - Are the RSLs in the supporting and summary tables coded with "c" for cancer and "nc" for non-cancer?



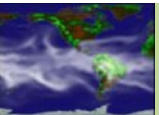
RSL Update Checklist cont.

- Are the other codes (S to see user's guide and M for exceeding ceiling limit) used when appropriate?
- Are all of the units in the tables correct?
- Make sure the header row texts are all visible.
- Make sure the parameters table is condensed as much as possible.
- The old hardcopy is compared to the new hardcopy to verify output is reasonable.
- Are there soil RSLs protective of the MCL for all contaminants that have an MCL?
- Are there soil RSLs protective of the tapwater RSL for all contaminants that have a tapwater RSL?
- Are there missing pages in any of the individual tables?
- Correct tables updated if necessary.
- Are all of the pages in all of the tables contained in the Composite Table?
- Tables are released to Michele for comment.
- Tables and test site are released to RSL workgroup.
- R3 begins copying changes.
- Review R3 test site.
- R3 goes live.
- Quick review of R3 live site.
- Tell the world.



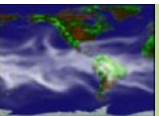
RSL Update Checklist cont.

- Miscellaneous
  - Incorporate fish table from Region 3
  - EQUIS output
  - SADA tables
  - Archive the html and pdf web pages
  - Archive the previous download tables



Spring 2019 Agenda

- Old Issues
  - Use HgCl RfD for Hg.
  - Using subchronic values more protective than chronic.
  - Where is the mutagen list website?
  - Maybe use other state tox values as tier 3.
  - DWSHA tox value use.
  - Update EQuIS format.
- New Issues
  - Endosulfan and Endrin surrogates.
  - Shorten the table and calculator key.
  - Update TPH text to clarify sources.
  - Change volatility status when groundwater temp is changed.
  - Let user enter their own PEF.
  - Fix some CAS issues.
  - All H' values to 0 for all inorganics other than mercury (bad old idea?).
  - Change chemical names for nitrate and nitrite to include "measured as nitrogen".



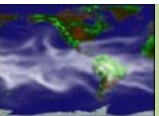
Toxicity Sources

1. EPA Integrated Risk Information System (IRIS)
2. EPA Provisional Peer Reviewed Toxicity Values (PPRTV)
3. EPA Office of Pesticide Programs (OPP) Human Health Benchmarks for Pesticides (HHBPs)
4. Agency for Toxic Substances and Disease Registry (ATSDR) minimal risk levels (MRLs)
5. California Environmental Protection Agency (CalEPA) Office of Environmental Health Hazard Assessment (OEHHA)
6. EPA PPRTV Appendix Screening Values
7. EPA Health Effects Assessment Summary Table (HEAST)

(https://semspub.epa.gov/work/03/2218797.pdf)

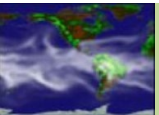
Chemical-specific Parameter Sources

- PHYSPROP
- EPA SuiteTM
- EPA Soil Screening Level (SSL)
- WATER9
- CHEMFATE
- Yaws' Handbook of Thermodynamic and Physical Properties of Chemical Compounds
- Baes, C.F (SCDM)
- NIOSH Pocket Guide to Chemical Hazards (NPG)
- CRC Handbook of Chemistry and Physics
- Perry's Chemical Engineers' Handbook
- Lange's Handbook of Chemistry
- RAGS Part E, Supplemental Guidance for Dermal Risk Assessment)
- ARS Pesticide Properties Database
- OTHER



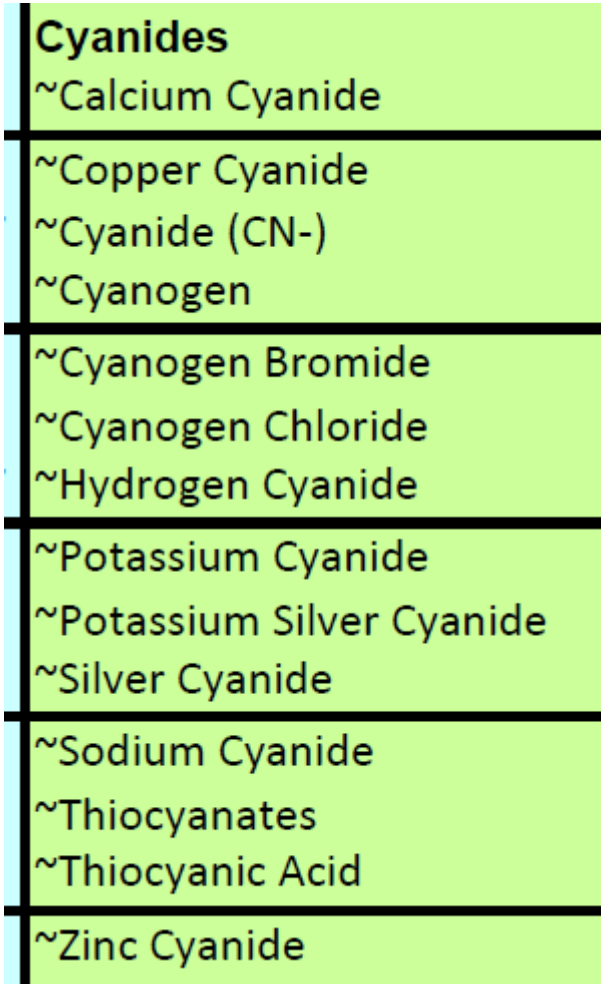
Chemical-specific Parameters

- Organic Carbon Partition Coefficient (Koc)
- Dermal Permeability Coefficient (Kp)
- Effective Predictive Domain (EPD)
- Fraction Absorbed (FA)
- Molecular Weight (MW)
- Water Solubility (S)
- Unitless Henry's Law Constant (H')
- Henry's Law Constant
- Diffusivity in Air (Dia)
- Diffusivity in Water (Diw)
- Fish Bioconcentration Factor (BCF)
- Soil-Water Partition Coefficient (Kd)
- Density
- Melting Point (MP)
- log Octanol-Water Partition Coefficient (logKow)
- Vapor Pressure (VP)
- Critical Temperature (Tc)
- Enthalpy of vaporization at the normal boiling point



Generic Tables

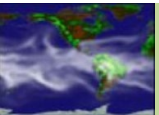
- Landuses
- Resident – child
- Why 3 workers?
- SSL (soil2gw)
- Media (Fish and Region 3 are exception)
- Targets (TR, THQ)
- Csat, max
- Key symbols (e.g., I = IRIS; P = PPRTV; F = See FAQ; M = mutagen; c = cancer; n = noncancer; s = concentration may exceed Csat)
- What's New
  - Tox compare
  - Params compare
  - RAGS E compare (EPD, FA, Kow)
- Chemical Groups



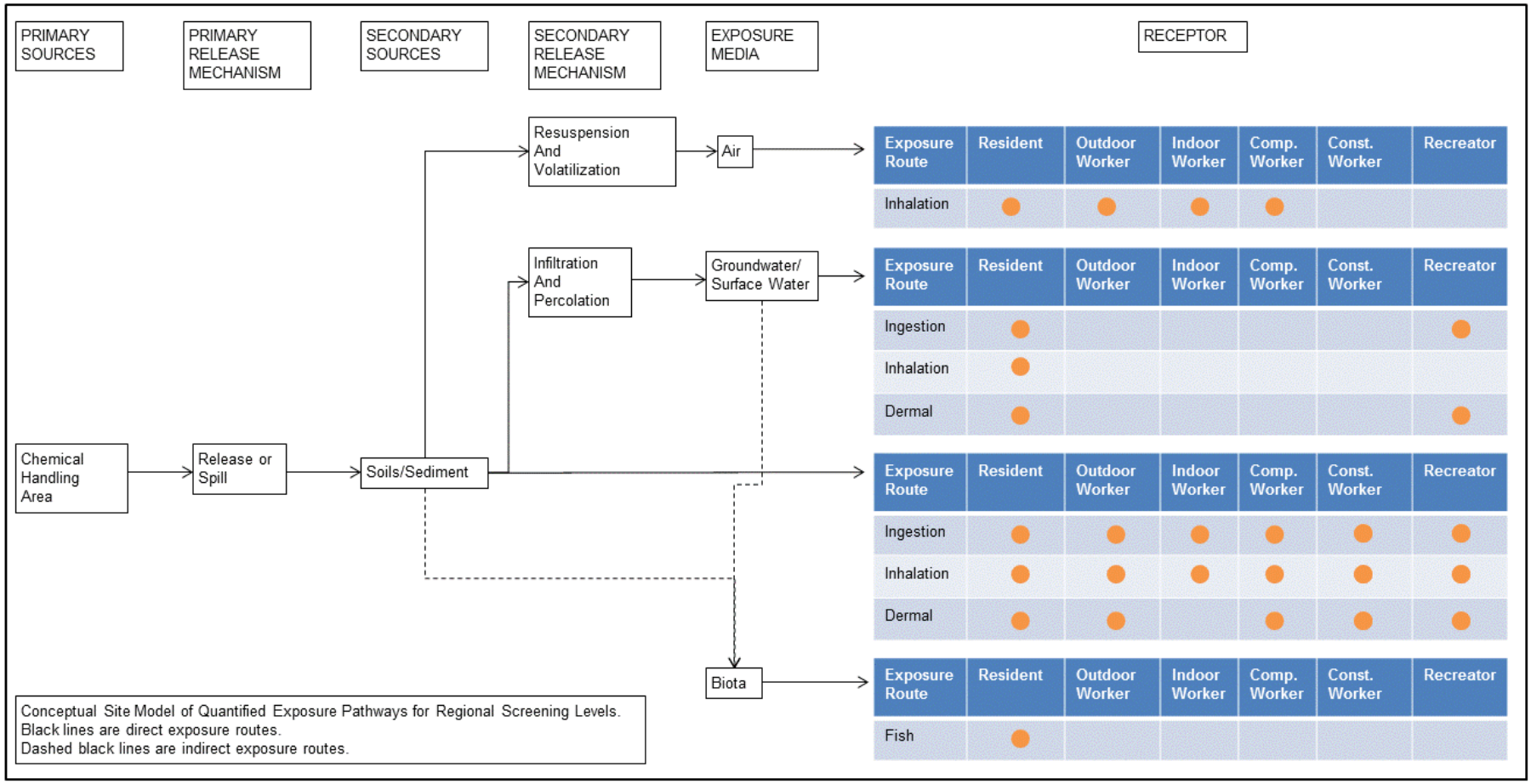
Generic Tables cont.

Toxicity and Chemical-specific Information												
SFO (mg/kg-day)$^{-1}$	key	IUR (ug/m^3)$^{-1}$	key	RfD_o (mg/kg-day)	key	RfC_i (mg/m^3)	key	voc	muta-gen	GIABS	ABS	C_{sat} (mg/kg)
1.8E-02	C	5.1E-06	C	1.5E-01	I					1	0.1	
8.7E-03	I			4.0E-03	I					1	0.1	
		2.2E-06	I			9.0E-03	I	V		1		1.1E+05
				2.0E-02	I					1	0.1	
				9.0E-01	I	3.1E+01	A	V		1		1.1E+05
						2.0E-03	X	V		1		1.1E+05

Screening Levels									
Resident Soil (mg/kg)	key	Industrial Soil (mg/kg)	key	Resident Air (ug/m^3)	key	Industrial Air (ug/m^3)	key	Tapwater (ug/L)	key
2.7E+01	c	9.6E+01	c	4.8E-01	c	2.4E+00	c	3.7E+00	c
5.6E+01	c**	2.0E+02	c*					7.7E+00	c**
1.0E+01	c**	5.2E+01	c**	1.1E+00	c**	5.6E+00	c**	2.2E+00	c**
1.2E+03	n	1.2E+04	n					2.7E+02	n
6.1E+04	n	6.3E+05	nms	3.2E+04	n	1.4E+05	n	1.2E+04	n
5.3E+01	n	2.2E+02	n	2.1E+00	n	8.8E+00	n	4.2E+00	n
8.7E+02	n	3.7E+03	n	6.3E+01	n	2.6E+02	n	1.3E+02	n
7.8E+03	ns	1.0E+05	nms					1.5E+03	n
1.3E-01	c	4.5E-01	c	1.9E-03	c	9.4E-03	c	1.3E-02	c



Landuses

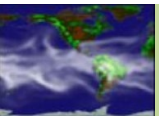

PRIMARY SOURCES
PRIMARY RELEASE MECHANISM
SECONDARY SOURCES
SECONDARY RELEASE MECHANISM
EXPOSURE MEDIA
RECEPTOR
Chemical Handling Area
Release or Spill
Soils/Sediment
Resuspension And Volatilization
Air
Infiltration And Percolation
Groundwater/ Surface Water
Biota
Exposure Route | Resident | Outdoor Worker | Indoor Worker | Comp. Worker | Const. Worker | Recreator
Inhalation
Exposure Route | Resident | Outdoor Worker | Indoor Worker | Comp. Worker | Const. Worker | Recreator
Ingestion
Inhalation
Dermal
Exposure Route | Resident | Outdoor Worker | Indoor Worker | Comp. Worker | Const. Worker | Recreator
Ingestion
Inhalation
Dermal
Exposure Route | Resident | Outdoor Worker | Indoor Worker | Comp. Worker | Const. Worker | Recreator
Fish
Conceptual Site Model of Quantified Exposure Pathways for Regional Screening Levels.
Black lines are direct exposure routes.
Dashed black lines are indirect exposure routes.

Calculator

- What's not in the table
- Recreator
  - Sediment
  - Surface water
- Indoor worker
- Outdoor worker
- Construction worker
- Fish

Calculator cont.

- Site-specific
  - Exposure parameters
  - Toxicity and chem-specific parameters
  - Age cohorts
  - New Chemical
- Chronic vs. Subchronic
- New features (Csat and max)

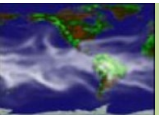


Calculator cont.

- Metadata
- EQuIS format
- Changing target risk or HQ
- VF changes
- PEF changes
- SSL changes

Confusing Chemicals

- **Lead** (why not use the Cal EPA tox values?)
- **Benzene** (Slope factors for benzene are actually ranges, yet the SL table shows a single number. The upper end of the range was chosen, because the SL Table is a screening tool. The consequences of screening out a chemical that could pose a significant risk are more serious than carrying the chemical through the risk assessment process.)
- **Cadmium and Manganese** ("Food" is for food and soil use; "water" is for water only. Cadmium RfDs on IRIS are based on the same study. The food RfD incorporates a 2.5% absorption adjustment while the water RfD incorporates a 5% absorption adjustment. For another medium (e.g., soil), choose the value with an absorption factor that most closely matches the expected site conditions. In most cases, the expected absorption is unknown and the RfD for food should be used. Manganese IRIS RfD is for all sources, including diet. IRIS recommends using a modifying factor of 3 when calculating risks associated with non-food sources. IRIS also recommends subtracting dietary exposure (default assumption in this case is 5 mg). Thus, the IRIS RfD has been lowered by a factor of 2 x 3, or 6. The table now reflects manganese for "non-food" sources.)



Confusing Chemicals cont.

- **Coppe**r (Currently, the RfD is 0.04 mg/kg-day with a reference of HEAST. Actually, HEAST presents a drinking water screening level of 1.3 mg/L. In order to use the value to assess oral exposures to other media, we "back out" the adult exposure assumptions (e.g., body weight of 70 kg, ingestion rate of 2 L/day) that go into the calculation of a drinking water screening level.)
- **Chromium** (In the RSL Table, the Cr(VI) specific value (assuming 100% Cr(VI)) is derived by multiplying the IRIS Cr(VI) Inhalation Unit Risk value by 7. This is considered to be a health-protective assumption and is also consistent with the State of California's interpretation of the Mancuso study that forms the basis of Cr(VI)'s estimated cancer potency. It’s a mutagen but controversial.)
- **Mercury** (Where is the oral RfD from Cal EPA? The EPA RSL group removed it. Not standard practice to pick apart the individual tox values.)

Confusing Chemicals cont.

- **Vinyl chloride** (unique set of equations that combine the prorated cancer with non-prorated child)
- **Dioxins and Furans** (TEFs; however if IRIS has a value, we present the RSL based on that value)
- **PAHs** and RPFs based on BaP
- **TCE** (Uses a CAF and MAF so one tox value can be used)
- **TPHs** (Noncancer only)

RSL Website Pages

Regional Screening Levels (RSLs)

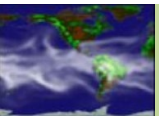
- Home Page
- User's Guide
- What's New
- Frequent Questions
- Equations
- RSL Calculator
- Generic Tables
- Contact Us

RSL Calculator in Default Mode

- Chronic
- Subchronic
- Metadata
- Site-specific options
- Selecting landuses
- Output data
  - View
  - Cut and paste
  - XLS
  - PDF

Master the Pick List

- Clicking
- Typing
- Select All



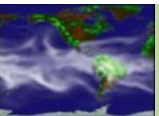
Site-specific Mode

- Exposure parameters
- Cohorts (pink and blue cells) for resident and recreator
- Toxicity values
- Chemical-specific parameters
- PEF and VF
- SSL protective of groundwater

Questions?

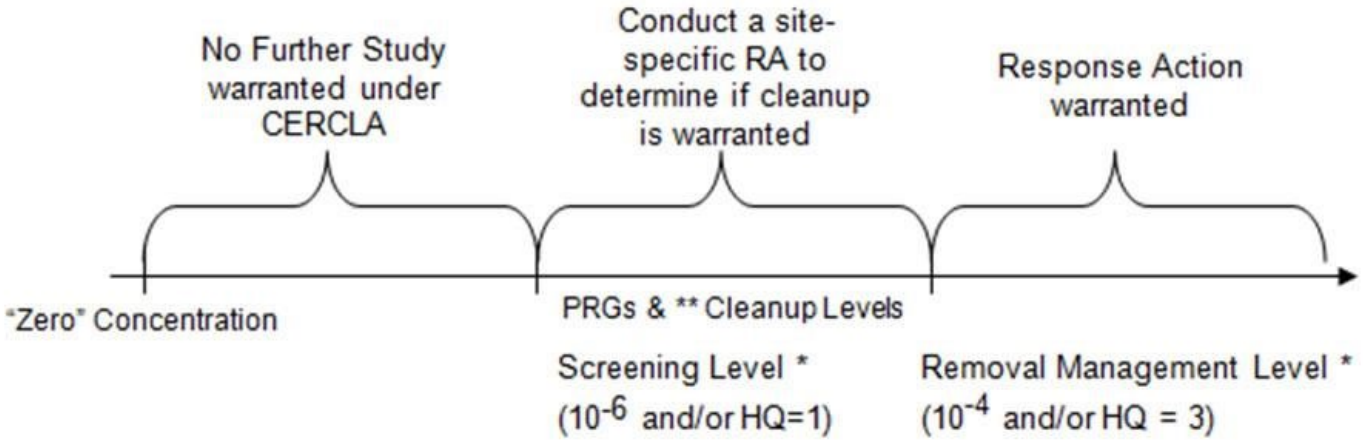
RML History

- RML = Regional Removal Management Level
- Assist On Scene Coordinators (OSC's) and others involved in decision-making concerning Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) removal actions
- Used to support the decision for EPA to undertake a removal action. Although they are not necessarily health protective concentrations for chronic exposure, exceedance of an RML by itself does not imply that adverse health effects will occur.
- 1998 was the latest release prior to our website.
- 2008 to present: What's New page portrays change history
- Unified tables are shared on Region 3, 6 and 9 websites as well as other Regional websites.
- Note: At this time, RMLs for air are not provided or addressed on this website. (Formerly called RALs.)



What RMLs Are and Are Not

- Not protective for long term exposures
- Not provided for air (other tables exist)
- Site-specific screening levels – yes
- Site-specific remediation levels – no



* - Screening Levels and RMLs are for individual chemicals
** - Cleanup levels take into account exposure to multiple chemicals

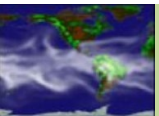
RML Website Pages

Regional Removal Management Levels

- Homepage
- Frequent Questions
- User's Guide
- RML calculator

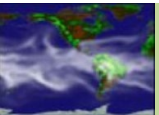
Questions?

RSL/RML Practice Sessions



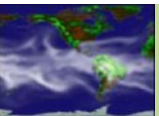
Day 2 Schedule

- 8:30 a.m. Breakfast (bagels, muffins, fruit, and coffee)
- 8:45 a.m. Vapor Intrusion Screening Levels (VISL) Background and Supporting Documentation
- 9:15 a.m. VISL Calculator
- 10:00 a.m. Break
- 10:15 a.m. Practice Sessions for VISL
- 11:15 a.m. Risk Assessment Information System (RAIS) Overview
- 12:00 p.m. Lunch
- 1:00 p.m. RAIS Calculators
- 2:30 p.m. Break
- 2:45 p.m. Practice Sessions for RAIS Calculators
- 4:45 p.m. Dismiss



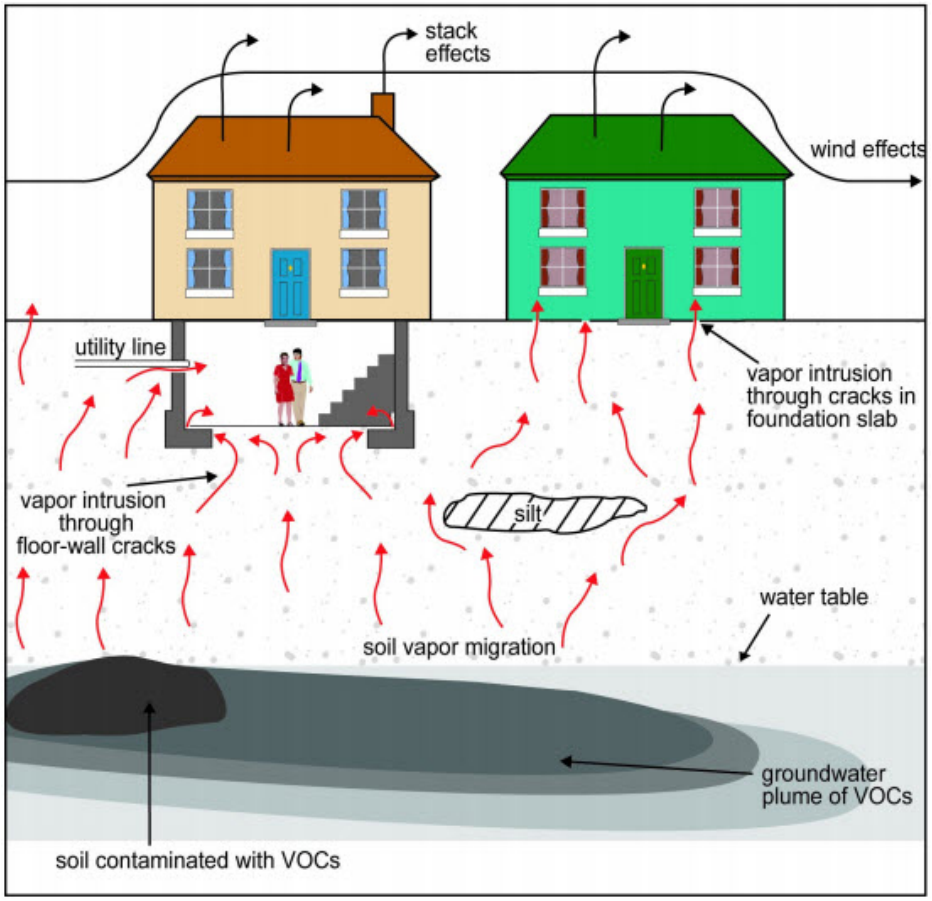
Day 2 Outline

1. Historical Perspective of VISLs
2. Understanding Changes Over time (What's New)
3. Getting Support (FAQ, Contact Information)
4. VISL User Guide Special Cases (Mutagens, TCE, Vinyl Chloride, Arsenic)
5. VISL Calculator
6. Resident, Worker
7. Water, Soil, Air
8. RAIS Calculators
9. PRGs
10. Risk Calculators
11. Toxicity Search Tools
12. Chemical Parameter Search Tools
13. Adult Lead Model
14. Applicable or Relevant and Appropriate Requirements (ARARs)
15. VISL and RAIS Practice Sessions



VISL History

- 2002: OSWER released DRAFT guidance
- 2013: DRAFT available for public comment
- 2015: Technical guide released, spreadsheet provided
- Spring 2018: VISL calculator made public



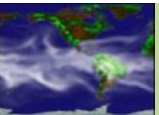
What VISLs Are and Are not

- VISLs are screening level concentrations for groundwater, soil gas (target sub-slab and near-source), and indoor air.
- VISLs assist Agency staff with making a vapor intrusion determination based on limited, initial data.
- VISLs are NOT cleanup levels.

VISL Website Pages

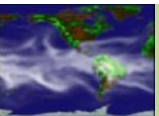
Contents

- VISL Home
- User's Guide
- What's New
- FAQ
- Equations
- Calculator



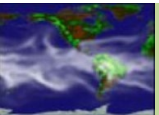
Questions?

VISL Practice Sessions



RAIS History

- 1980s: Oak Ridge Reservation was busy cleaning up the Manhattan Project Facilities, as were other DOE sites like gaseous diffusion plants in Ohio and Kentucky.
- Risk Assessment Council was developed to standardize the toxicity values, exposure equations, and essentially the entire remediation process.
- 1996: RAIS went live.

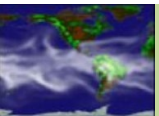


How Does the RAIS Differ from RSL?

- Greater number of chemicals
  - All of OPP
  - All of CalEPA (including lead toxicity values)
- Expanded toxicity sources
  - Draft MRLs
  - Addendum MRLs
  - All of OPP
  - Retired PPRTVs
  - Drinking Water Standards
  - Archived HEAST
  - Withdrawn from IRIS
- More land uses
  - Excavation Worker
  - Farmer
  - More Soil to Groundwater
- More Defaults
  - Farmer
  - Recreator
  - Fish

How Does the RAIS Differ from RSL? Cont.

- More Tools
  - Chemical Data Profile Tool (Shows all of the data available from the toxicity hierarchy)
  - Metadata Tool (demo)
  - Toxicity Value Tool (demo)
  - ARAR Tool (demo)
  - Ecological Benchmarks
  - Tutorials
  - Background Values
  - Media Transport



RAIS Website Pages

Chemical Tools

- Chemical Toxicity →
- Chemical Parameters
- PRG Calculator & User's Guide
- Risk Calculator & User's Guide
- ARAR Search
- Ecological Benchmarks
- Adult Lead Model →
- Media Transport Tools →
- Soil Background Values →

Tutorials

- What is Risk Assessment
- RAIS Main Tutorial
- NIH ToxTutor

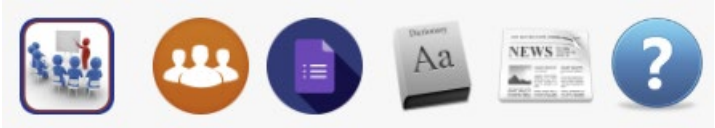
Radionuclide Tools

- Radionuclide Toxicity →
- Radionuclide Parameters
- PRG Calculator & User's Guide
- Risk Calculator & User's Guide
- Gamma Radiation Instrument Response Calculator
- Radionuclide Decay Chain Tool
- Media Transport Tools →

Guidance

- ORO Risk Assessment Guidance →
- EPA Regulatory Guidance →
- State Guidance

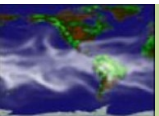
Supporting Pages



- Training
- Contact
- Report an Issue
- Document Search
- Glossary
- What's New
- FAQ
- Join User List
- Search the Site

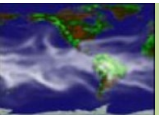
Questions?

RAIS Practice Sessions



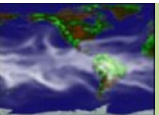
Day 3 Schedule

- 8:30 a.m. Breakfast (bagels, muffins, fruit, and coffee)
- 8:45 a.m. Introduction to Radiation
- 9:00 a.m. PRG Calculator
- 10:00 a.m. Break
- 10:15 a.m. DCC Calculator
- 11:00 a.m. BRG/BDCC Calculator
- 12:00 p.m. Lunch
- 1:00 p.m. SPRG/SDCC
- 1:45 p.m. RAIS Radiation Calculators
- 2:30 p.m. Break
- 2:45 p.m. Practice Sessions for Radiation Calculators
- 4:30 p.m. Dismiss



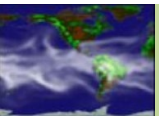
Day 3 Outline

1. Radiation Risk Assessment Introduction Video
2. EPA PRG Calculator
   - Resident, Worker, Construction, Recreator, Farmer
   - Air, Water, Soil, Food
3. EPA DCC Calculator
4. EPA Building PRG and Building DCC Calculators
   - Dust, Air, Indoor Building
5. EPA Surfaces PRG and Surfaces DCC Calculators
   - Dust, Air, Outdoor Surfaces
6. RAIS Radiation Tools
   - PRG
   - Risk
   - Decay



Radiation Risk Assessment

- Review of how radiation fits in Superfund
- Quick review of EPA RSL calculator
- Step by step comparison to the EPA PRG calculator
- Identification of pitfalls
- Quick look at EPA DCC calculator
- Questions



Superfund Sites

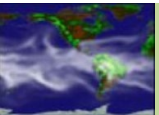
- 1,337 NPL sites
  - 66 are radiation sites
  - 53 mores sites proposed for NPL
    - 1 is a radiation site
- 1,189 NPL sites are “construction completion”
  - 38 are radiation sites
- 392 Sites have been deleted from NPL
  - 9 are radiation sites

How to Address Radiation in a Chemical Program?

- With only 66 radioactively contaminated sites out of 1,337 total, the focus of the Superfund program has been on chemicals.
- **Question:** How best to address radiation?
- **Answer:** Address radiation in a consistent manner with chemicals, except to account for the technical differences posed by radiation
  - Radiation easily fits within Superfund framework
  - Improves public confidence by taking mystery out of radiation

Why Does Radiation Easily Fit within the Superfund Framework?

- Primary effect is cancer
- People ingest, inhale, eat same amount of contaminated dust and food whether it is chemical or radioactive contamination
- Dust gets resuspended the same whether it is chemically or radioactively contaminated
- Inorganic elements move through the subsurface whether they are radioactive or not



CERCLA Cleanup Levels NOT Based On

- DOSE (mrem/year)

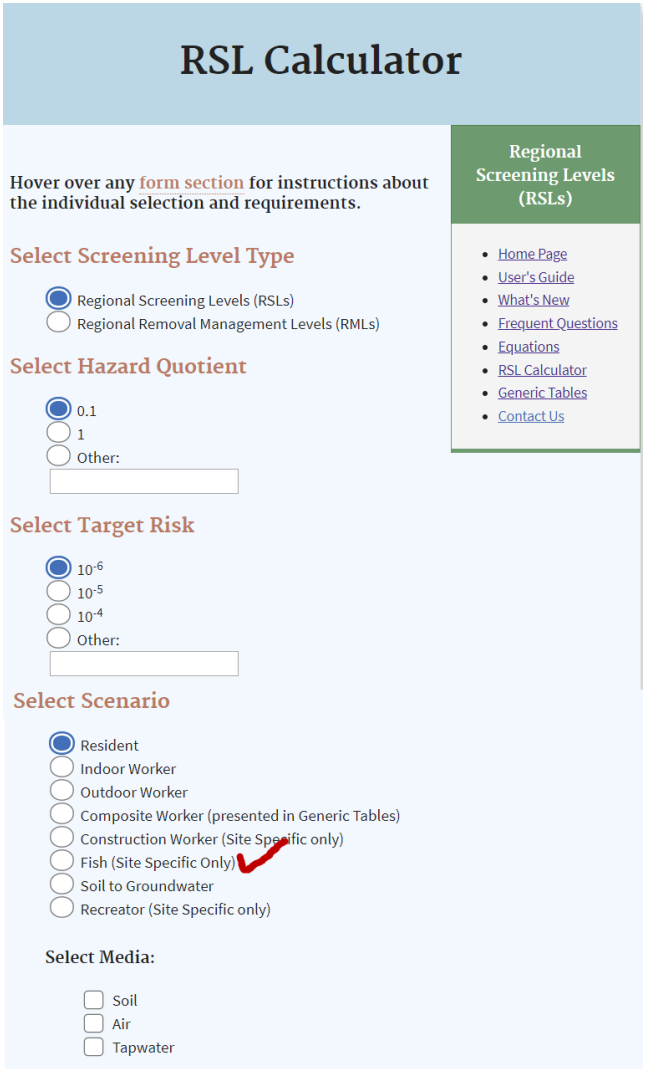
Consistency (Rad & Chem)

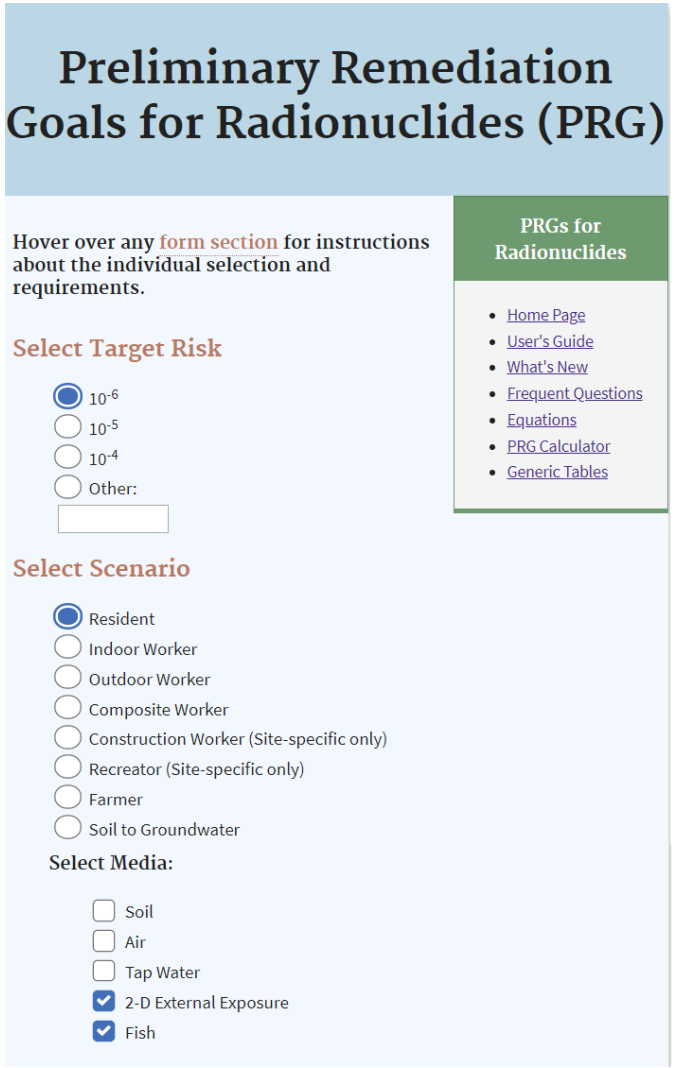
- Reiterate more strongly that risk assessments (e.g., models used) should be consistent with chemicals at site and with other regional sites
- Don’t use a steady state model for chemical and a transfer/dynamic model for radionuclides
  - Using RSL calculator for chemicals then RESRAD defaults for radionuclides is inconsistent.

Consistency on Surveys (Rad & Chem)

- Reiterate more strongly that site surveys (e.g., characterization and confirmation) should be consistent with chemicals at the site and with other regional sites
- Don’t use not-to-exceed (NTE) for chemicals and area averaging (AA) for radionuclides for residential
  - NTE for residential cleanup of chemicals but AA approach like MARSIMM for the radionuclides

RSL vs PRG (1)


RSL Calculator
Hover over any form section for instructions about the individual selection and requirements.
Regional Screening Levels (RSLs)
Home Page
User's Guide
What's New
Frequent Questions
Equations
RSL Calculator
Generic Tables
Contact Us
Select Screening Level Type
Regional Screening Levels (RSLs)
Regional Removal Management Levels (RMLs)
Select Hazard Quotient
0.1
1
Other:
Select Target Risk
10-6
10-5
10-4
Other:
Select Scenario
Resident
Indoor Worker
Outdoor Worker
Composite Worker (presented in Generic Tables)
Construction Worker (Site Specific only)
Fish (Site Specific Only)
Soil to Groundwater
Recreator (Site Specific only)
Select Media:
Soil
Air
Tapwater


Preliminary Remediation Goals for Radionuclides (PRG)
Hover over any form section for instructions about the individual selection and requirements.
PRGs for Radionuclides
Home Page
User's Guide
What's New
Frequent Questions
Equations
PRG Calculator
Generic Tables
Select Target Risk
10-6
10-5
10-4
Other:
Select Scenario
Resident
Indoor Worker
Outdoor Worker
Composite Worker
Construction Worker (Site-specific only)
Recreator (Site-specific only)
Farmer
Soil to Groundwater
Select Media:
Soil
Air
Tap Water
2-D External Exposure
Fish

External Exposure

Kevin Bacon getting his bacon fried in X-men.

RSL vs PRG (2)

Select Screening Level Choice

- (●) Defaults
- ( ) Site Specific

Select Risk Output

- (●) No
- ( ) Yes

Select RfD/RfC Choice

- (●) Chronic
- ( ) Subchronic

*Chronic selection will retrieve Chronic-only RfDs/RfCs; Subchronic selection will retrieve subchronic values where possible.

Select Site Info Type

- (●) Defaults
- ( ) Site-specific

Select Risk Output

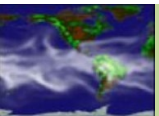
- (●) No
- ( ) Yes

Show Individual Produce Output

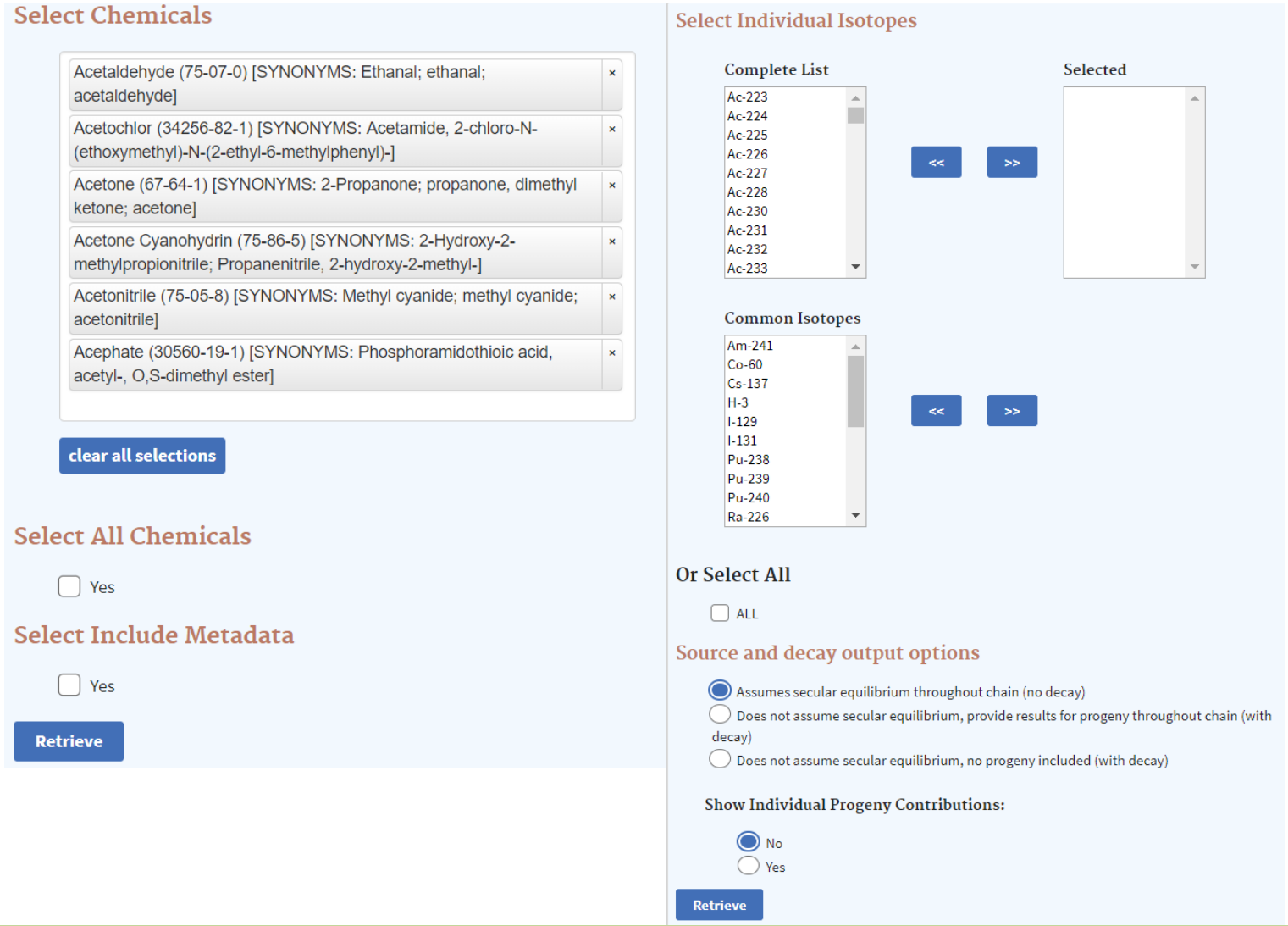
- (●) No
- ( ) Yes

Select Units

- (●) pCi
- ( ) Bq



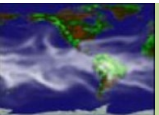
RSL vs PRG (3)


Select Chemicals
Acetaldehyde (75-07-0) [SYNONYMS: Ethanal; ethanal; acetaldehyde]
Acetochlor (34256-82-1) [SYNONYMS: Acetamide, 2-chloro-N-(ethoxymethyl)-N-(2-ethyl-6-methylphenyl)-]
Acetone (67-64-1) [SYNONYMS: 2-Propanone; propanone, dimethyl ketone; acetone]
Acetone Cyanohydrin (75-86-5) [SYNONYMS: 2-Hydroxy-2-methylpropionitrile; Propanenitrile, 2-hydroxy-2-methyl-]
Acetonitrile (75-05-8) [SYNONYMS: Methyl cyanide; methyl cyanide; acetonitrile]
Acephate (30560-19-1) [SYNONYMS: Phosphoramidothioic acid, acetyl-, O,S-dimethyl ester]
clear all selections
Select All Chemicals
Yes
Select Include Metadata
Yes
Retrieve
Select Individual Isotopes
Complete List
Ac-223
Ac-224
Ac-225
Ac-226
Ac-227
Ac-228
Ac-230
Ac-231
Ac-232
Ac-233
<<
>>
Selected
Common Isotopes
Am-241
Co-60
Cs-137
H-3
I-129
I-131
Pu-238
Pu-239
Pu-240
Ra-226
<<
>>
Or Select All
ALL
Source and decay output options
Assumes secular equilibrium throughout chain (no decay)
Does not assume secular equilibrium, provide results for progeny throughout chain (with decay)
Does not assume secular equilibrium, no progeny included (with decay)
Show Individual Progeny Contributions:
No
Yes
Retrieve

RSL vs PRG (4)

Variable
THQ (target hazard quotient) unitless
TR (target risk) unitless
LT (lifetime) years
ET_{res} (exposure time) hours/day
$ET_{res\text{-}c}$ (child exposure time) hours/day
$ET_{res\text{-}a}$ (adult exposure time) hours/day
$ET_{0\text{-}2}$ (mutagenic exposure time) hours/day
$ET_{2\text{-}6}$ (mutagenic exposure time) hours/day
$ET_{6\text{-}16}$ (mutagenic exposure time) hours/day
$ET_{16\text{-}26}$ (mutagenic exposure time) hours/day
ED_{res} (exposure duration) years
$ED_{res\text{-}c}$ (exposure duration - child) years
$ED_{res\text{-}a}$ (exposure duration - adult) years
$ED_{0\text{-}2}$ (mutagenic exposure duration) years

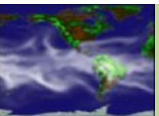
Variable
TR (target cancer risk) unitless
t_{res} (time - resident) yr
ED_{res} (exposure duration - resident) yr
ET_{res} (exposure time - resident) hr/day
$ET_{res\text{-}c}$ (exposure time - resident child) hr/day
$ET_{res\text{-}a}$ (exposure time - resident adult) hr/day
$ET_{res\text{-}i}$ (exposure time - indoor resident) hr/day
$ET_{res\text{-}o}$ (exposure time - outdoor resident) hr/day
$ED_{res\text{-}c}$ (exposure duration - resident child) yr
$ED_{res\text{-}a}$ (exposure duration - resident adult) yr
EF_{res} (exposure frequency - resident) day/yr
$EF_{res\text{-}c}$ (exposure frequency - resident child) day/yr
$EF_{res\text{-}a}$ (exposure frequency - resident adult) day/yr
$IRS_{res\text{-}a}$ (soil intake rate - resident adult) mg/day



RSL vs PRG (5)

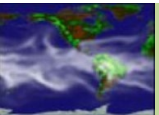
Chemical	SL .1 g)	Inhalation SL Child THQ=0.1 (mg/kg)	Noncarcinogenic SL Child THI=0.1 (mg/kg)	Ingestion SL Adult THQ=0.1 (mg/kg)	Dermal SL Adult THQ=0.1 (mg/kg)	Inhalation SL Adult THQ=0.1 (mg/kg)	Noncarcinogenic SL Adult THI=0.1 (mg/kg)	Screening Level (mg/kg)
Acephate		-	7.59E+00	1.00E+02	2.37E+02	-	7.04E+01	7.59E+00 nc
Acetaldehyde		8.18E+00	8.18E+00	-	-	8.18E+00	8.18E+00	8.18E+00 nc
Acetochlor		-	1.26E+02	1.67E+03	3.95E+03	-	1.17E+03	1.26E+02 nc
Acetone		4.40E+04	6.07E+03	7.51E+04	-	4.40E+04	2.77E+04	6.07E+03 nc

Isotope	Ingestion PRG TR=1E-06 (pCi/g)	Inhalation PRG TR=1E-06 (pCi/g)	External Exposure PRG TR=1E-06 (pCi/g)	Produce Consumption PRG TR=1E-06 (pCi/g)	Total PRG TR=1E-06 (pCi/g)
*Secular Equilibrium PRG for Am-241	5.60E-01	2.60E+01	5.73E-02	1.31E-02	1.04E-02
*Secular Equilibrium PRG for Co-60	2.34E+01	8.39E+04	9.35E-03	5.87E-02	8.06E-03
*Secular Equilibrium PRG for Cs-137	2.10E+01	7.51E+04	4.56E-02	9.04E-02	3.03E-02
*Secular Equilibrium PRG for H-3	9.93E+03	1.25E-01	-	1.20E-01	6.12E-02



RSL vs PRG (6)

Nuclide	Halflife	Mode	Mass	Branching Fraction	Daughter	Branching Fraction	Daughter
Am-241	432.2y	A	241.056829	1.00e+0	Np-237		
Np-237	2.144E+6y	A	237.048173	1.00e+0	Pa-233		
Pa-233	26.967d	B-	233.040247	1.00e+0	U-233		
U-233	1.592E+5y	A	233.039635	1.00e+0	Th-229		
Th-229	7.34E+3y	A	229.031762	1.00e+0	Ra-225		
Ra-225	14.9d	B-	225.023611	1.00e+0	Ac-225		
Ac-225	10.0d	A	225.023229	1.00e+0	Fr-221		
Fr-221	4.9m	A	221.014254	1.00e+0	At-217		
At-217	3.23E-2s	A	217.004718	1.00e+0	Bi-213		
Bi-213	45.59m	B-, A	212.994384	9.79e-1	Po-213	2.09e-2	Tl-209
Po-213	4.2E-6s	A	212.992857	1.00e+0	Pb-209		
Tl-209	2.161m	B-	208.985358	1.00e+0	Pb-209		
Pb-209	3.253h	B-	208.981090	1.00e+0	Stable Bi-209		



RSL vs PRG (7)

- **Carcinogenic**
  - Ingestion

$$SL_{res\text{-}soil\text{-}ca\text{-}ing}\left(\frac{mg}{kg}\right) = \frac{TR \times AT_{res}\left(\frac{365\ days}{year}\right) \times LT\left(70\ years\right)}{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1} \times RBA \times IFS_{res\text{-}adj}\left(\frac{36{,}750\ mg}{kg}\right) \times \left(\frac{10^{-6}\ kg}{mg}\right)}$$

where:

$$IFS_{res\text{-}adj}\left(\frac{36{,}750\ mg}{kg}\right) = \left(\frac{EF_{res\text{-}c}\left(\frac{350\ days}{year}\right) \times ED_{res\text{-}c}\left(6\ years\right) \times IRS_{res\text{-}c}\left(\frac{200\ mg}{day}\right)}{BW_{res\text{-}c}\left(15\ kg\right)} + \frac{EF_{res\text{-}a}\left(\frac{350\ days}{year}\right) \times \left(ED_{res}\left(26\ years\right) - ED_{res\text{-}c}\left(6\ years\right)\right) \times IRS_{res\text{-}a}\left(\frac{100\ mg}{day}\right)}{BW_{res\text{-}a}\left(80\ kg\right)}\right)$$

Resident Soil PRGs

- incidental ingestion of soil

$$PRG_{res\text{-}soil\text{-}ing}\left(pCi/g\right) = \frac{TR}{SF_s\left(\frac{risk}{pCi}\right) \times IFS_{res\text{-}adj}\left(1{,}120{,}000\ mg\right) \times \left(\frac{g}{1000\ mg}\right)}$$

where:

$$IFS_{res\text{-}adj}\left(1{,}120{,}000\ mg\right) = \left(\left(EF_{res\text{-}c}\left(\frac{350\ days}{year}\right) \times ED_{res\text{-}c}\left(6\ years\right) \times IRS_{res\text{-}c}\left(\frac{200\ mg}{day}\right)\right) + \left(EF_{res\text{-}a}\left(\frac{350\ days}{year}\right) \times ED_{res\text{-}a}\left(20\ years\right) \times IRS_{res\text{-}a}\left(\frac{100\ mg}{day}\right)\right)\right)$$

- incidental ingestion of soil,

$$CDI_{res\text{-}soil\text{-}ing}\left(pCi\right) = C_{soil}\left(\frac{pCi}{g}\right) \times IFS_{res\text{-}adj}\left(1{,}120{,}000\ mg\right) \times \left(\frac{g}{1000\ mg}\right)$$

where:

$$IFS_{res\text{-}adj}\left(1{,}120{,}000\ mg\right) = \left(\left(EF_{res\text{-}c}\left(\frac{350\ days}{year}\right) \times ED_{res\text{-}c}\left(6\ years\right) \times IRS_{res\text{-}c}\left(\frac{200\ mg}{day}\right)\right) + \left(EF_{res\text{-}a}\left(\frac{350\ days}{year}\right) \times ED_{res\text{-}a}\left(20\ years\right) \times IRS_{res\text{-}a}\left(\frac{100\ mg}{day}\right)\right)\right)$$

- The following half life should be multiplied by CDI equations:

$$CDI_{decay} = \left(\frac{\left(1\text{-}e^{-\lambda t}\right)}{t\left(year\right) \times \lambda\left(\frac{1}{year}\right)}\right)$$

- The following half life should be multiplied by PRG equations:

$$PRG_{decay} = \left(\frac{t\left(year\right) \times \lambda\left(\frac{1}{year}\right)}{\left(1\text{-}e^{-\lambda t}\right)}\right)$$

RSL vs PRG (8)

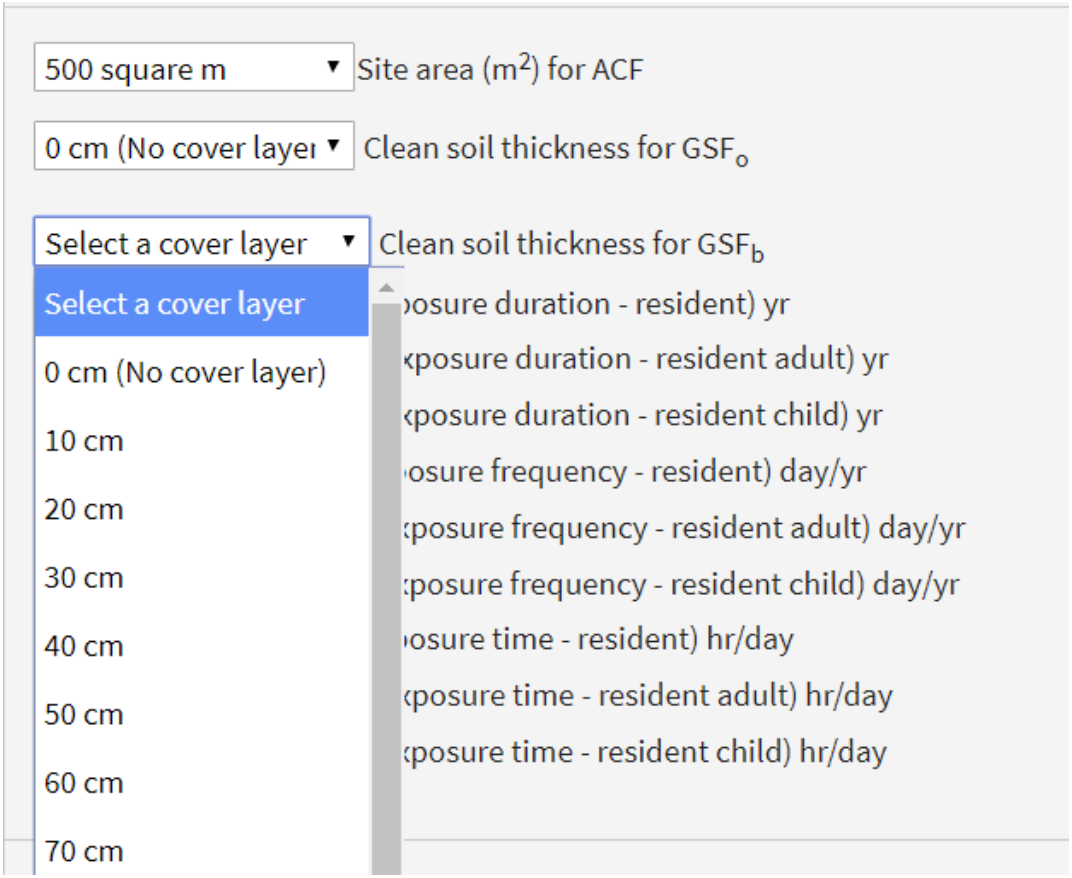
Exposure Assessment Details

Age Segment (yr)	AF (mg/cm²)	BW (kg)	ED (yr)	EF (day/yr)	ET (hr/day)	IRS (mg/day)	SA (cm²/day)
0-2	0.2	15	2	350	24	200	2373
2-6	0.2	15	4	350	24	200	2373
6-16	0.07	80	10	350	24	100	6032
16-26	0.07	80	10	350	24	100	6032
Child (0-6)	0.2	15	6	350	24	200	2373
Adult (6-26)	0.07	80	20	350	24	100	6032

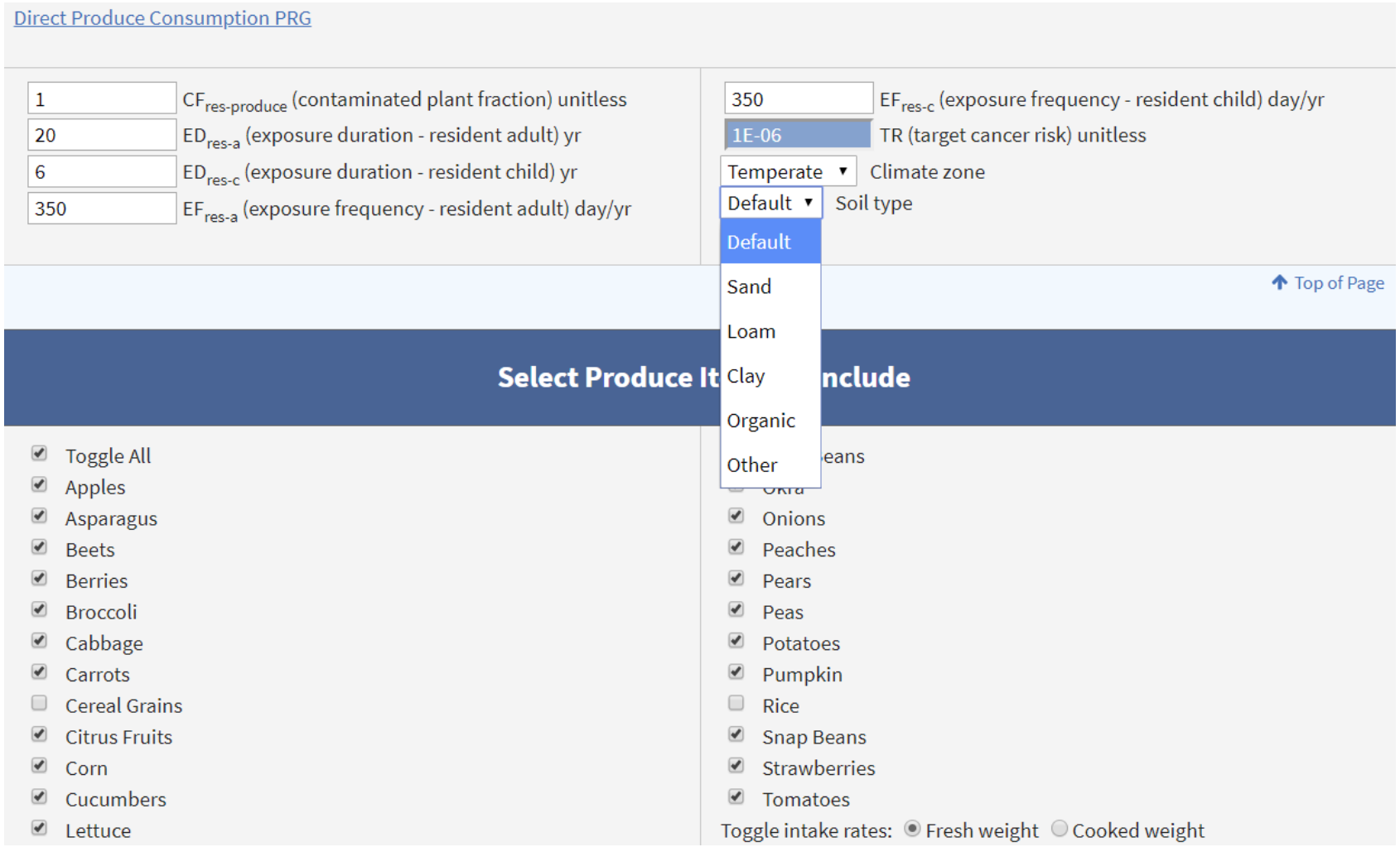
Parameters Common to all Exposure Routes

26	ED_{res} (exposure duration - resident) yr
20	$ED_{res\text{-}a}$ (exposure duration - resident adult) yr
6	$ED_{res\text{-}c}$ (exposure duration - resident child) yr
350	EF_{res} (exposure frequency - resident) day/yr
350	$EF_{res\text{-}a}$ (exposure frequency - resident adult) day/yr
350	$EF_{res\text{-}c}$ (exposure frequency - resident child) day/yr
24	ET_{res} (exposure time - resident) hr/day
24	$ET_{res\text{-}a}$ (exposure time - resident adult) hr/day
24	$ET_{res\text{-}c}$ (exposure time - resident child) hr/day
26	t_{res} (time - resident) yr

RSL vs PRG (9)


500 square m
Site area (m2) for ACF
0 cm (No cover layer
Clean soil thickness for GSFo
Select a cover layer
Clean soil thickness for GSFb
Select a cover layer
0 cm (No cover layer)
10 cm
20 cm
30 cm
40 cm
50 cm
60 cm
70 cm
posure duration - resident) yr
xposure duration - resident adult) yr
xposure duration - resident child) yr
osure frequency - resident) day/yr
posure frequency - resident adult) day/yr
posure frequency - resident child) day/yr
osure time - resident) hr/day
xposure time - resident adult) hr/day
posure time - resident child) hr/day

RSL vs PRG (10)


Direct Produce Consumption PRG
1
CF res-produce (contaminated plant fraction) unitless
20
ED res-a (exposure duration - resident adult) yr
6
ED res-c (exposure duration - resident child) yr
350
EF res-a (exposure frequency - resident adult) day/yr
350
EF res-c (exposure frequency - resident child) day/yr
1E-06
TR (target cancer risk) unitless
Temperate
Climate zone
Default
Soil type
Default
Sand
Loam
Clay
Organic
Other
Top of Page
Select Produce It nclude
Toggle All
Apples
Asparagus
Beets
Berries
Broccoli
Cabbage
Carrots
Cereal Grains
Citrus Fruits
Corn
Cucumbers
Lettuce
eans
Okra
Onions
Peaches
Pears
Peas
Potatoes
Pumpkin
Rice
Snap Beans
Strawberries
Tomatoes
Toggle intake rates:
Fresh weight
Cooked weight

RSL vs PRG (11)

Select Animal Products to Include

- [x] Toggle All
- [x] Beef
- [x] Eggs and Poultry
- [x] Fish
- [x] Goat
- [x] Goat Milk
- [x] Dairy
- [x] Sheep
- [x] Sheep Milk
- [x] Swine

Toggle intake rates: (•) Fresh weight ( ) Cooked weight

Eggs and Poultry

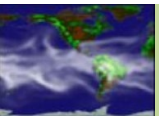
1	$CF_{far\text{-}egg}$ (egg contaminated fraction) unitless
1	$CF_{far\text{-}poultry}$ (poultry contaminated fraction unitless)
775810	$IFE_{far\text{-}adj}$ (age-adjusted egg ingestion factor) g
1376550	$IFP_{far\text{-}adj}$ (age-adjusted poultry ingestion factor) g
59.6	$IRE_{far\text{-}a}$ (egg ingestion rate - farmer adult) g/day
31.7	$IRE_{far\text{-}c}$ (egg ingestion rate - farmer child) g/day
107.4	$IRP_{far\text{-}a}$ (poultry ingestion rate - farmer adult) g/day
46.9	$IRP_{far\text{-}c}$ (poultry ingestion rate - farmer child) g/day

Toggle poultry type: (•) Chicken ( ) Duck ( ) Turkey ( ) Goose

$$PRG_{soil\text{-}far\text{-}tot}\ (pCi/g) = \frac{1}{\frac{1}{PRG_{soil\text{-}far\text{-}sol\text{-}ing}} + \frac{1}{PRG_{soil\text{-}far\text{-}sol\text{-}inh}} + \frac{1}{PRG_{soil\text{-}far\text{-}sol\text{-}ext}} + \frac{1}{PRG_{soil\text{-}far\text{-}produce\text{-}ing\text{-}tot}} + \frac{1}{PRG_{soil\text{-}far\text{-}egg\text{-}ing}} + \frac{1}{PRG_{soil\text{-}far\text{-}poultry\text{-}ing}} + \frac{1}{PRG_{soil\text{-}far\text{-}fish\text{-}ing}} + \frac{1}{PRG_{soil\text{-}far\text{-}beef\text{-}ing}} + \frac{1}{PRG_{soil\text{-}far\text{-}dairy\text{-}ing}} + \frac{1}{PRG_{soil\text{-}far\text{-}swine\text{-}ing}}}$$

Common Pitfalls

- Radionuclides are metals-mostly!
  - Radon presents unique challenges
  - Metals don't have a VF or Andelman's constant
- Radionuclides decay (equation difference, what was the parent?)
- Dermal exposure from soil is not done for rads
- Dermal contact with tapwater is done for rads but called "immersion"
- In addition to inhalation, rads add "submersion"
- Rad PRGs still use inhalation rate
- 2-D external exposure is done for rads with shielding
- Produce is included in the rad resident scenario
- Rad tool has a farmer
- Make sure the rad and chemical risk assessors talk to each other
- Make sure Kds and TFs are same for metals in chem and rad work
- PRG calculator also gives results on a mass basis, careful!



DCC

DCC Calculator

Using the DCC Calculator

Select Scenario

- (•) Resident
- ( ) Indoor Worker
- ( ) Outdoor Worker
- ( ) Composite Worker
- ( ) Construction Worker (Site-specific only)
- ( ) Recreator (Site-specific only)
- ( ) Farmer
- ( ) Soil to Groundwater

Select Media:

- [ ] Soil
- [ ] Tap Water
- [ ] Air
- [ ] 2-D External Exposure
- [ ] Fish

DCC

Select ICRP rule

- (•) 107 – Center for Radiation Protection Knowledge
- ( ) 60/68/72
- ( ) 30

DCC

Parameters Common to all Exposure Route Equations

0.77	AAF_{res-a} (annual age fraction – resident adult) unitless
0.23	AAF_{resc} (annual age fraction – resident child) unitless
1	DL (dose limit) mrem/yr
26	ED_{res} (exposure duration – resident) yr
20	ED_{res-a} (exposure duration – resident adult) yr
6	ED_{res-c} (exposure duration – resident child) yr
350	EF_{res} (exposure frequency – resident) day/yr
350	EF_{res-a} (exposure frequency – resident adult) day/yr
350	EF_{res-c} (exposure frequency – resident child) day/yr
24	ET_{res} (exposure time – resident) hr
24	ET_{res-a} (exposure time – resident adult) hr
24	ET_{res-c} (exposure time – resident child) hr
1	t_{res} (time – resident) yr

DCC

Soil Ingestion

$$DCC_{res\text{-}soil\text{-}ing}(pCi/g) = \frac{DL\left(\frac{mrem}{year}\right) \times t_{res}(year) \times \lambda\left(\frac{1}{year}\right)}{\left(1\text{-}e^{-\lambda t_{res}}\right) \times DCF_o\left(\frac{mrem}{pCi}\right) \times IFS_{res\text{-}adj}\left(\frac{43{,}050\ mg}{year}\right) \times \left(\frac{g}{1000\ mg}\right)}$$

where:

$$IFS_{res\text{-}adj}\left(\frac{43{,}050\ mg}{year}\right) = \left(\left(EF_{res\text{-}c}\left(\frac{350\ days}{year}\right) \times IRS_{res\text{-}c}\left(\frac{200\ mg}{day}\right) \times AAF_{res\text{-}c}(0.23)\right) + \left(EF_{res\text{-}a}\left(\frac{350\ days}{year}\right) \times IRS_{res\text{-}a}\left(\frac{100\ mg}{day}\right) \times AAF_{res\text{-}a}(0.77)\right)\right)$$

where:

$$AAF_{res\text{-}c}(0.23) = \left(\frac{ED_{res\text{-}c}(6\ years)}{ED_{res}(26\ years)}\right) \text{ and: } AAF_{res\text{-}a}(0.77) = \left(\frac{ED_{res\text{-}a}(20\ years)}{ED_{res}(26\ years)}\right)$$

DCC

Site-Specific

Resident DCCs for Soil - Secular Equilibrium

Isotope	Ingestion DCC DL=1 (pCi/g)	Inhalation DCC DL=1 (pCi/g)	External Exposure DCC DL=1 (pCi/g)	Produce Consumption DCC DL=1 (pCi/g)	Total DCC DL=1 (pCi/g)
*Secular Equilibrium DCC for Am-241	4.74E+00	2.77E+02	1.34E+00	6.89E-02	**6.46E-02**
*Secular Equilibrium DCC for Co-60	1.14E+03	1.80E+06	2.20E-01	1.68E+00	**1.94E-01**
*Secular Equilibrium DCC for Cs-137	4.72E+02	1.42E+06	1.09E+00	1.78E+00	**6.75E-01**

DCC

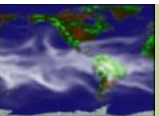
Isotope	50001 m^2 Soil Volume Area Correction Factor	0 cm Soil Volume Gamma Shielding Factor	Wet Soil-to-plant transfer factor (pCi/g-fresh plant per pCi/g-wet soil)	Ingestion Dose (mrem/yr)	Inhalation Dose (mrem/yr)	External Exposure Dose (mrem/yr)	Produce Consumption Dose Back-calculated to Soil (mrem/yr)	Total Dose (mrem/yr)
Am-241	.91E-01	1.00E+00	2.20E-05	2.08E+00	9.09E-02	6.73E-01	2.97E+02	3.00E+02
Co-60	.00E+00	1.00E+00	8.50E-03	4.51E-02	2.87E-05	2.64E+02	6.63E+00	2.70E+02
Cs-137	.78E-01	1.00E+00	2.90E-02	1.15E-01	3.82E-05	1.38E-02	1.82E+01	1.84E+01
Total Dose		-	-	*2.24E+00*	*9.10E-02*	*2.64E+02*	*3.22E+02*	*5.88E+02*

Resident Risk for Soil

Chemical	e	Concentration (mg/kg)	Ingestion Risk	Dermal Risk	Inhalation Risk	Carcinogenic Risk
Arsenic, Inorganic		5.50E+01	7.12E-05	1.00E-05	6.20E-08	8.13E-05
Chromium(VI)		5.50E+01	1.80E-04	-	3.35E-06	1.83E-04
Cobalt		5.50E+01	-	-	1.30E-07	1.30E-07
Zirconium		5.50E+01	-	-	-	-
**Total Risk/HI*		-	*2.51E-04*	*1.00E-05*	*3.54E-06*	*2.64E-04*

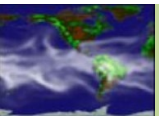
EPA Rad Tool History

- PRG – January 2001
- DCC – January 2002
- BPRG – April 2009
- BDCC – August 2010
- SPRG – August 2010
- SDCC – August 2010



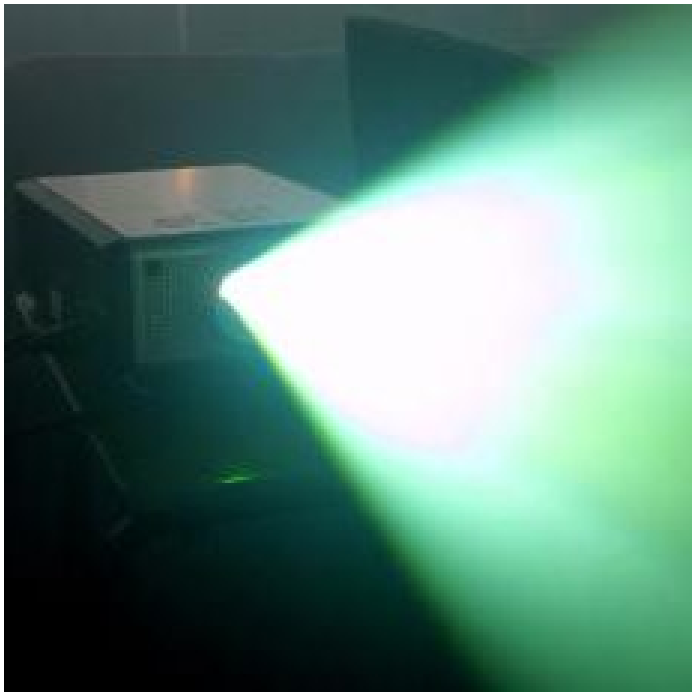
RSL/PRG/DCC

- Told you it was easy!
- Any questions?

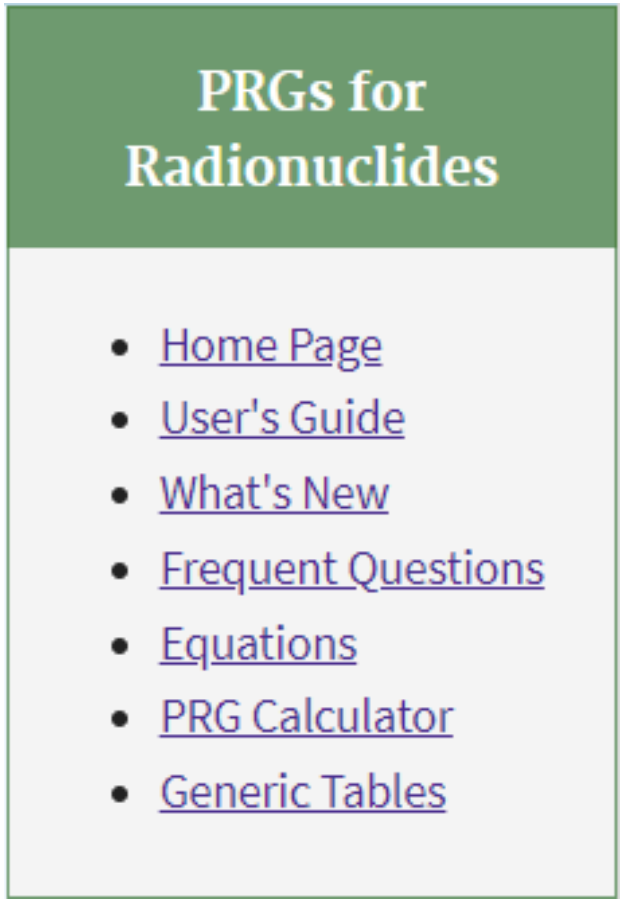


Show Video

- Quick primer of material we have covered



EPA PRG Website Pages



Questions?

EPA DCC Website Pages

Contents

- DCC Home
- DCC Calculator
- DCC User's Guide
- DCC Equations
- DCC Download
- DCC What's New
- DCC FAQ

Questions?

EPA BPRG Website Pages

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- BPRG User's Guide
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Questions?

EPA BDCC Website Pages

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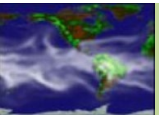

Questions?

EPA SPRG Website Pages

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- SPRG Home
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- SPRG FAQ

Questions?

EPA SDCC Website Pages

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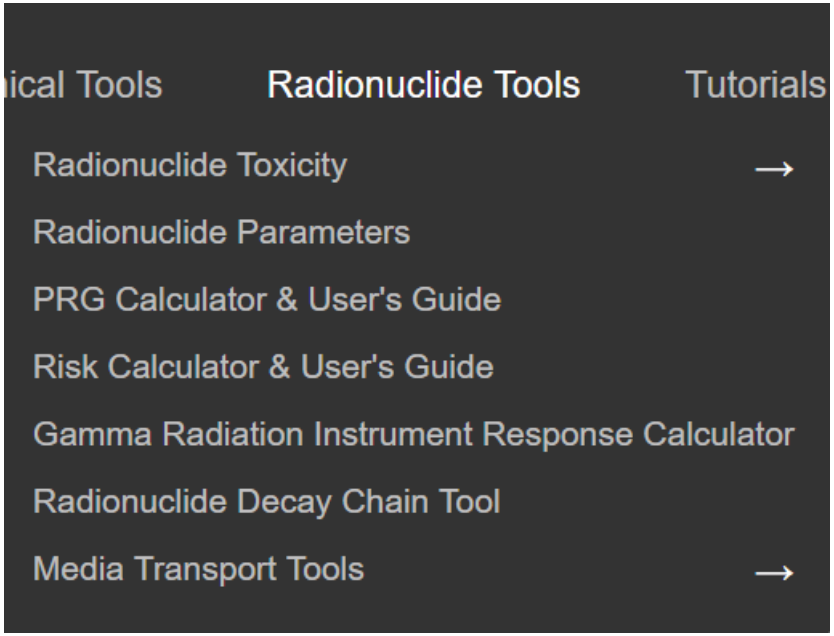
- SDCC Equations
- SDCC Download
- SDCC What's New
- SDCC FAQ

Questions?

RAIS Radionuclide Tools



Questions?

Rad Tool Practice Sessions