INTRODUCTION TO TURBO FRMAC

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Turbo FRMAC

Sandia National Laboratories

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U.S. DEPARTMENT OF ENERGY

NNSA

OUTLINE

- Introductions
- Turbo FRMAC introduction
- Basics of Assessment Science
- Basics of Turbo FRMAC
- Examples
- Web-based training opportunities

- If Time:
- *Administration of Potassium Iodide (KI)
- *Projected Public Dose

INTRODUCTIONS

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TURBO FRMAC

Turbo FRMAC, developed and maintained by Sandia National Laboratories is designed to help the decision maker in a radiological emergency understand the significance of the field sample results and modeling information, so that proper response actions can be implemented. It is intended to aid the leadership in identifying the proper action needed in order to appropriately protect the public.

QUESTION ANSWERED BY TURBO FRMAC

- Do radiation values exceed regulatory or guidance limits?
- Should crops be destroyed or can they be utilized?
- Should animal products be destroyed or can they be utilized?
- Do residents need to be evacuated, sheltered in place, or should another action be taken?
- How long can emergency workers work in a given area?

FIELD-OBSERVABLE VALUES

TF generates field-observable values specific to the radiological event that can be used to determine:

- How long an emergency worker can work in the contaminated area during a radiological emergency?
- The dose received from drinking contaminated water or milk.
- The dose from eating contaminated food.
- The dose expected up- or down-wind of a given field sample.
- Other similar radiological health values

INTRODUCTION

INTRODUCTION

Sandia National Laboratories (SNL), located in Albuquerque, New Mexico, USA

Government owned, contractor operated

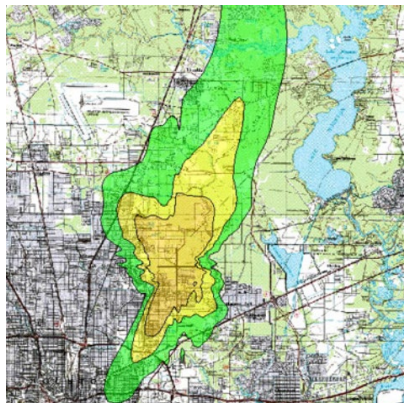
Provide research and technical solutions, expert analysis, and highly trained emergency response professionals to support the U.S. government's response to a nuclear or radiological accident

DOE/NNSA CONSEQUENCE MANAGEMENT PROGRAM

Consequence Management Mission

The mission of the National Nuclear Security Administration's Consequence Management Program is to reduce casualties and protect lives, property, and the environment in response to a nuclear or radiological incident.

MODEL | MEASURE| ASSESS | INTERPRET | ADVISE



TIMELY | ACTIONABLE | SCIENTIFICALLY DEFENSIBLE

FEDERAL RADIOLOGICAL MONITORING AND ASSESSMENT CENTER (FRMAC)

Mission: Provide timely, high-quality predictions, measurements, analyses, and assessments to promote efficient and effective emergency response for the protection of the public from the consequences of nuclear or radiological incidents

Aerial Measurements

Field Monitoring

Sample Control and Analysis

Data Assessment

FRMAC PARTICIPATION

- Department of Agriculture (USDA)
- Department of Defense (DoD)
- Department of Energy (DOE)/National Nuclear Security Administration (NNSA)
- Department of Health & Human Services (DHHS)/Food & Drug Administration (FDA) and Centers for Disease Control & Prevention (CDC)
- Department of Homeland Security (DHS)/Federal Emergency Management Agency (FEMA)
- Environmental Protection Agency (EPA)
- Nuclear Regulatory Commission (NRC)
- Law Enforcement (FBI)
- State/Local/Tribal/Territorial agencies

U.S. PROTECTIVE ACTION GUIDANCE

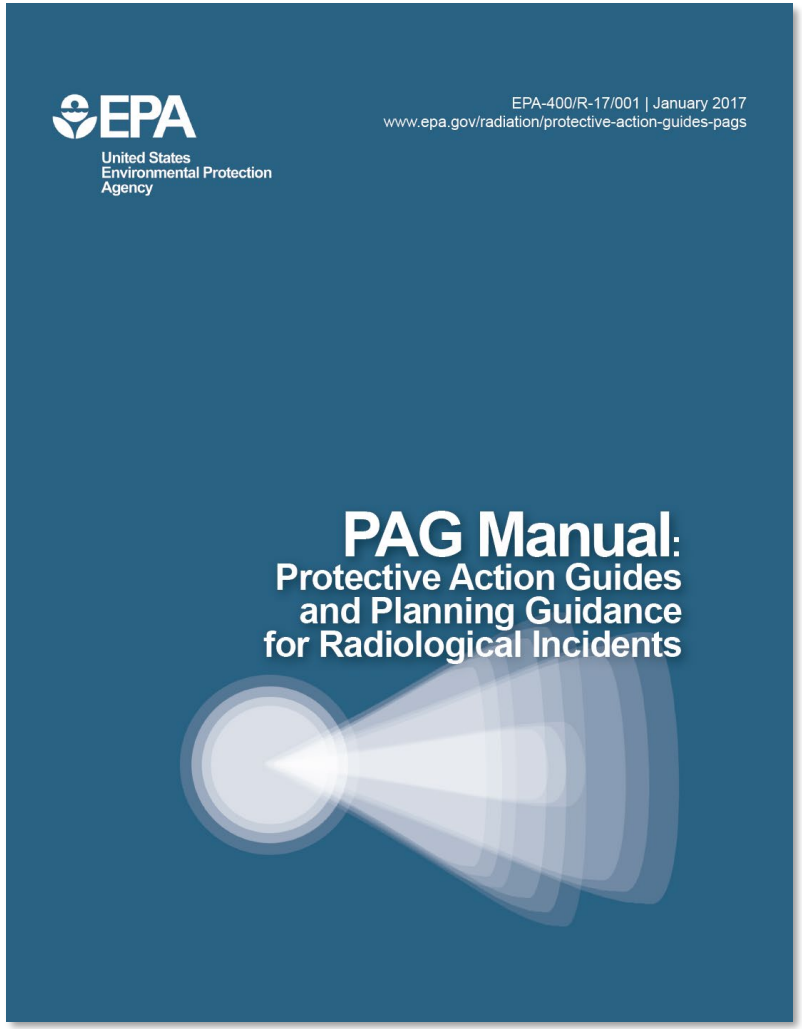
Environmental Protection Agency (EPA) Protective Action Guide (PAG) Manual

PAGs are based on 3 principles:

- 1. Prevent acute effects
- 2. Reduce risk of chronic effects
- 3. Balance protection with other factors and ensure that actions result in more benefit than harm

PAGs are predetermined for use in emergencies for a general population without regard to the magnitude or type of radiological release

Decision makers may implement protective actions at higher or lower levels than the recommended PAGs



PAG MANUAL GUIDANCE

- PAGs are not dose limits or strict numeric criteria

  NOTE: Decision Makers may implement protective actions at higher or lower levels than the recommended PAGs

- PAGs do not:
  - Establish an acceptable level of risk for normal, nonemergency conditions
  - Represent the boundary between safe and unsafe conditions
  - Represent legally binding regulations or standards
  - Supersede environmental laws

INGESTION PAGS- WATER

- Drinking water PAG is for use during an emergency and is not a substitute for compliance with EPA's drinking water regulations under the Safe Drinking Water Act
- EPA expects actions will be taken to return drinking water system to compliance with the regulatory levels by the earliest feasible time
- FDA Food PAGs and EPA Water PAGs are considered separately
- EPA recommends the use of the Sum of Fraction rule if multiple radionuclides are present
- EPA allows a water system to blend uncontaminated water with contaminated water to minimize radiation doses

INGESTION PAGS- FOOD

FDA Ingestion PAG Manual: ACCIDENTAL RADIOACTIVE CONTAMINATION OF HUMAN FOOD AND ANIMAL FEEDS: RECOMMENDATIONS FOR STATE AND LOCAL AGENCIES

- Sets limits on the radionuclide concentration(s) permitted in human food distributed in commerce
- Does not set limits on the radionuclide concentration(s) permitted in animal feeds
- PAGs are based on limiting the lifetime total cancer mortality in the general population
- PAGs assume a lifetime dose based the consumption of contaminated food for the 1st year following the accident
- PAGs are based on the entire diet and assume 30% of the total dietary intake is contaminated

ASSESSMENT CAPABILITY

Analyze models and data available to develop an understanding of the radiological environment

Provide decision makers with radiological information that can be used to issue protective actions

Example for Demonstration Only

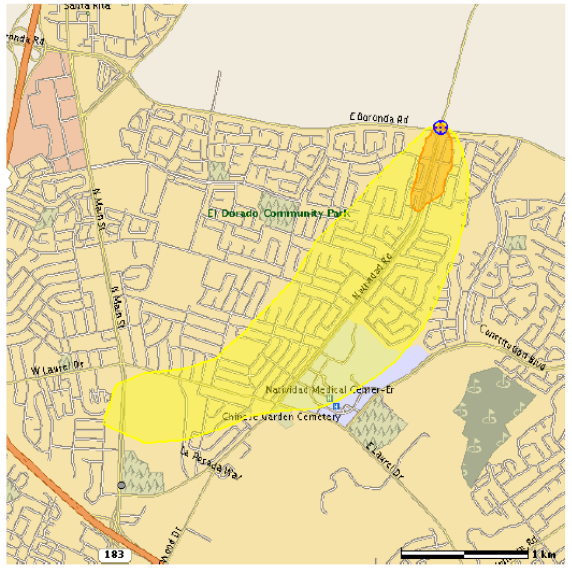
NARAC

Automated Report: Testing
(36.7158,-121.623)
RDD Release at 30 Jun 2011 13:00 UTC

Predicted Evacuation and Sheltering Areas - Most Limiting Criteria

The Whole Body Dose is the most limiting of the EPA Guide criteria

Avoidable Dose - Applicable 12 hr after start of release



Shelter of entire population warranted, often followed by a delayed, deliberate evacuation. Those already outdoors should be removed from the area (exceeds 5 rem). Estimated Population: 360 Area: 0.1 km2 Extent: 0.7 km

Evacuation or sheltering normally initiated (1 to 5 rem). Estimated Population: 10,300 Area: 2.7 km2 Extent: 3.6 km

Notes:
- EPA's Early Phase Guides provide separate criteria to limit dose to both the whole body and the thyroid. Separate predictions of the affected area were compared based on each criteria.
- The Whole Body Dose criterion is the most limiting in this case.
- Protective actions are normally based on the most limiting case.
- Prompt evacuation and/or sheltering reduces radiation dose and cancer risk. Sheltering-in-place may be more protective than evacuation while the radioactive cloud is present.
- Protective actions are only based on dose that can be avoided.
- Prediction excludes dose received before 01 Jul 2011 01:00 UTC.

Assumptions:
- Areas shown are model predictions based on an estimated release of airborne radioactivity, but no measurements yet available.
- Avoidable dose predicted from 12 hr to 108 hr after release start.
- Dose predicted for maximally exposed adult externally exposed to radiation from contamination on the ground and inhalation of resuspended contaminated dust. Also includes dose due to external exposure from and inhalation of the radioactive cloud, if present.

Briefing Product for Public Officials
Produced: 17 May 2013 21:56 UTC
Check for updates

Technical Details: CMHT
Advice & Recommendations: A-Team

Example for Demonstration Only

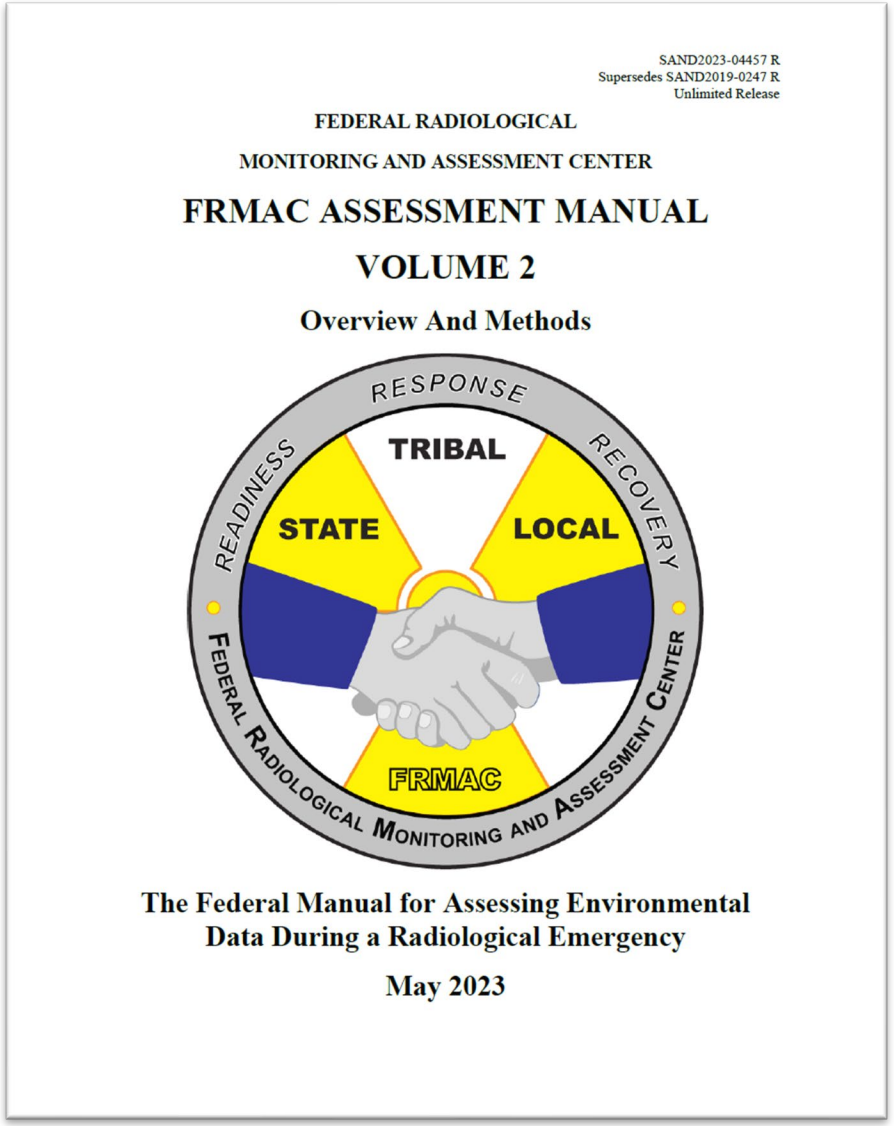
page 1 of 3

Production.rcE21475.rcC1

FRMAC ASSESSMENT MANUAL

- The technical consensus of multiple U.S. federal agencies with expertise in and authority over aspects of radiological emergency response
- Defines the standard dose assessment methods for responding to nuclear or radiological incidents
- Serves as the scientific basis for Turbo FRMAC
- SNL leads development of this manual

https://www.nnss.gov/pages/programs/FRMAC/FRMAC_DocumentsManuals.html



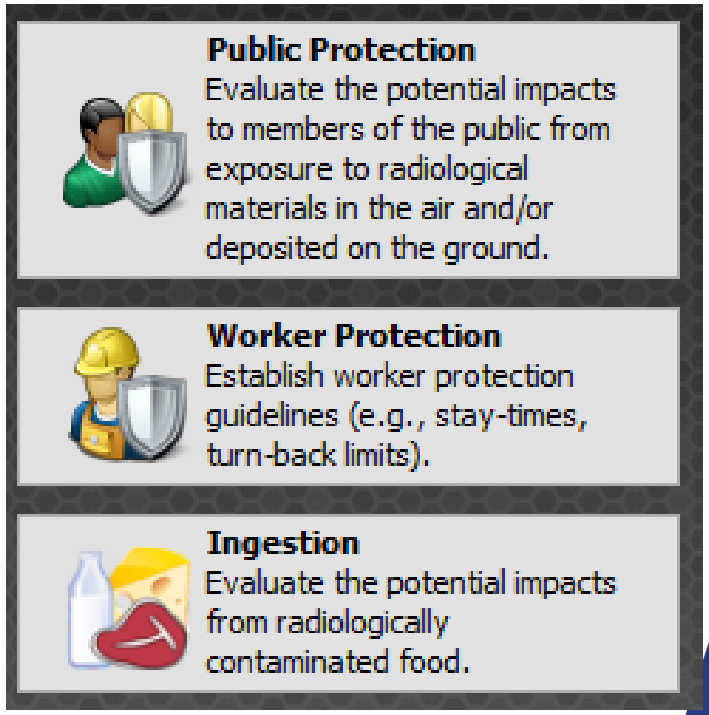
TURBO FRMAC

- Software performs complex calculations to quickly evaluate radiological hazards during an emergency response by assessing impacts to the public, workers, and the food supply
- Automates FRMAC Assessment Manual methods
- Eliminates most human errors
- Deployable software application developed by SNL
- Does not require internet connection
- Updated periodically to implement new and revised methods
- NOT a replacement for health physics knowledge and experience

TURBO FRMAC PURPOSE

Results are used to support protective action decisions, such as:

- Should a population be sheltered, evacuated, or relocated?
- When can a relocated population return home?
- What field measurements would indicate that a protective action is warranted?
- How long can a worker remain in a contaminated area?
- Might a food crop in an area need to be considered for removal from commerce?
- When can a crop be planted so as not to exceed food contamination guidelines?



INITIAL ASSESSMENT PROCESS

Determine initial source term

Potential data sources include regulatory agencies, intel, models, and measurements

Calculate DRL

Turbo FRMAC is used to calculate DRLs

Run atmospheric dispersion models and contour DRL

Resulting map products are used by local officials to decide where to take protective actions

Collect field measurements and use to refine source term

DRLs can also be calculated for specific areas and compared to field measurements

MODEL LIMITATIONS

Turbo FRMAC is **not** an atmospheric dispersion model, so assumptions are used to estimate the relative radionuclide activities in the air and on the ground

FRMAC atmospheric dispersion modeling is handled by the National Atmospheric Release Advisory Center (NARAC) at Lawrence Livermore National Laboratory in Livermore, CA

However, monitoring and sampling, and atmospheric dispersion model data can be entered to improve the accuracy of dose projections and DRLs

Because Turbo FRMAC does not perform atmospheric dispersion, DRLs are calculated for a single radionuclide mixture that does not account for spatial variance

NARAC

NARAC is a national support and resource center for emergency planning, real-time assessment, emergency response, and detailed studies of atmospheric releases of nuclear, radiological, chemical, biological, and hazardous natural materials. NARAC provides timely and accurate plume predictions to aid emergency preparedness and response efforts in protecting the public and the environment.

Lawrence Livermore National Laboratory

40TH ANNIVERSARY 1979–2019

NARAC
National Atmospheric Release Advisory Center
LAWRENCE LIVERMORE NATIONAL LABORATORY

EXAMPLES OF TURBO FRMAC USE

Turbo FRMAC has proved to be a valuable tool to guide protective action decisions following real-world releases including the 2011 Fukushima Daiichi Nuclear Power Plant incident and other accidental releases.

Turbo FRMAC is also used during planning and preparedness activities at all levels of U.S. government.

BASICS OF ASSESSMENT SCIENCE

OVERVIEW

- FRMAC Assessment Concepts
  - Public Protection
  - Ingestion

- Calculation Examples in Turbo FRMAC

PUBLIC PROTECTION CALCULATION CONCEPTS

PUBLIC PROTECTION ASSESSMENT CONCEPTS

- Dose Pathways
- Mixture & Deposition Time
- Time Phases
- Evaluation Time
- Avoidable Dose
- Weathering
- Breathing Rate
- Lung Clearance Type
- Resuspension
- Integrated Air Activity
- Deposition Velocity
- Particle Size Distribution
- Radionuclides with Different Chemical/Physical Forms
- Decay Chain Truncation
- Equilibrium Rules
- Occupancy & Sheltering

COMMONLY-USED TERMS

Protective Action - An activity conducted in response to an incident or potential incident to avoid or reduce radiation dose to members of the public

Protective Action Guide (PAG) - A projected dose to an individual from released radioactive material at which a specific protective action to reduce or avoid that dose is recommended

Projected Dose - The prediction of the dose that a population or individual might receive

Derived Response Level (DRL) - A level of radioactivity in an environmental medium that would be expected to produce a dose equal to the corresponding PAG

TIME

FRMAC Assessment Manual defines the following:

- Release Time (t_0) – The start time of the event/incident/release; Corresponds to the “Time of Deposition”
- Start Time (t_1) – The start of the Time Phase (integration period) under consideration
- End Time (t_2) – The end of the Time Phase (integration period) under consideration

DEFAULT FRMAC TIME PHASES

*Outlined Time Phases correspond to EPA PAG Manual definitions.

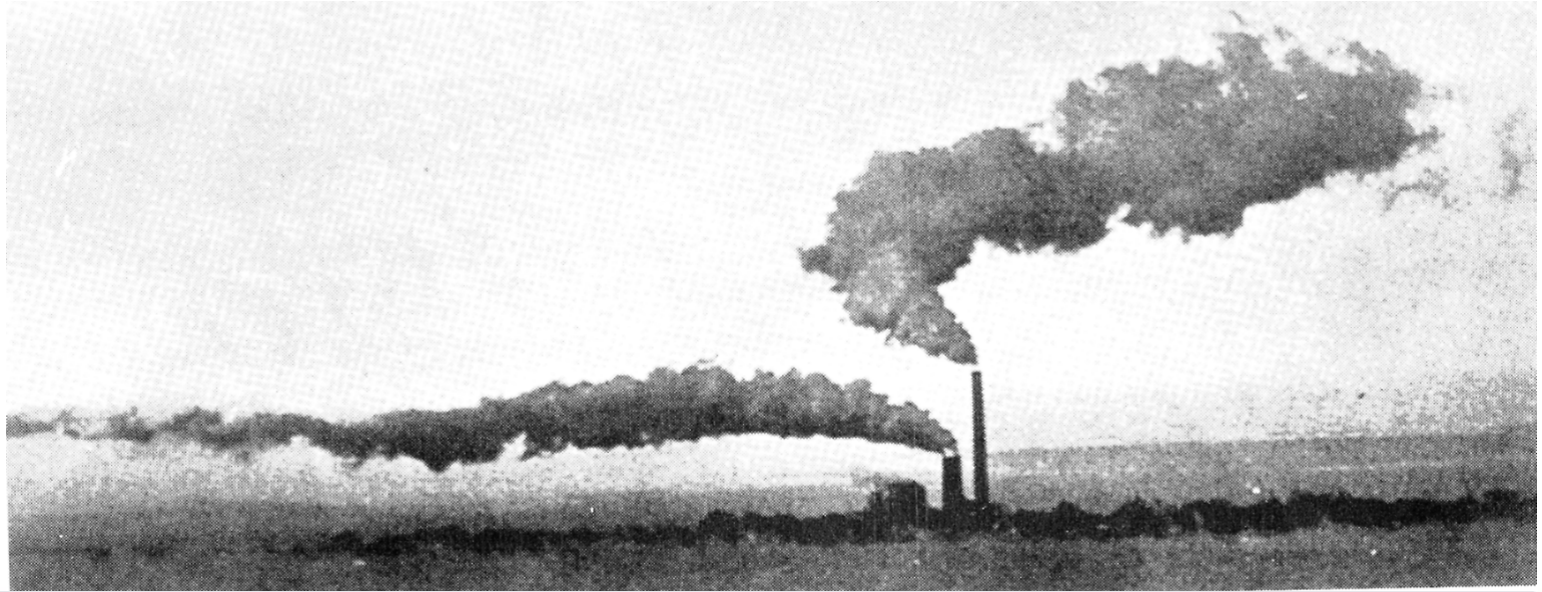
Time Phase	Time Phase Start	Time Phase End	Dose Pathways Included	Comments
Early Phase (Total Dose)	0	96 hr	Plume and Ground	Protective Actions can be implemented before arrival of plume.
Early Phase (Avoidable Dose)	12 hr	108 hr	Ground	Protective Actions **CAN NOT** be implemented before arrival of plume.
First Year	12 hr	8772 hr	Ground	Plume pathways not included regardless of when Protective Actions can be implemented.
Second Year	365 day	730 day	Ground	
Plume Pathways: Inhalation of plume-borne material and Submersion Ground Pathways: Inhalation of resuspended material and Groundshine				

TIME PHASES– EARLY PHASE

- Begins with the radiological release
- May last hours to days; Generally considered 4 days (~96 hours)
- Protective Actions: Evacuation and/or Shelter in Place

TIME PHASES- INTERMEDIATE PHASE

- Release under control or terminated
- May overlap the Early and Late phases and could last weeks to months
- Includes the 1st and subsequent years
- Protective Action: Relocation



INTERMEDIATE PHASE PAGS

Note: Relocation PAGs are treated separately from food and water ingestion.

- Projection of intermediate phase doses should not include these ingestion pathways.
- In some instances, however, where withdrawal of food and/or water from use would, in itself, create a health risk, relocation may be an appropriate alternative protective action.
- In this case, the ingestion dose should be considered along with the projected dose from deposited radionuclides via other pathways, for decisions on relocation.

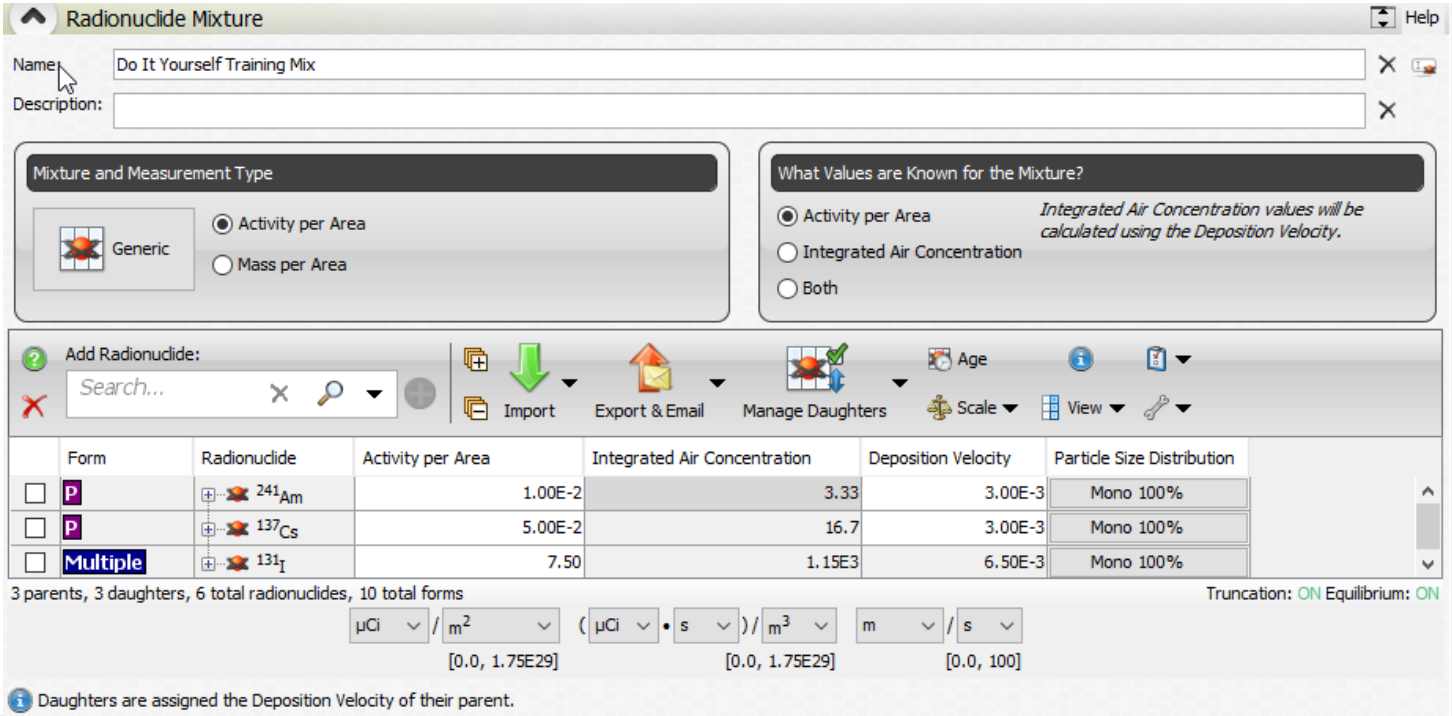
TIME PHASES– LATE PHASE

- Begins after the Intermediate Phase and proceeds independently of Intermediate Phase Protective Actions
- May last months to years
- Transition from strategies driven by urgency, to strategies aimed at reducing longer-term exposures and improving living conditions
- PAGs will not be used to guide restoration and recovery
- Protective Action – Relocation, potentially permanently. Decontamination and/or condemnation of structures

MIXTURE AND DEPOSITION TIME

Mixture is assumed to be deposited at t_0 (release time)

- FRMAC Assessment Manual methods and Turbo FRMAC use mixture deposited at t_0
- A mixture at any other time must be back-decayed and back-weathered to t_0 to calculate appropriate dose for the specified time phase



EVALUATION TIME

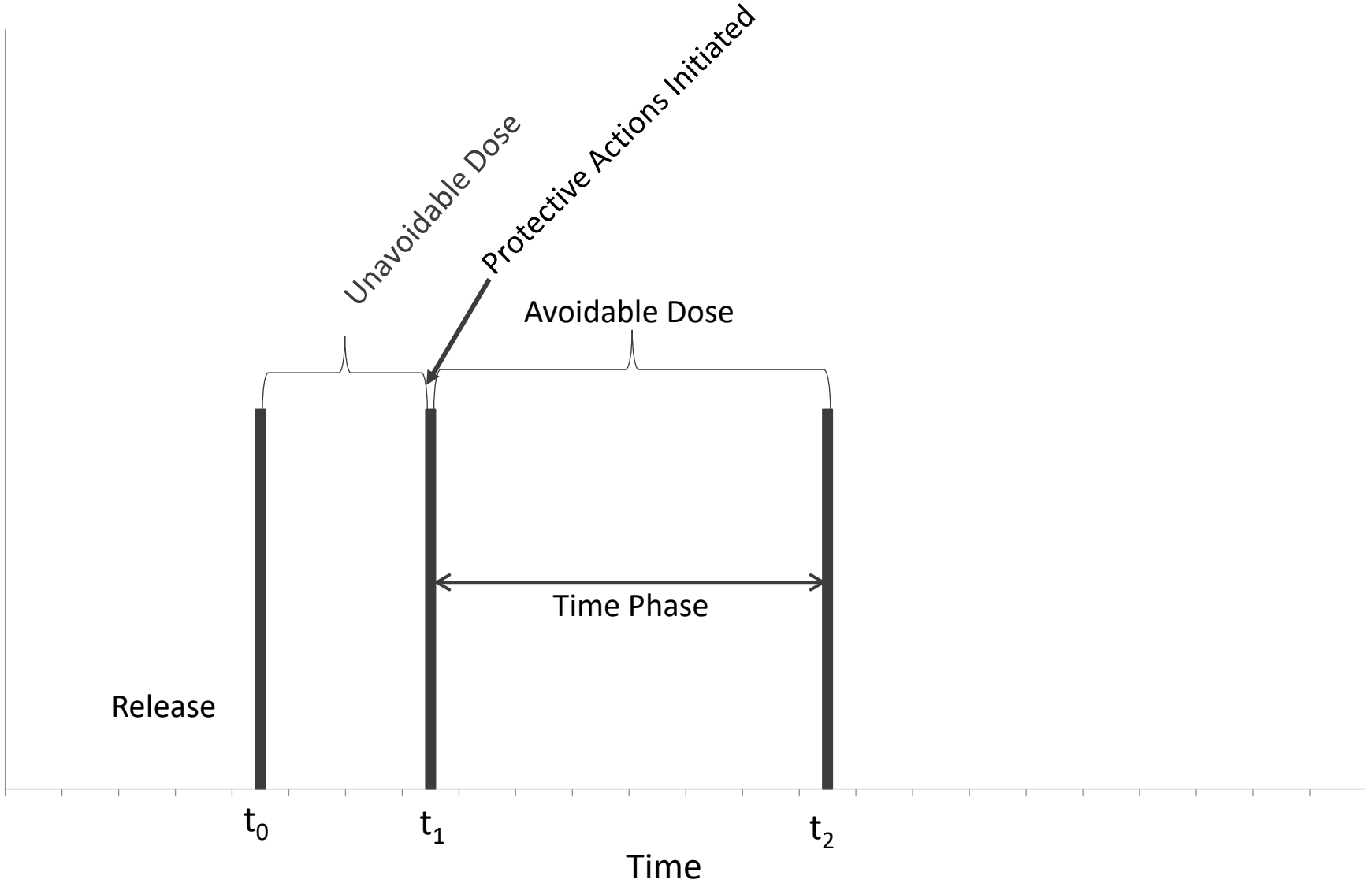
- Evaluation Time (t_n) – The point in time, relative to the start of the event, for which the calculation, measurement, or prediction is valid
  - Evaluation Time (t_n) is generally set to the start of the time phase ($t_n = t_1$), but may be set to any time (before, during, or after the time phase).
- Atmospheric modeling software requires a set duration to model the transport and deposition of plume particulate. For dose assessment to remain consistent with initial atmospheric modeling assumptions, the default t_n is set to 12 hours.
  - For most incident types, 12 hours is sufficient for total plume content deposition
  - If the plume will not be completely deposited by 12 hours, work with atmospheric modelers to choose an appropriate t_n

AVOIDABLE DOSE

- The decision to implement protective actions should be based on the projected dose that would be avoided if the protective actions were implemented (EPA 2017). This is called the Avoidable Dose.
- Unavoidable dose incurred before the implementation of protective action should be excluded when evaluating the need for those protective actions, unless specifically requested by the decision maker.
- To exclude the Unavoidable Dose from a dose assessment, start the Time Phase(s) at some time after the start of the exposure period and ONLY include those dose pathways appropriate to the selected Time Phase(s)

Example: A release has occurred but Decision Makers know it will take 12 hours to initiate Protective Actions. The Unavoidable Dose will be excluded if the Assessment Scientist sets the Time Phase to begin at 12 hours after the release and does not include the Plume Pathways (unless the plume is ongoing).

AVOIDABLE AND UNAVOIDABLE DOSE



WEATHERING AND RESUSPENSION

Weathering – The adjustment for the decrease that occurs over time as the deposited material migrates deeper into the soil column from deposition (t_0) to evaluation time (t_n)

Resuspension – The fraction of radioactive material transferred from the surface to the breathing zone at given time after initial deposition

RESUSPENSION OPTIONS

Resuspension (K) may be:

1. A time varying equation
2. A constant value (e.g., 1.00E-06 m^{-1}), or
3. The ratio of air concentration to ground concentration (determined from samples)

For Example:
Air sample = 1.6E-09 µCi/m^3
Ground sample = 4.5E-03 µCi/m^2

$$K = \frac{\text{air sample}}{\text{ground sample}} = \frac{1.6\text{E-}09\ \frac{\mu Ci}{m^3}}{4.5\text{E-}03\ \frac{\mu Ci}{m^2}} = 3.6\text{E-}07 m^{-1}$$

Calculated Resuspension valid only for a specific location and a specific time

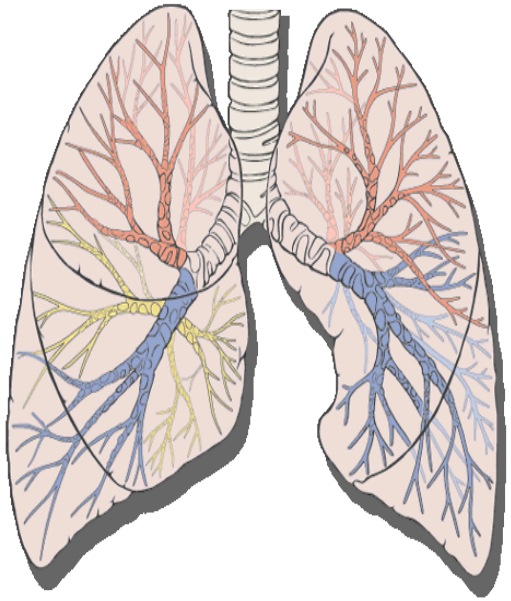
BREATHING RATE

Age Group	Activity								Total Volume	Activity Avg. Rate
	Sleeping		Sitting		Light Exercise		Heavy Exercise			
	Rate m^3/hr	Time hr/day	Rate m^3/hr	Time hr/day	Rate m^3/hr	Time hr/day	Rate m^3/hr	Time hr/day	m^3/day	m^3/hr
Newborn (3 month)	0.09	17.0	NA	NA	0.19	7.0	NA	NA	2.86	0.12
Infant (1 year)	0.15	14.0	0.22	3.33	0.35	6.67	NA	NA	5.20	0.22
5 yr old	0.24	12.0	0.32	4.0	0.57	8.0	NA	NA	8.76	0.37
10 yr old	0.31	10.0	0.38	4.67	1.12	9.33	NA	NA	15.28	0.64
15 yr old (m)	0.42	10.0	0.48	5.5	1.38	7.5	2.92	1.0	20.10	0.84
15 yr old (f)	0.35	10.0	0.4	7.0	1.3	6.75	2.57	0.25	15.72	0.66
Adult (m) (Sedentary)	0.45	8.5	0.54	5.5	1.5	9.75	3.0	0.25	22.18	0.92
Adult (f) (Sedentary)	0.32	8.5	0.39	5.5	1.25	9.75	2.7	0.25	17.68	0.74
See ICRP 66, Tables 8, B.16A, and B.16B for methods to calculate breathing rates.										

FRMAC default calculations use these two.

LUNG CLEARANCE TYPE

- FRMAC's default Lung Clearance Type (LCT) is ICRP Recommended
- Certain radionuclides have specific LCTs that should be used instead of the default when more appropriate information is available



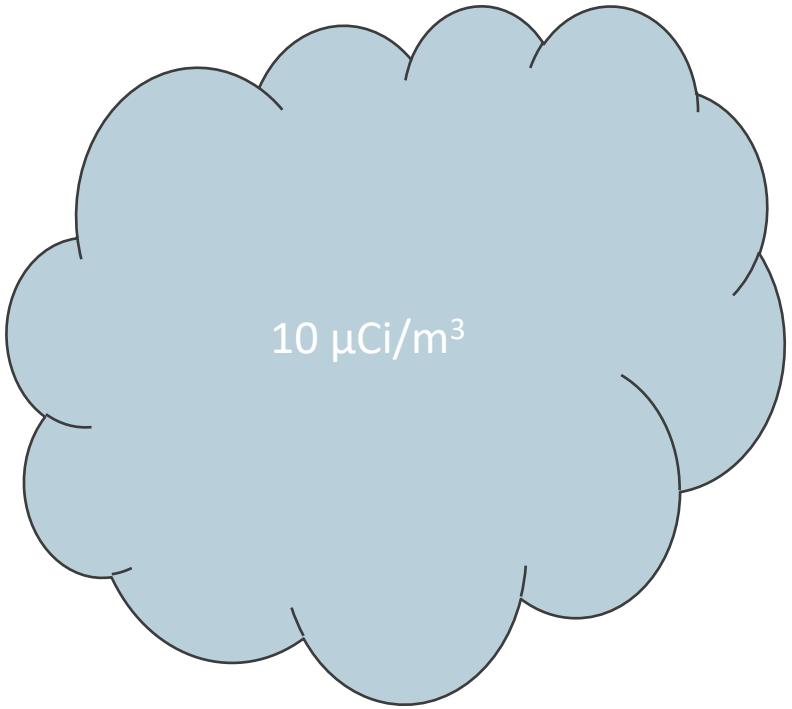
INTEGRATED AIR ACTIVITY

Radiological assessments that include the dose from plume passage require Integrated Air Activity ($\mu Ci \cdot s/m^3$)

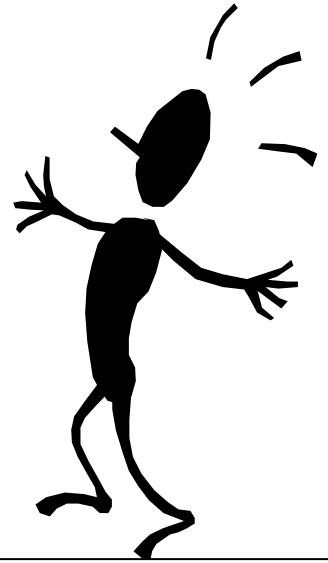
- Integrated Air Activity is the concentration of a radionuclide in air integrated over the plume passage time
- Integrated Air Activity results are obtained from Environmental Continuous Air Monitors (ECAMs)

INTEGRATED AIR ACTIVITY

3 sec



$$\tilde{A} = 10\ \frac{\mu Ci}{m^3} * 3\ s = 30\ \frac{\mu Ci \bullet s}{m^3}$$

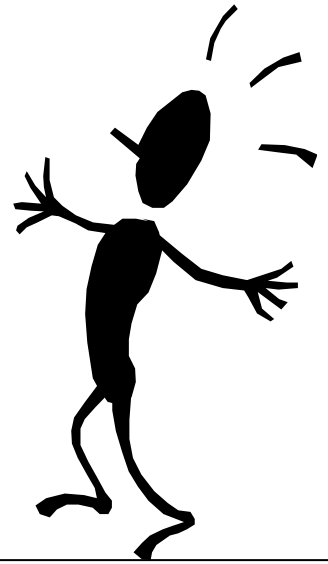


INTEGRATED AIR ACTIVITY

15 sec

$$\tilde{A} = 10\ \frac{\mu Ci}{m^3} * 15\ s = 150\ \frac{\mu Ci \bullet s}{m^3}$$

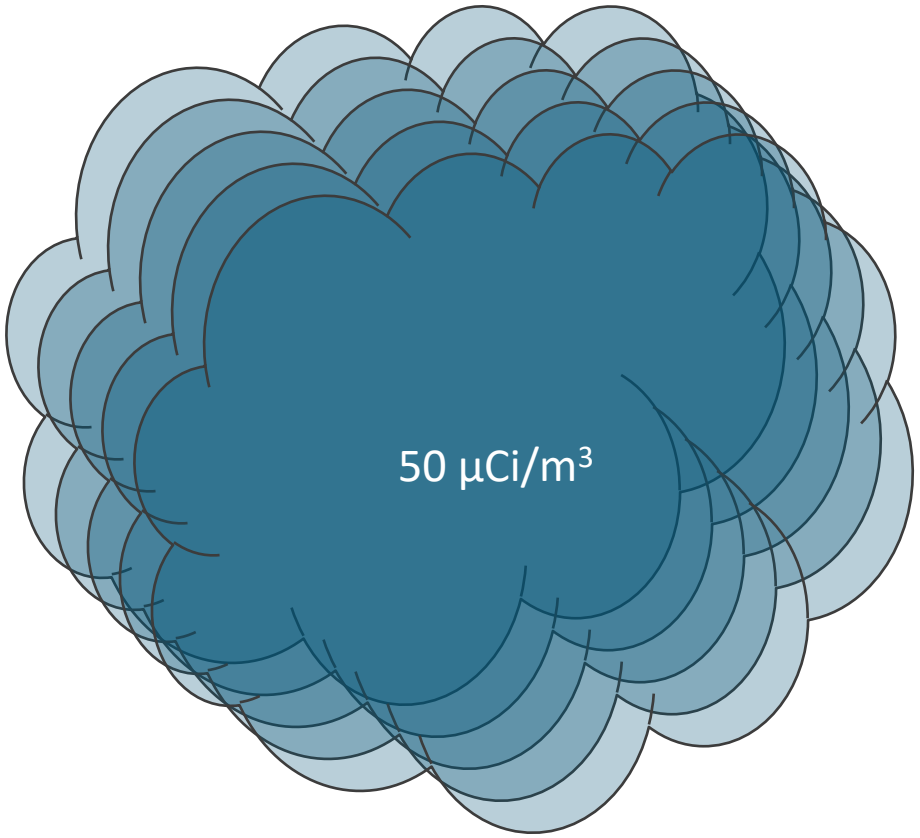
10 µCi/m³

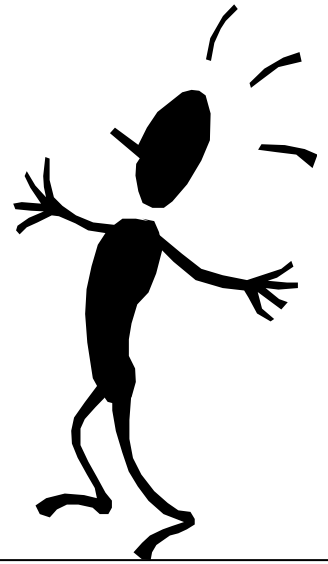


INTEGRATED AIR ACTIVITY

3 sec

$$\tilde{A} = 50\ \frac{\mu Ci}{m^3} * 3\ s = 150\ \frac{\mu Ci \bullet s}{m^3}$$





DEPOSITION VELOCITY

- Deposition velocity (V_d, units of $m \cdot s^{-1}$) is defined as the ratio of the dry deposition flux ($g \cdot s^{-1} \cdot m^{-2}$) to the air concentration ($g \cdot m^{-3}$) of particulate matter or gases.
- Deposition Velocity (V_d) is used to convert between Integrated Air Activity ($\tilde{A}_i$) and Areal Activity (Deposition, Dp_i) when only one type of data is available
- Complex process and depends upon many variables including meteorological conditions (e.g., wind speed, washout) and physical properties (e.g., particle size, gas, vapor, and aerosol)
- FRMAC default deposition velocities are based on dry deposition conditions

$$Dp_i = \tilde{A}_i * V_d$$

$$\frac{\mu Ci}{m^2} = \frac{\mu Ci \bullet s}{m^3} * \frac{m}{s}$$

DEPOSITION VELOCITY

- Wet deposition (washout) is not considered by FRMAC because:
  - washout is likely to affect only part of the area impacted by the incident (i.e., only where it rains or snows during plume passage)
  - washout effects are highly dependent on variables for which FRMAC is unlikely to have data (e.g., raindrop size)

- However, if data is available to determine specific wet deposition, the Assessment Scientist can modify the default deposition velocity to include wet deposition in assessment calculations

DEPOSITION VELOCITY

FRMAC's default Deposition Velocities (V_d)

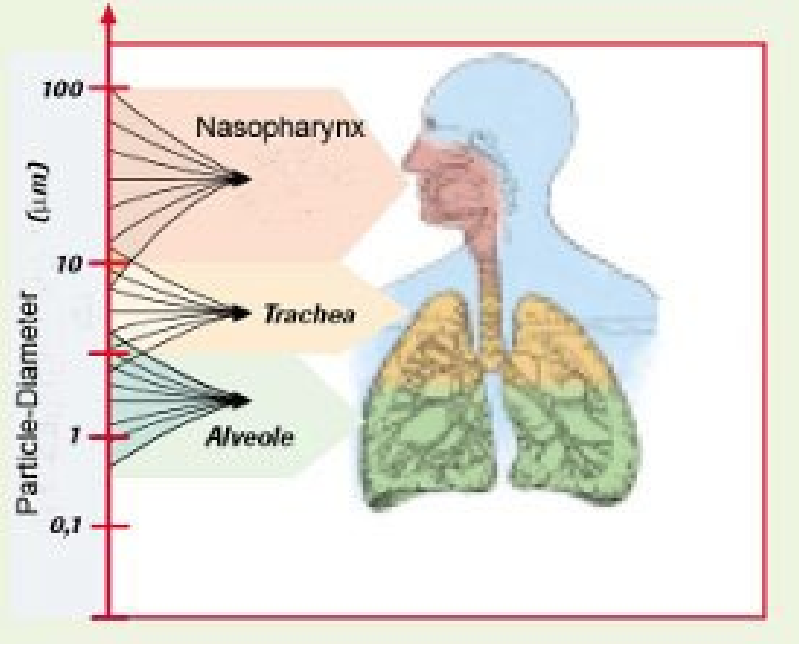
Chemical/Physical Form	V_d (m/s)
Particulates	3.0E-03
Iodine Particulates	6.5E-03
Reactive Iodine Gas (I_2)	6.4E-03
Non-Reactive Iodine Gas (CH_3I)	0.0
Noble Gases	0.0

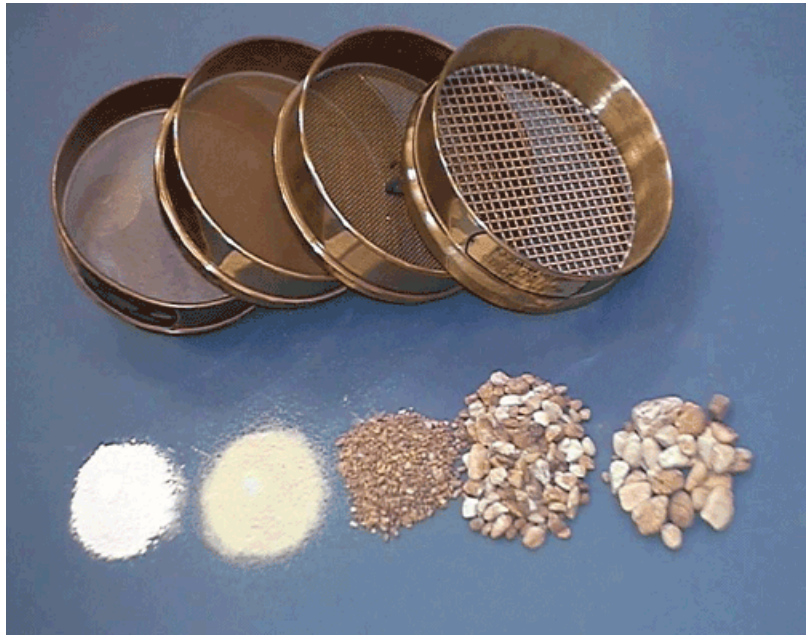
FRMAC's default Deposition Velocities (V_d) are "Effective" values that are in good agreement with NARAC and NRC (RASCAL) models

PARTICLE SIZE DISTRIBUTION

- FRMAC's default approach considers all radionuclides to be in the "particulate" chemical/physical form
- FRMAC's default Particle Size is 1 micron Activity Median Aerodynamic Diameter (AMAD)

Note: Separate particle size distributions can be entered for plume particles and resuspension particles.





RADIONUCLIDES WITH DIFFERENT CHEMICAL/PHYSICAL FORMS

- In addition to particulate form, certain radionuclides may exist in gas or vapor form

- These radionuclides can be partitioned into their multiple forms when this information is known

Carbon	Carbon Monoxide (CO) Carbone Dioxide (CO_2)
Hydrogen	Tritiated Water Vapor (HTO) Elemental Tritium (HT) Organically Bound Tritium
Iodine	Iodine Vapor Methyl Iodide (CH_3I)
Mercury	Mercury Vapor
Nickel	Nickel Vapor
Ruthenium	Ruthenium Vapor
Sulfur	Sulfur Dioxide (SO_2) Carbon Disulfide (CS_2)
Tellurium	Tellurium Vapor

RADIONUCLIDES WITH DIFFERENT CHEMICAL/PHYSICAL FORMS

Iodine released from a nuclear power plant (NPP) under accident conditions is partitioned as follows in order to be consistent with NRC calculations

Particulate	25%
I_2	30%
CH_3I	45%

DECAY CHAIN TRUNCATION

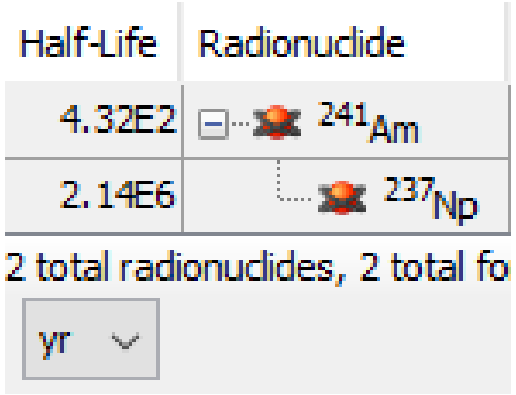
To increase calculation speed, we have established a set of rules for truncating daughters when the daughters' contribution to dose will be negligible.

- The first daughter is always included in calculations.
- Truncation is enabled by default in Turbo FRMAC calculations

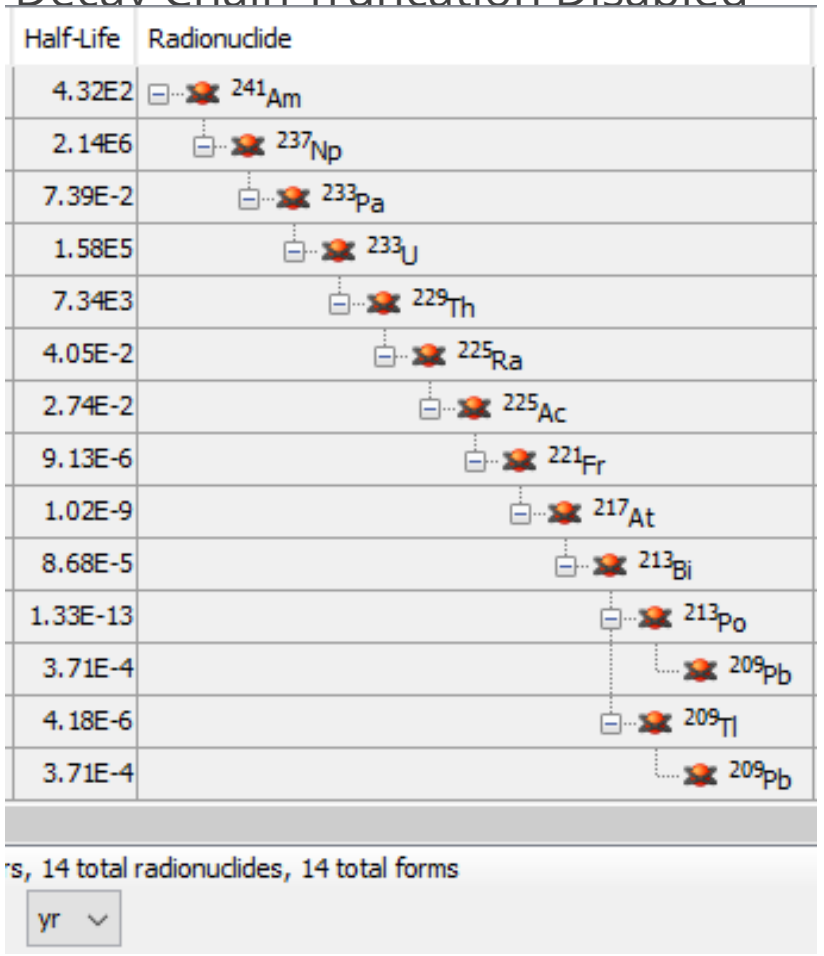
DECAY CHAIN TRUNCATION

Example of Decay Chain Truncation

Decay Chain Truncation Enabled



Decay Chain Truncation Disabled



EQUILIBRIUM RULES

The following Equilibrium Rules apply to the Mixture:

Daughter radionuclides are considered to be in equilibrium (secular, or transient when the branching ratio ≠ 1) with the Parent at deposition (t = 0) if;

- Daughter's half-life is less than the half-life of the ultimate parent (i.e., first parent in decay series), and
- Daughter's half-life is less than 1.5 years

Daughter radionuclides meeting the above rules are assigned the Parent's half-life and decay constants for calculations

Equilibrium Rules are applied after Truncation

Equilibrium Rules are enabled by default in Turbo FRMAC, unless importing a mixture from the RASCAL software

EQUILIBRIUM RULES

Example of Equilibrium Rule

Equilibrium Rules Enabled

Half-Life	Radionuclide	Activity per Area
1.60E3	^{226}Ra	2.00E2
1.05E-2	^{222}Rn	2.00E2
5.80E-6	^{218}Po	2.00E2
6.34E-8	^{218}At	4.00E-2
3.78E-5	^{214}Bi	4.00E-2
5.21E-12	^{214}Po	4.00E-2
22.3	^{210}Pb	0.0
1.37E-2	^{210}Bi	0.0
0.379	^{210}Po	0.0
5.10E-5	^{214}Pb	2.00E2
3.78E-5	^{214}Bi	2.00E2
5.21E-12	^{214}Po	2.00E2
22.3	^{210}Pb	0.0
1.37E-2	^{210}Bi	0.0
0.379	^{210}Po	0.0

s, 15 total radionuclides, 15 total forms

yr / μCi / m^2

Equilibrium Rules Disabled

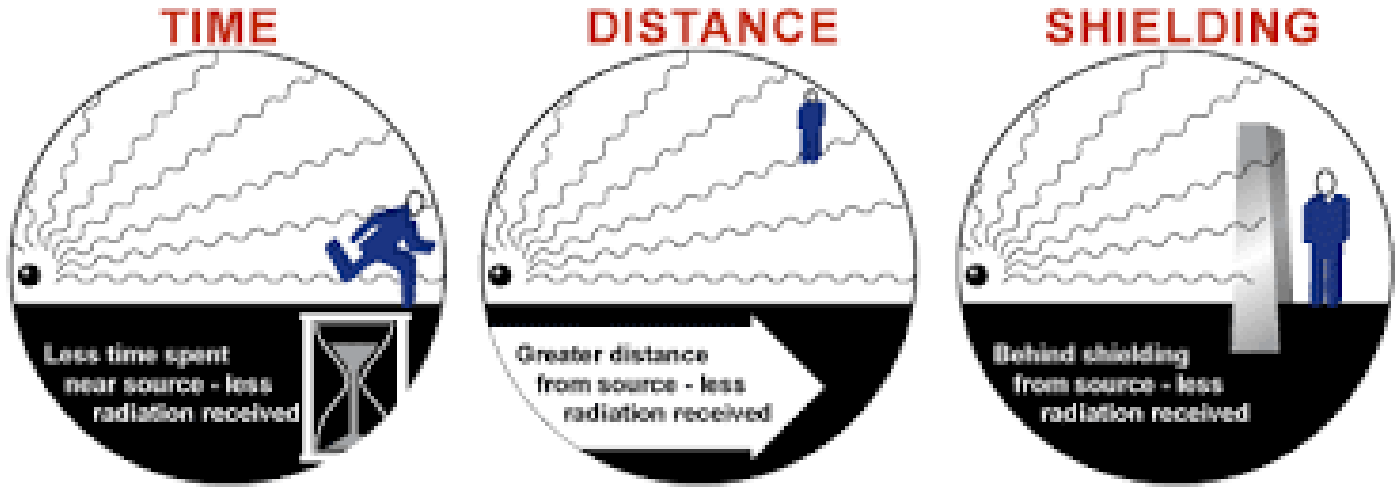
Radionuclide	Activity per Area
^{226}Ra	2.00E2
^{222}Rn	0.0
^{218}Po	0.0
^{218}At	0.0
^{214}Bi	0.0
^{214}Po	0.0
^{210}Pb	0.0
^{210}Bi	0.0
^{210}Po	0.0
^{214}Pb	0.0
^{214}Bi	0.0
^{214}Po	0.0
^{210}Pb	0.0
^{210}Bi	0.0
^{210}Po	0.0

15 total radionuclides, 15 total forms

μCi / m^2

OCCUPANCY AND SHELTERING

FRMAC's default approach assumes that the receptor is outside in the contaminated area continuously during the time phase without any protective measures



OCCUPANCY AND SHELTERING

- Occupancy Factors account for the fact that receptors may be:
  - Unsheltered in the contaminated area for a portion of the Time Phase
  - Sheltered inside a structure in the contaminated area for a portion of the Time Phase
  - Absent from the contaminated area for a portion of the Time Phase
- Building Protection Factors account for the fact that being sheltered inside a structure reduces the dose to an individual in an area of contamination

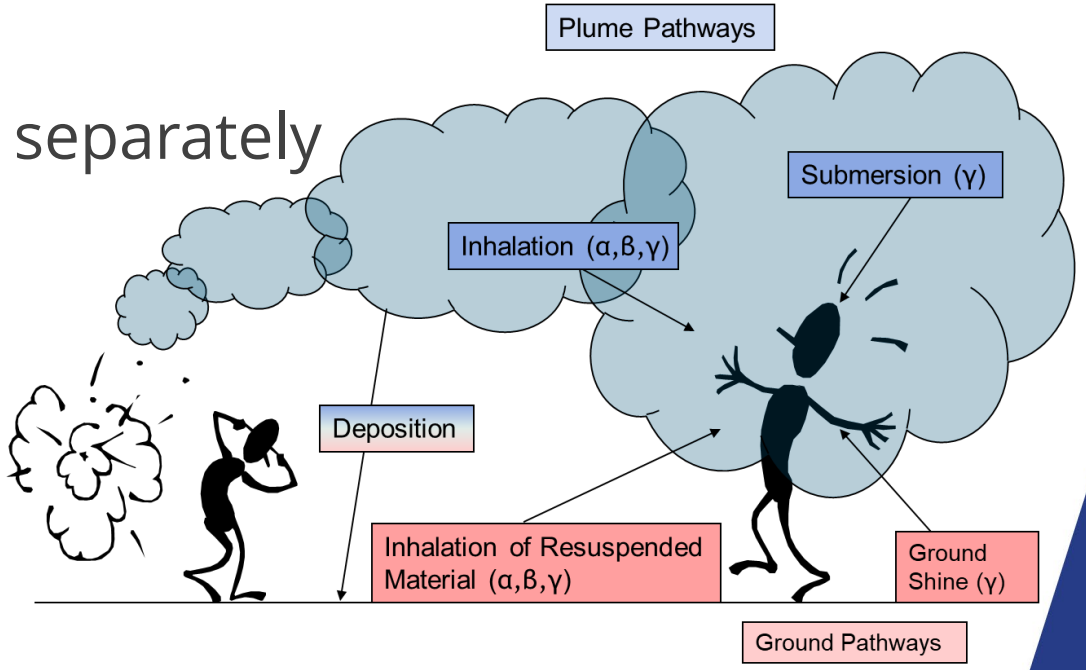
HOW ARE PUBLIC PROTECTION DOSES CALCULATED IN TURBO FRMAC?

Public protection calculations include four exposure pathways:

- Plume Inhalation
- Plume Submersion
- Resuspension Inhalation
- Groundshine

Ingestion exposure pathway is handled separately

Dose is integrated over a user-specified time period



TYPES OF PUBLIC PROTECTION CALCULATIONS

- Derived Response Level (DRL)
- Administration of Potassium Iodide (KI)
- Projected Public Dose (PPD)
- Dose Parameters

TYPES OF DERIVED RESPONSE LEVELS (DRL)

DRLs can be both calculated and measurable quantities that are used to generate contours on dispersion models to project areas where Protective Actions should be considered

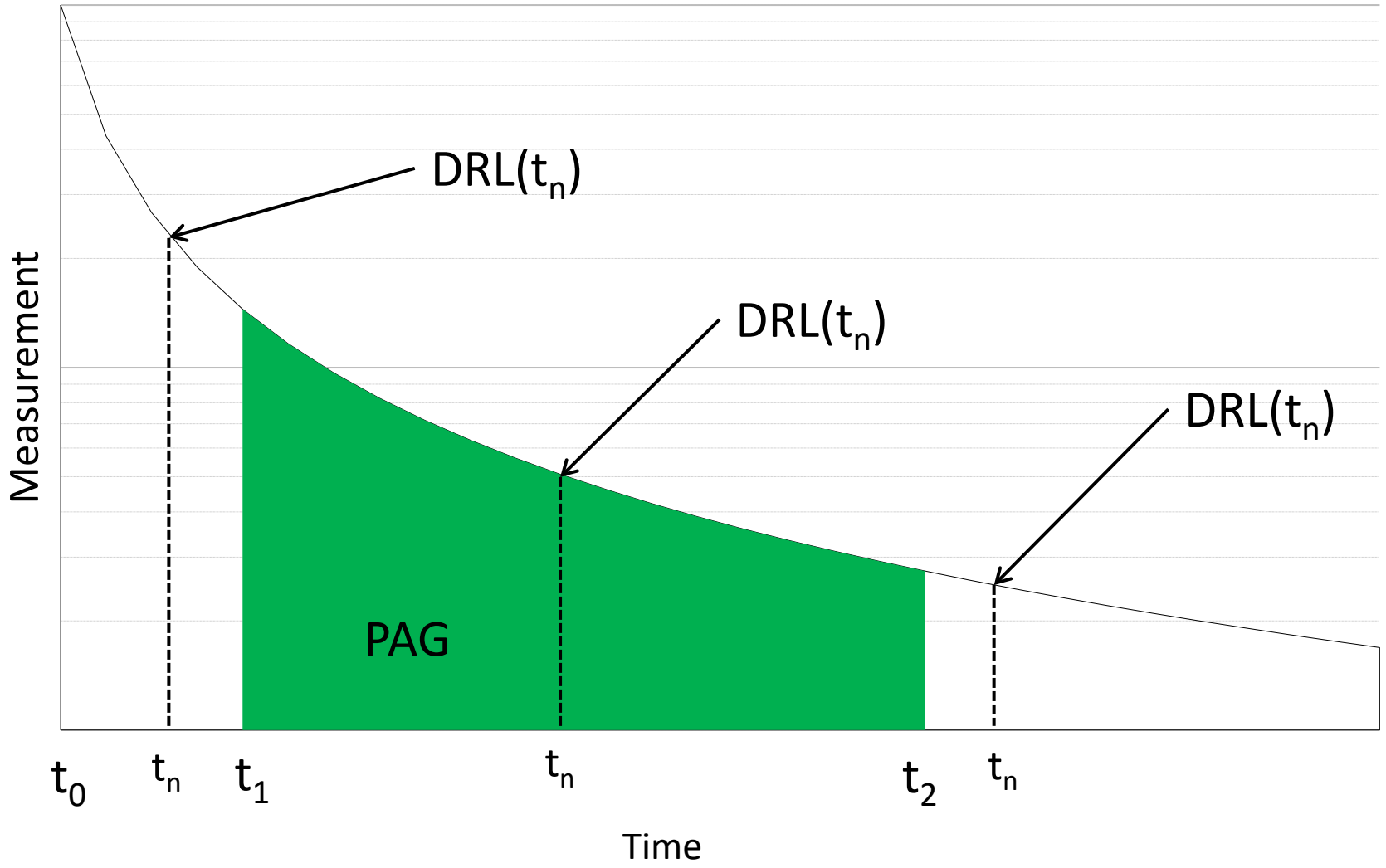
Integrated Air DRLs - The integrated air activity of a radionuclide at which the total dose from all radionuclides in a release would equal the PAG over the time phase under consideration

Deposition DRLs - The areal activity at a specific evaluation time of a radionuclide at which the total dose from all radionuclides in a release would equal the PAG over the time phase under consideration

Dose Rate/Exposure Rate DRLs - The external dose or exposure rate from all radionuclides in a release that would produce a dose equal to the PAG over the time phase under consideration

Which flavor of DRL to use depends on the question being asked

DRLS AND EVALUATION TIME



FRMAC DEFAULT ASSUMPTIONS

- Adult receptor, Whole Body (Effective) dose
- The receptor is outside and unprotected
- The plume is in contact with the ground
- Airborne noble gases are not deposited
- Deposition is immediate
- Deposition is assumed to be dry particulates with a default particle size of 1-micron Activity Median Aerodynamic Diameter (AMAD)
- ICRP Recommended Lung Clearance Type
- ICRP 60 based dose coefficients and breathing rates
- Maxwell and Anspaugh (2011) resuspension model[1]
- Anspaugh (2002) weathering model[2]

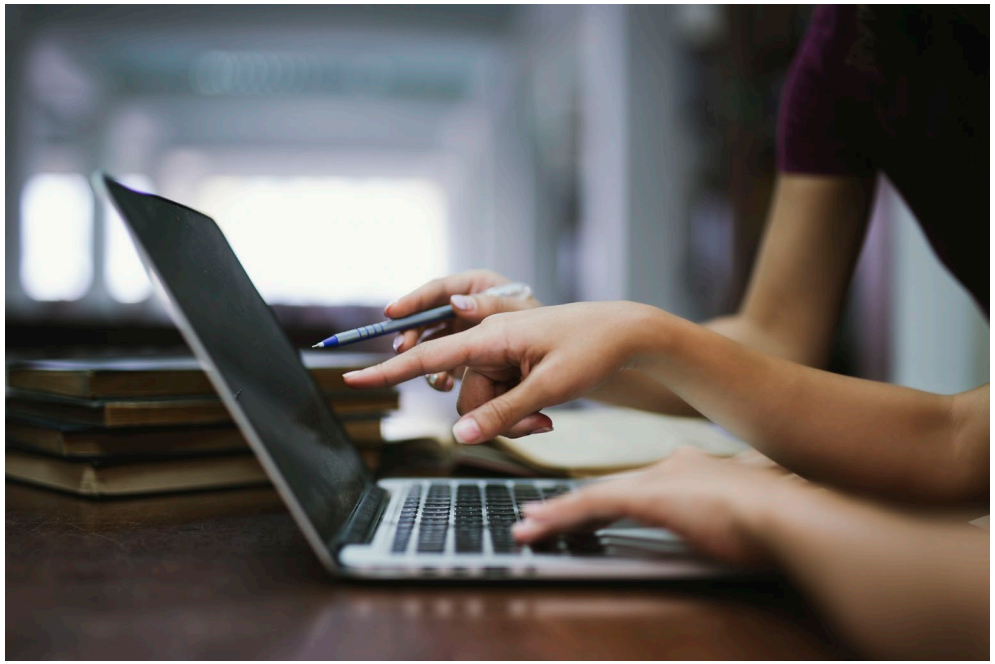
Turbo FRMAC settings can be adjusted to use different models or event-specific data

[1] Maxwell, R. and Anspaugh, L., "An Improved Model for Prediction of Resuspension" in *Health Physics*, Vol. 101, pp. 722-730, December 2011
[2] Anspaugh, L., et al., "Movement of Radionuclides in Terrestrial Ecosystems by Physical Processes" in *Health Physics*, Vol. 82, pp. 670-679, April 2002

PUBLIC PROTECTION CALCULATION EXAMPLE

WALK THROUGH EXAMPLES

Please get out your laptops and open up your install of Turbo FRMAC to follow along. We will walk through this example together.



SETTING THE STAGE

We have a request:

The local decision maker wants to know if they should order a Relocation for their downwind population

You must calculate the 1st Year DRL values.

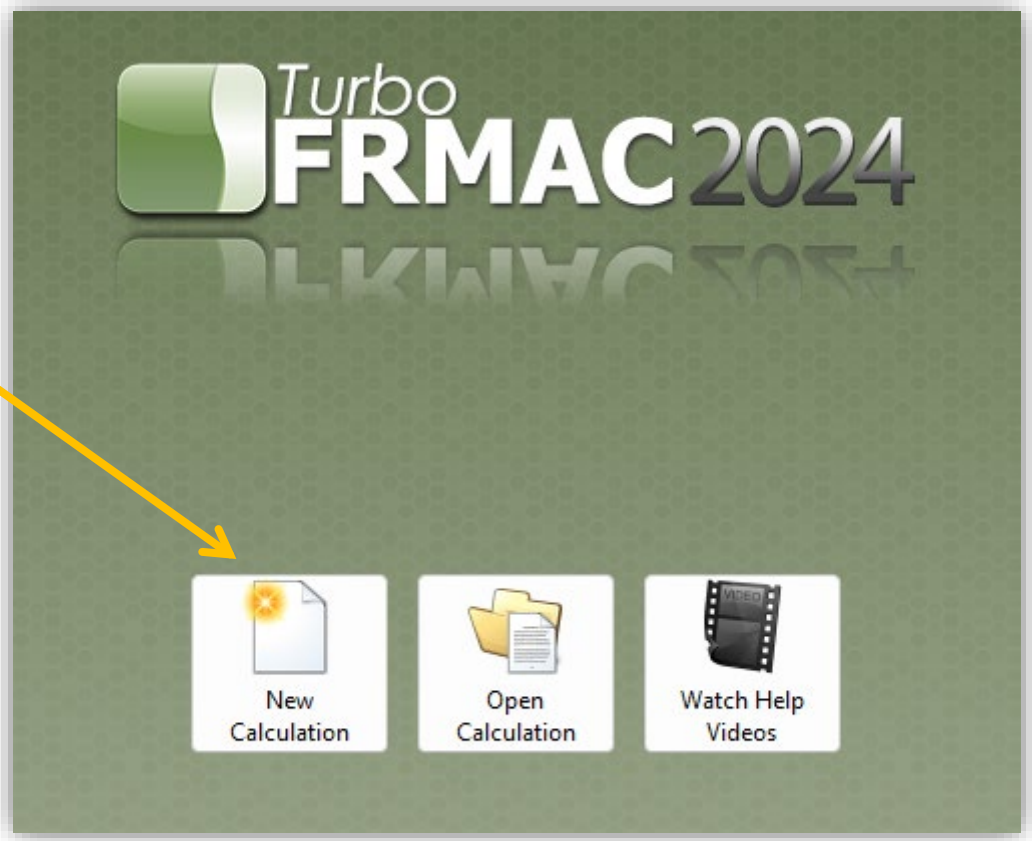
- Are the 1st year DRLs exceeded?
- What is the 1st Year PAG?
- Which Pathways should we use?

Assume the following Mixture

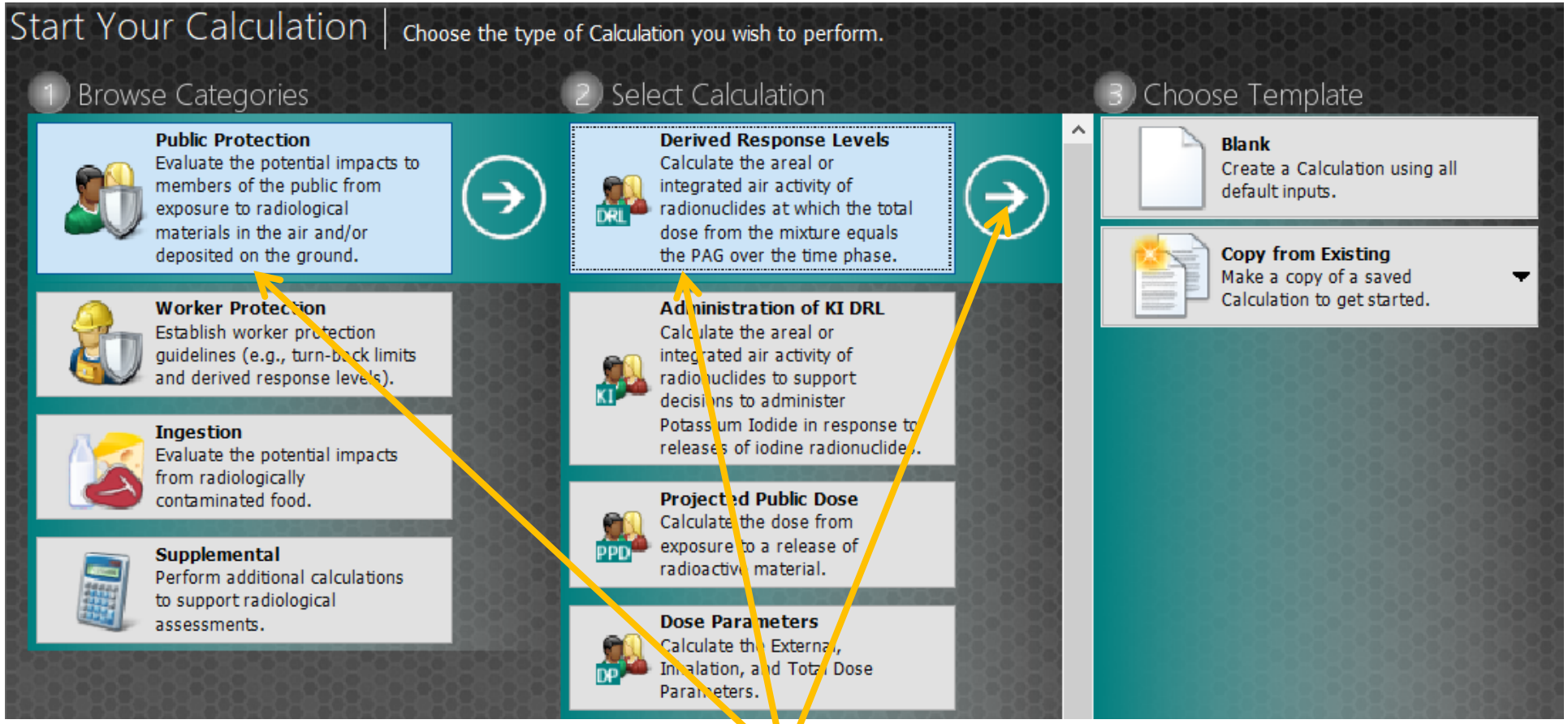
Radionuclide	Activity per Area ($\mu Ci/m^2$)
^{60}Co	2
^{148}Gd	1
^{90}Sr	3
$^{90}Y^a$	3
[a] ^{90}Y included as a daughter in equilibrium	

OPEN TURBO FRMAC

Select New Calculation



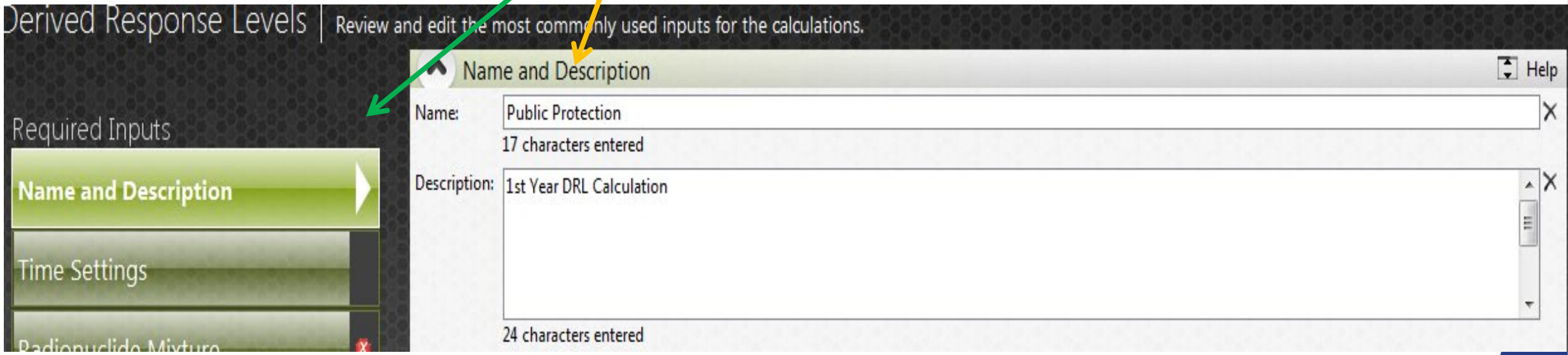
SELECT NEW CALCULATION



Select Public Protection, then Derived Response Level, then Blank

NAME AND DESCRIBE CALCULATION

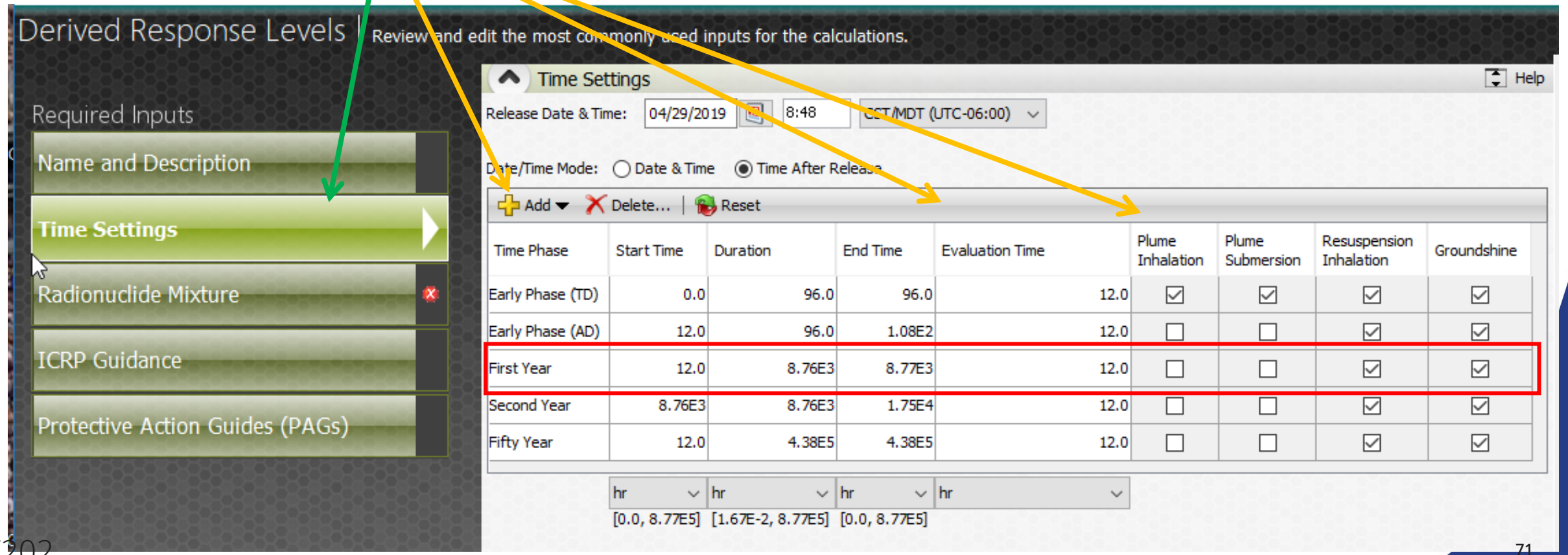
Click on Name and Description Button
Type in a Name and Description for the calculation



VERIFY TIME PHASES AND EVALUATION TIME

Click on Time Settings Button
Verify Time Phases, Evaluation Time and Pathways are correct

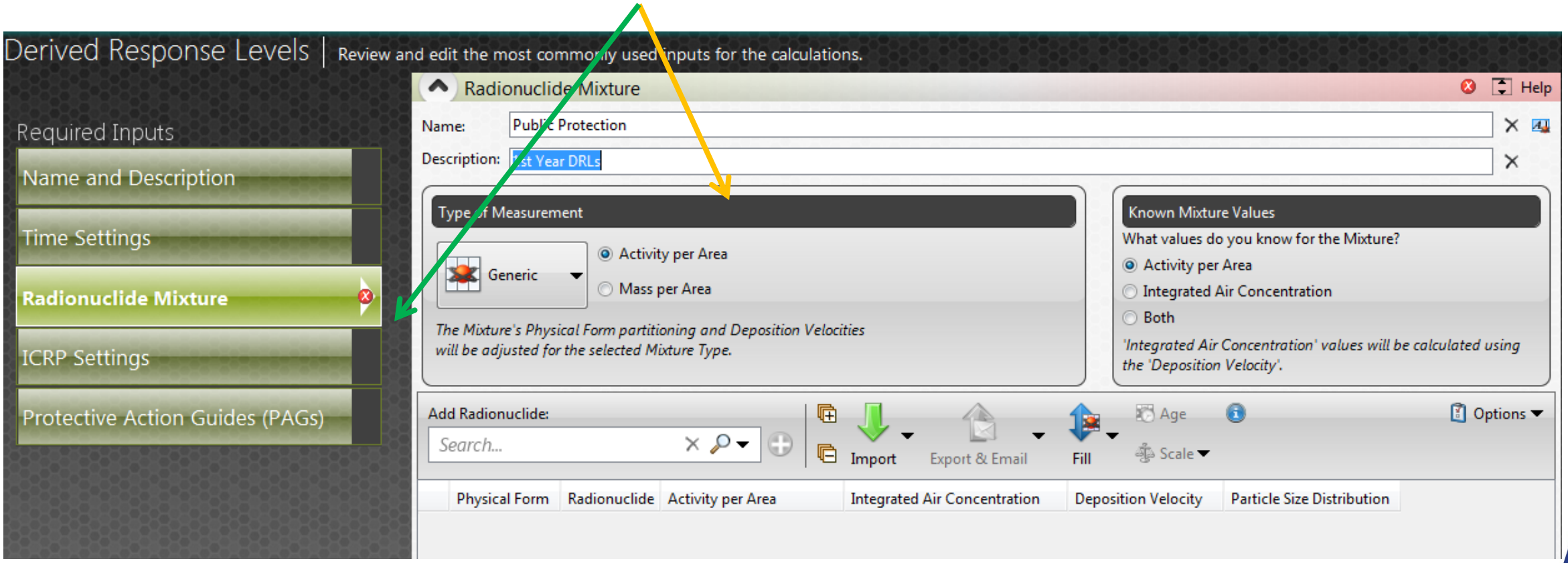
What pathways are chosen for the 1st year?



BUILD RADIONUCLIDE MIXTURE

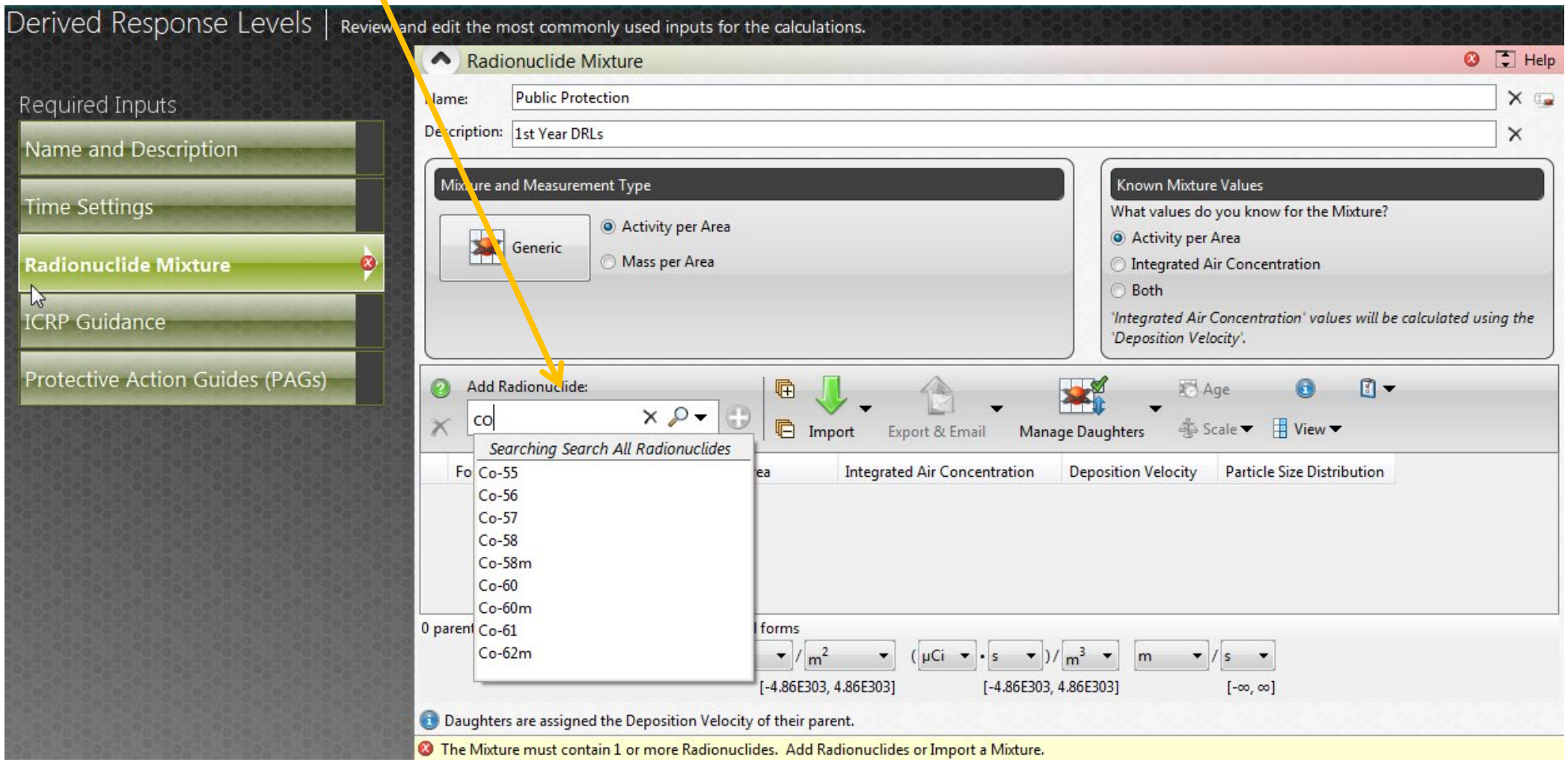
Click on Radionuclide Mixture Button

Type in a Name and Description for the Radionuclide Mixture



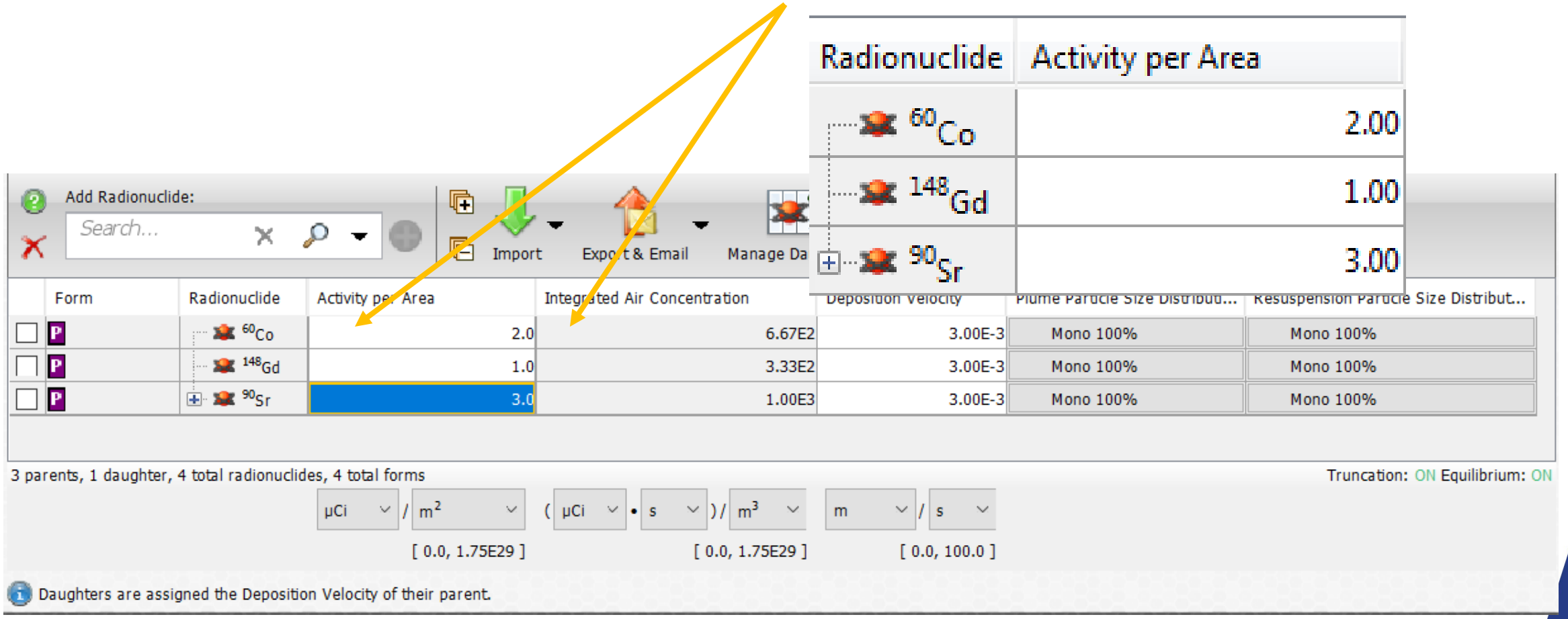
BUILD RADIONUCLIDE MIXTURE

Click on Search and begin to populate Radionuclides



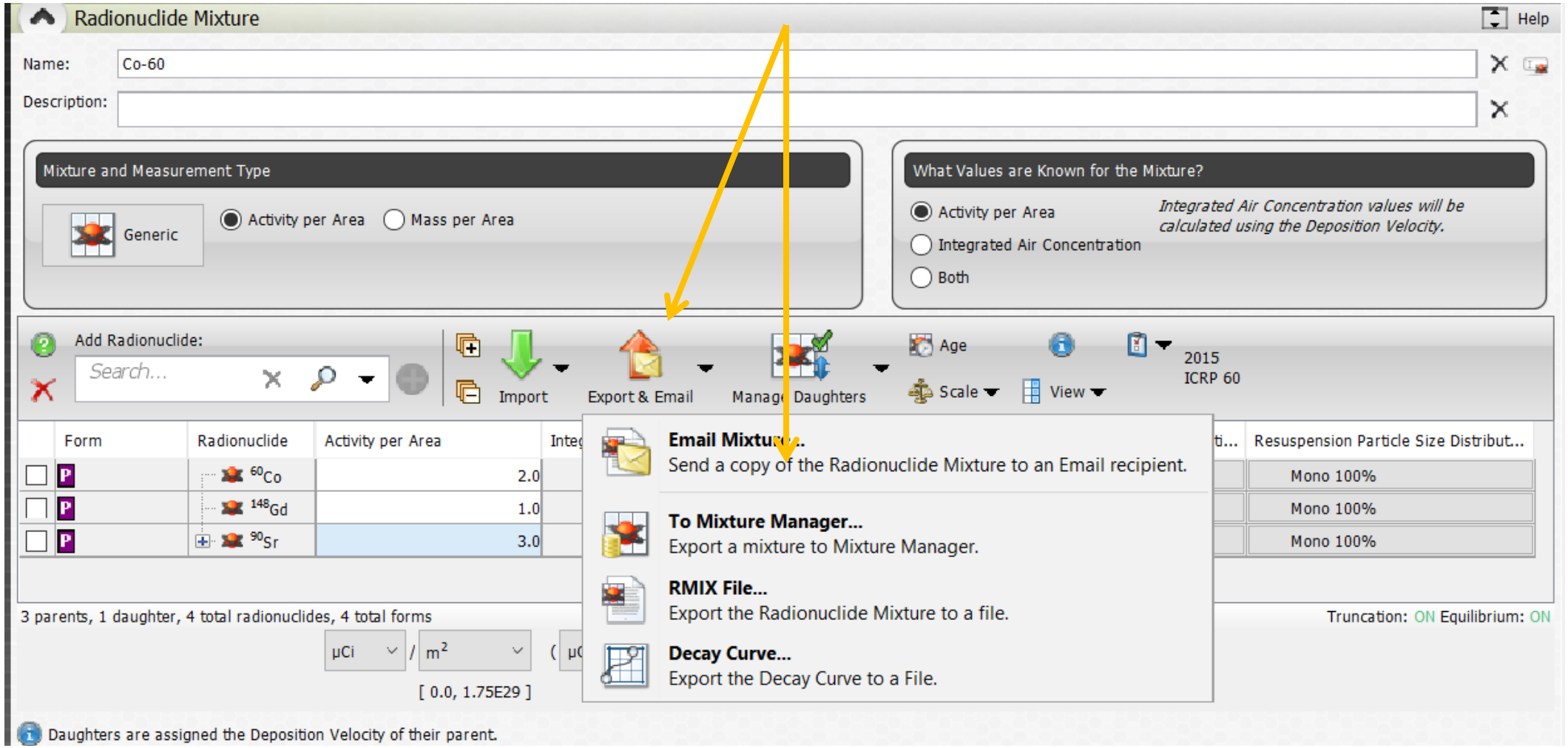
BUILD RADIONUCLIDE MIXTURE

Enter each Radionuclide in the mix and enter the Activity Concentration



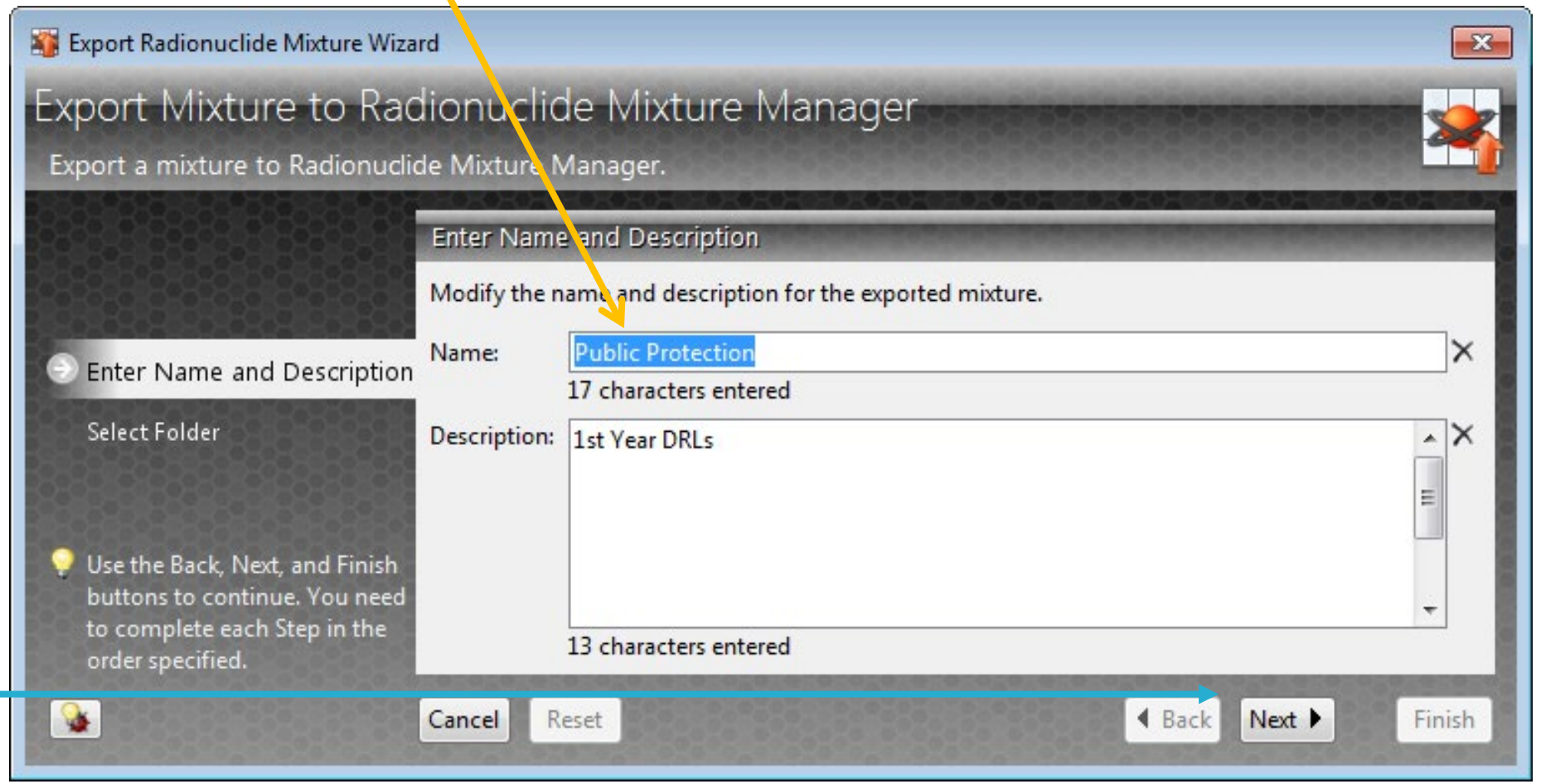
EXPORT AND SAVE RADIONUCLIDE MIXTURE

Select Export & Email then select To Mixture Manager



EXPORT AND SAVE RADIONUCLIDE MIXTURE

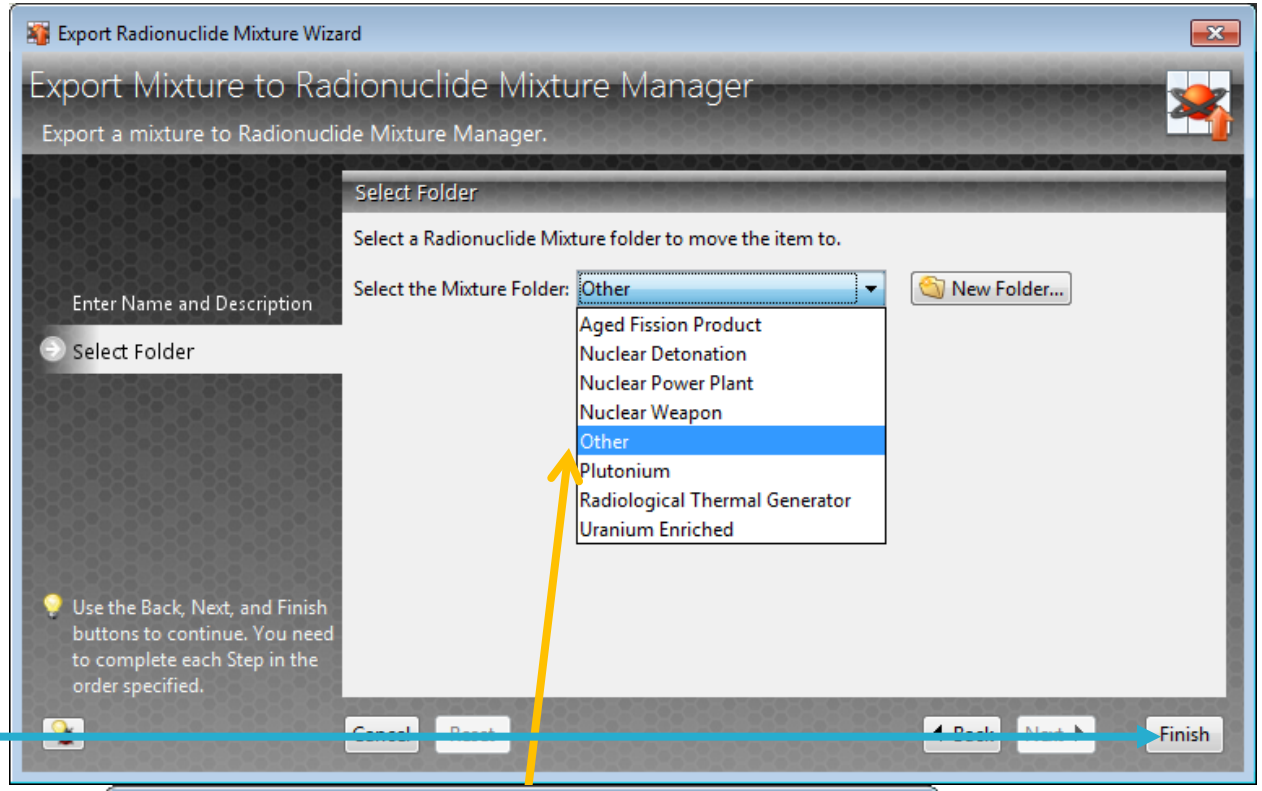
Verify Name and Description are correct



Click Next

EXPORT AND SAVE RADIONUCLIDE MIXTURE

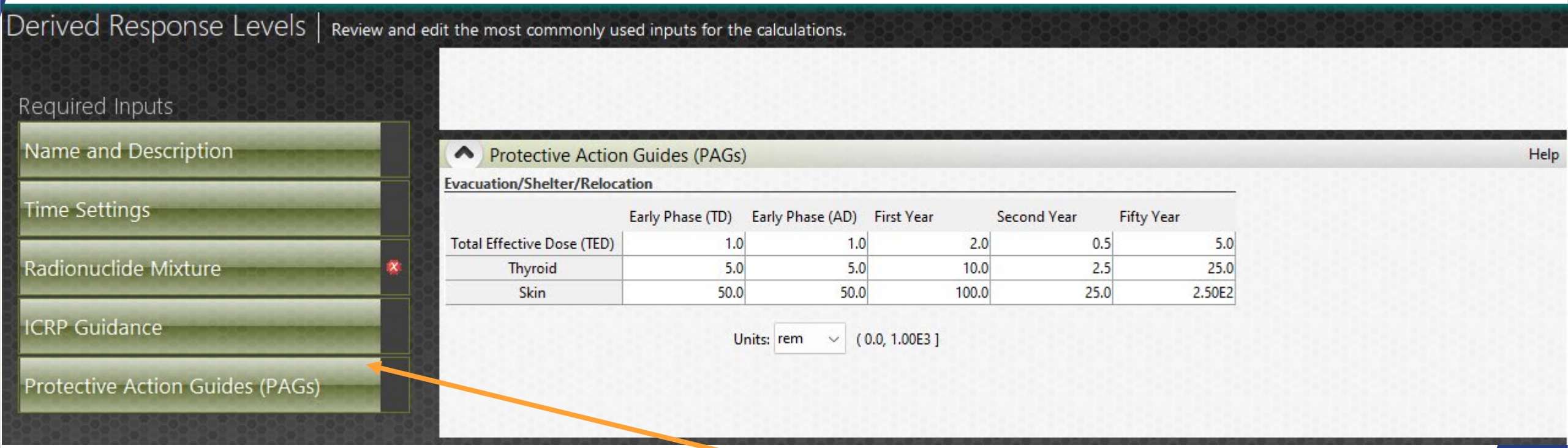
Select the Mixture Folder “Other”



Click Finish

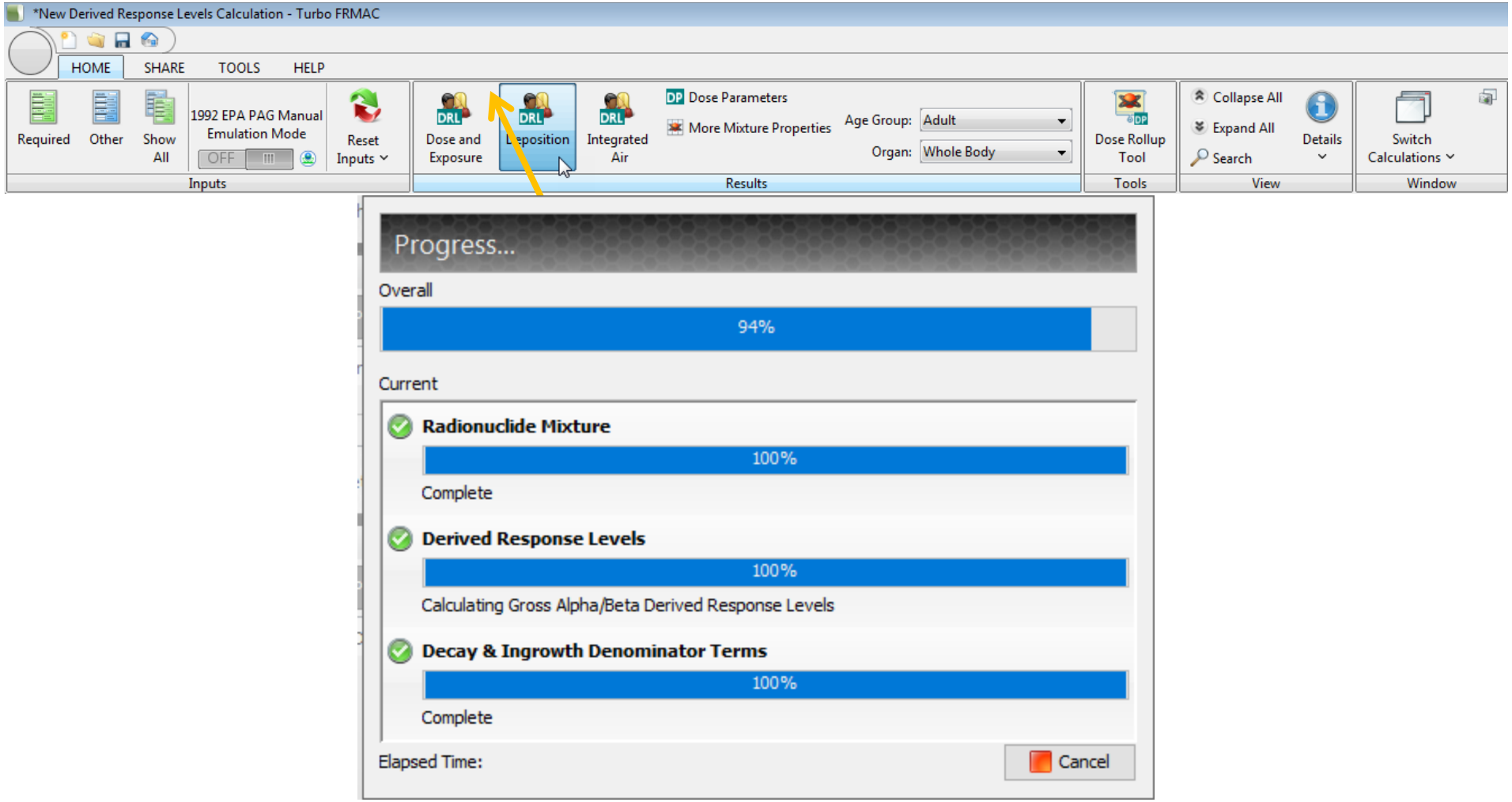
WHAT IS THE PAG FOR THIS CALCULATION?

Select Protective Action Guides to see what the default PAGs are for this calculation. The user may alter the PAGs here, if need be.



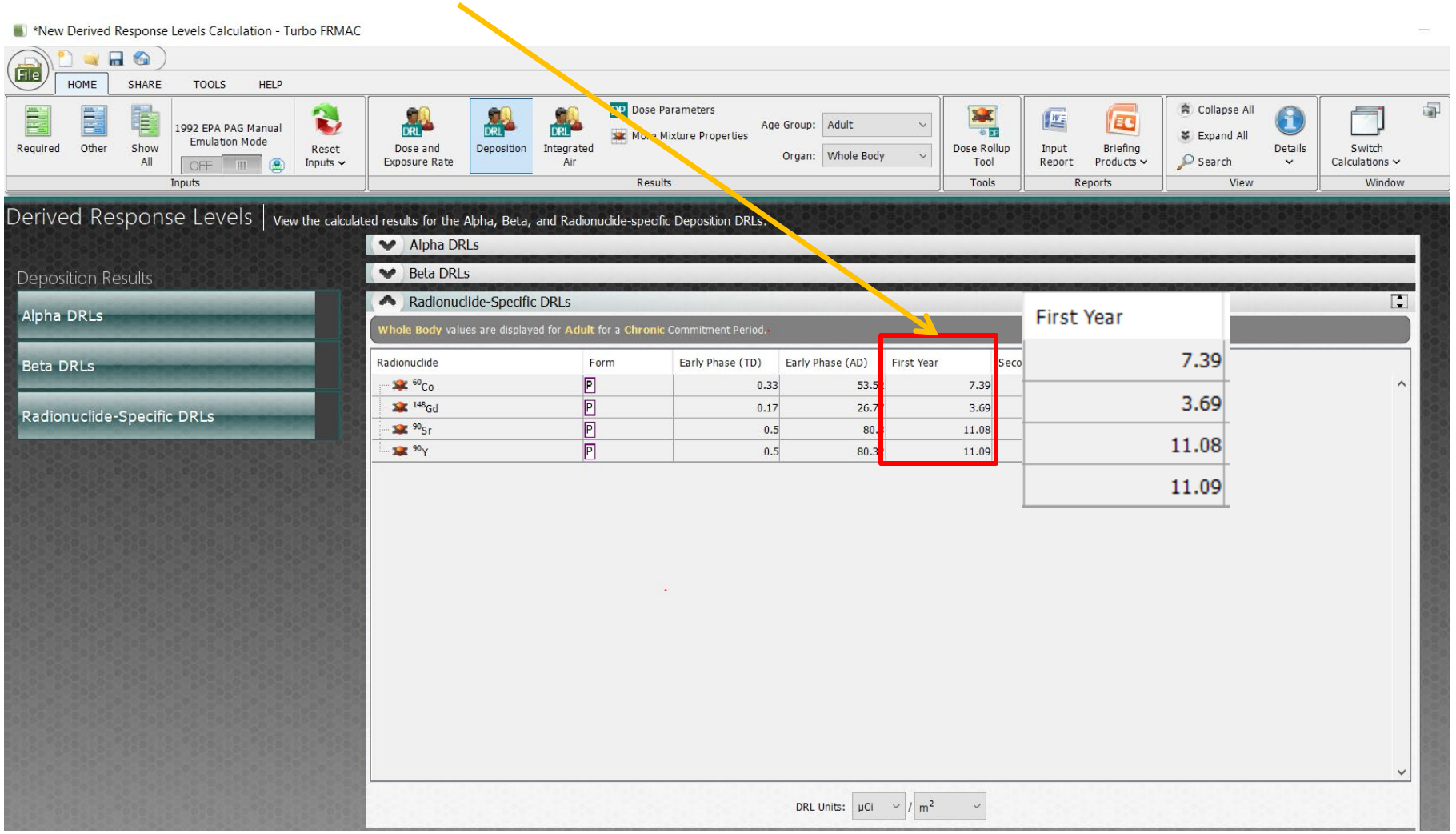
RUN CALCULATION

Click the Deposition button



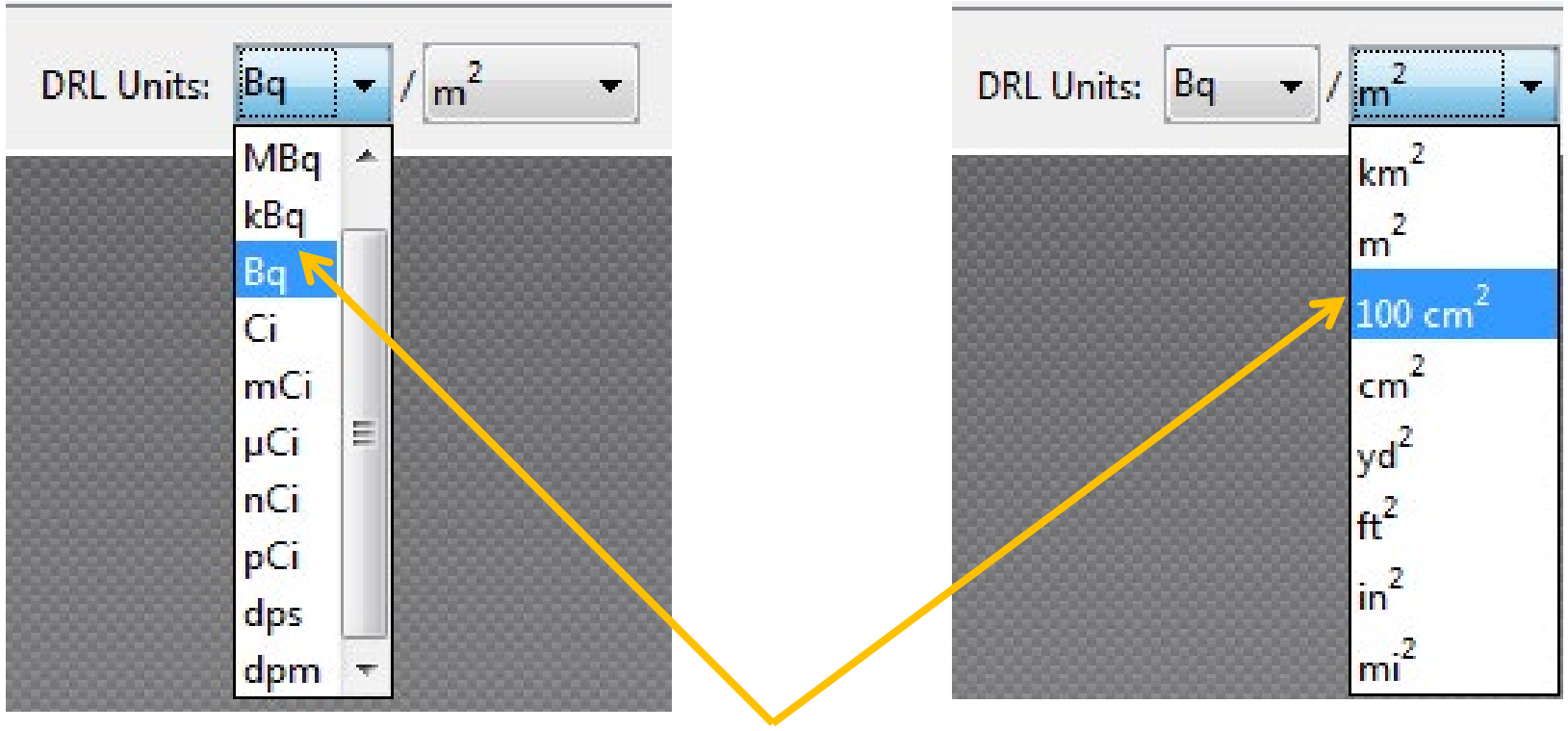
NEW DEPOSITION DRL CREATED

Final Results displayed



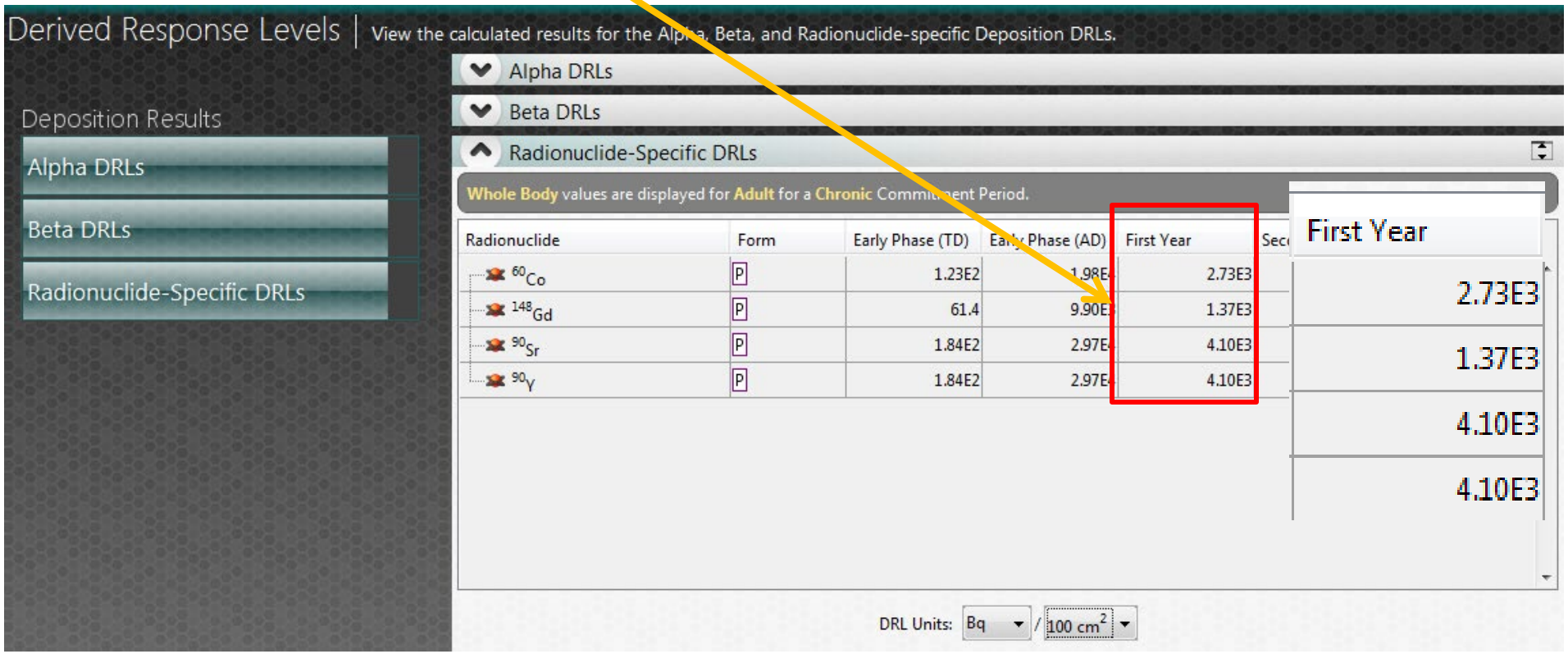
NEW DEPOSITION DRL CREATED

Change Units



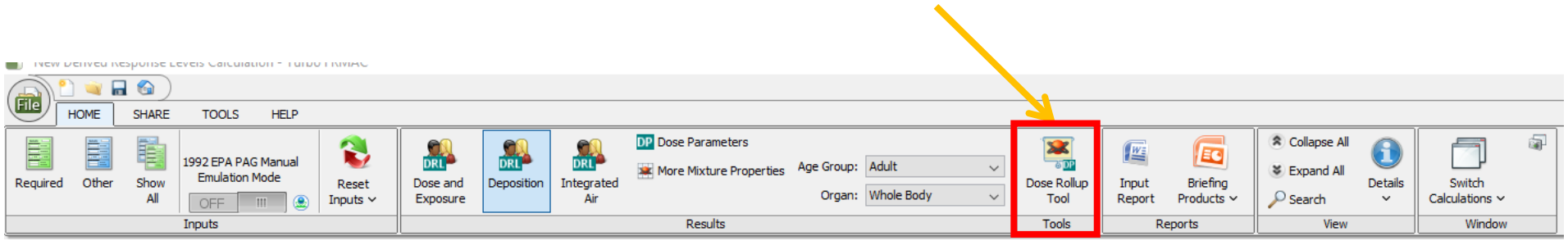
NEW DEPOSITION DRL CREATED

Final Results displayed



DOSE PARAMETERS

Find the Dose Parameter Rollup Tool button at the top right of the ribbon



Click the Dose Parameter Rollup Tool button

DOSE PARAMETERS

Interactive Dose Rollup Tool

View radionuclide dose parameters ranked by their contribution to total dose by dose pathway or mixture total dose.

Select an Age Group, Organ, and Time Phase, and then choose the Sort order.

Age Group: Adult

Organ: Whole Body

Time Phase: Early Phase (TD)

Sort by: Total Dose

Commitment Period: Chronic

Rolled-up Dose Parameters (summed over decay chain)

A Radionuclide node that is collapsed displays the sum of the doses from the radionuclide and the daughters in the decay chain.

Expand All | Collapse All

Cumulative % values include the entire decay chain contribution.

Radionuclide	Rank	Form	Plume Inhalation	Plume Submersion	Resuspension Inhalation	Groundshine	Total Dose	% of Mixture Total	Cumulative % of Mixture Total
Gd-148	1	P	5.91E3	0.0	32.96	0.0	5.95E3	98.78	98.78
▶ Sr-90	2	P	57.07	3.29E-3	0.32	0.35	57.74	0.96	99.74
Co-60	3	P	10.49	0.29	5.84E-2	4.81	15.66	0.26	100.0

3 radionuclides

Mixture Total Dose:	5.98E3	0.3	33.33	5.17	6.02E3
Percent Contribution:	99.36%	0.00%	0.55%	0.09%	

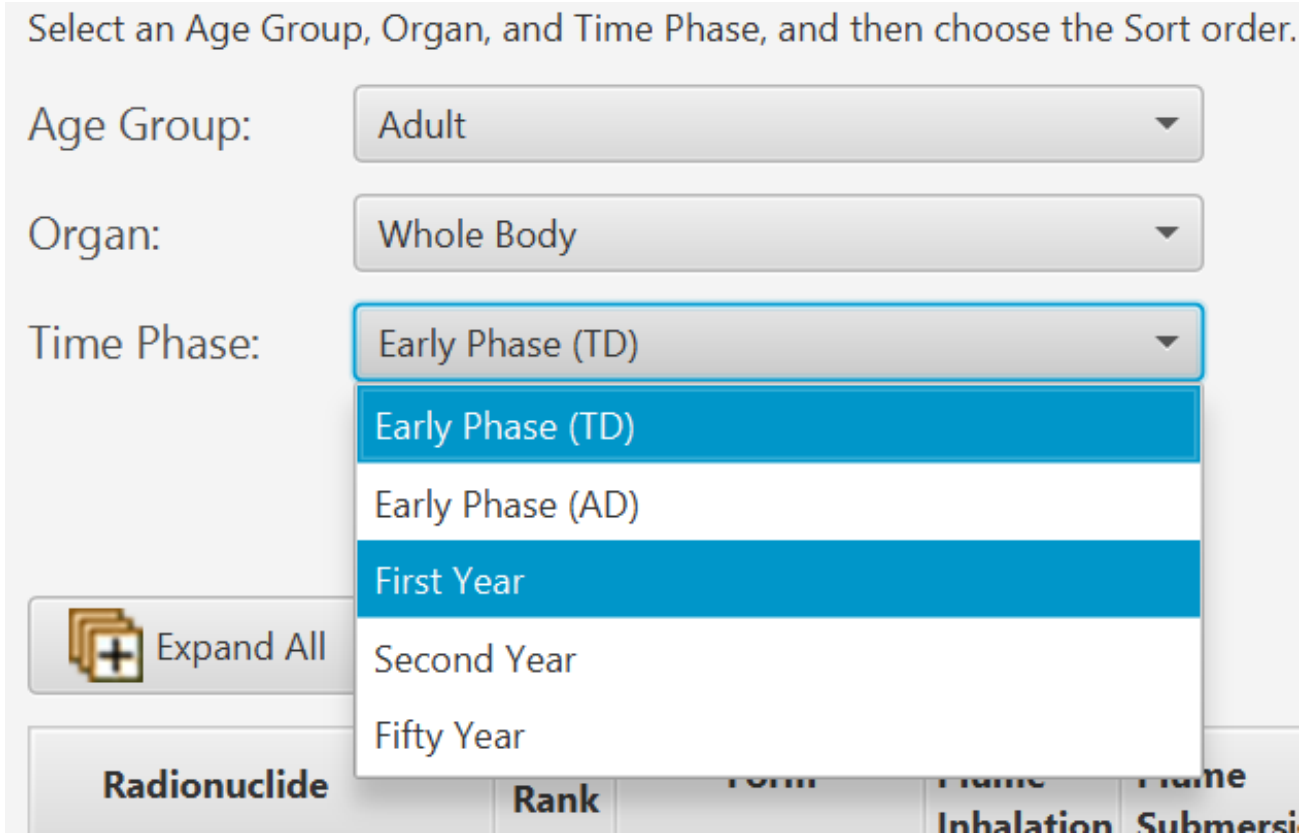
Units: mrem

Close

The interactive window allows the user to select age group, organ, and time phase of interest

DOSE PARAMETERS

Select the First Year Time Phase from the drop down.



1ST YEAR DOSE PARAMETERS

The 1st Year Dose Parameters are listed by order of percent contribution to the total dose.

Radionuclide	Rank	Form	Plume Inhalation	Plume Submersion	Resuspension Inhalation	Groundshine	Total Dose	% of Mixture Total	Cumulative % of Mixture Total
Co-60	1	P	0.0	0.0	0.23	3.79E2	3.79E2	69.98	69.98
Gd-148	2	P	0.0	0.0	1.32E2	0.0	1.32E2	24.42	94.4
▶ Sr-90	3	P	0.0	0.0	1.27	29.03	30.3	5.6	100.0

Yellow highlighted rows indicate the dose is “rolled up” (combined) with the dose from the daughters.

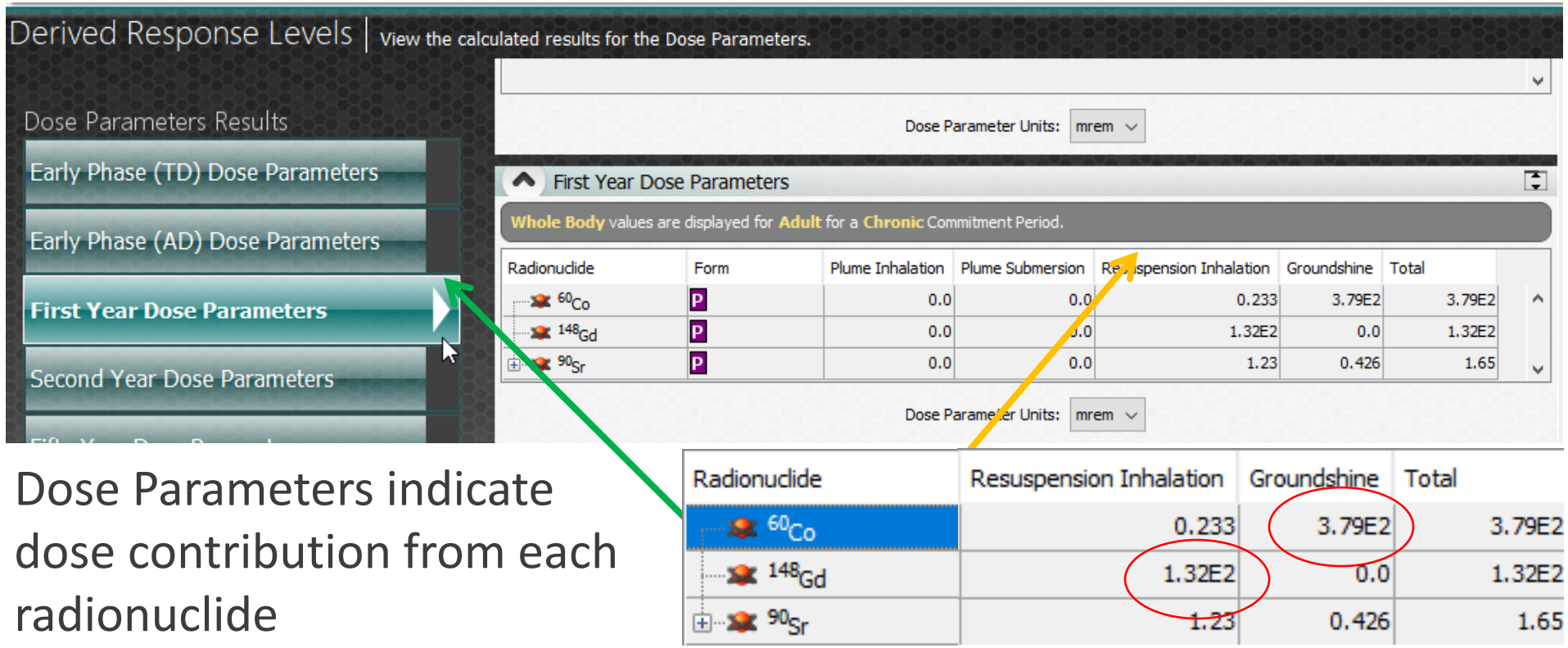
This can be expanded out to show individual contributions from each daughter.

Radionuclide	Rank	Form	Plume Inhalation	Plume Submersion	Resuspension Inhalation	Groundshine	Total Dose	% of Mixture Total	Cumulative % of Mixture Total
Co-60	1	P	0.0	0.0	0.23	3.79E2	3.79E2	69.98	69.98
Gd-148	2	P	0.0	0.0	1.32E2	0.0	1.32E2	24.42	94.4
▼ Sr-90	3	P	0.0	0.0	1.23	0.43	1.65	0.31	100.0
Y-90		P	0.0	0.0	4.79E-2	28.6	28.65	5.29	--

DOSE PARAMETERS

Select First Year Dose Parameter button

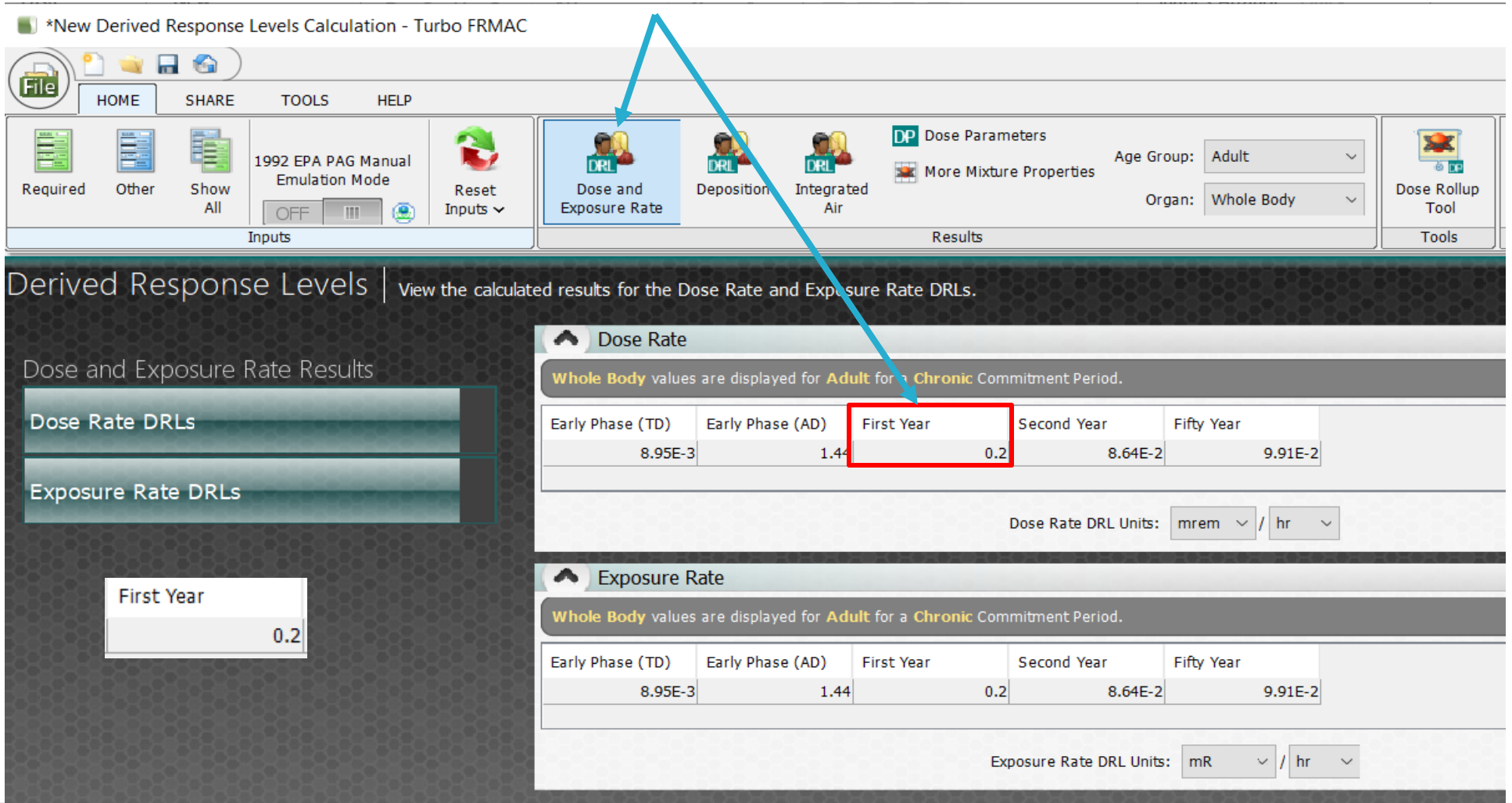
Dose Parameter panel comes into view



Dose Parameters indicate dose contribution from each radionuclide

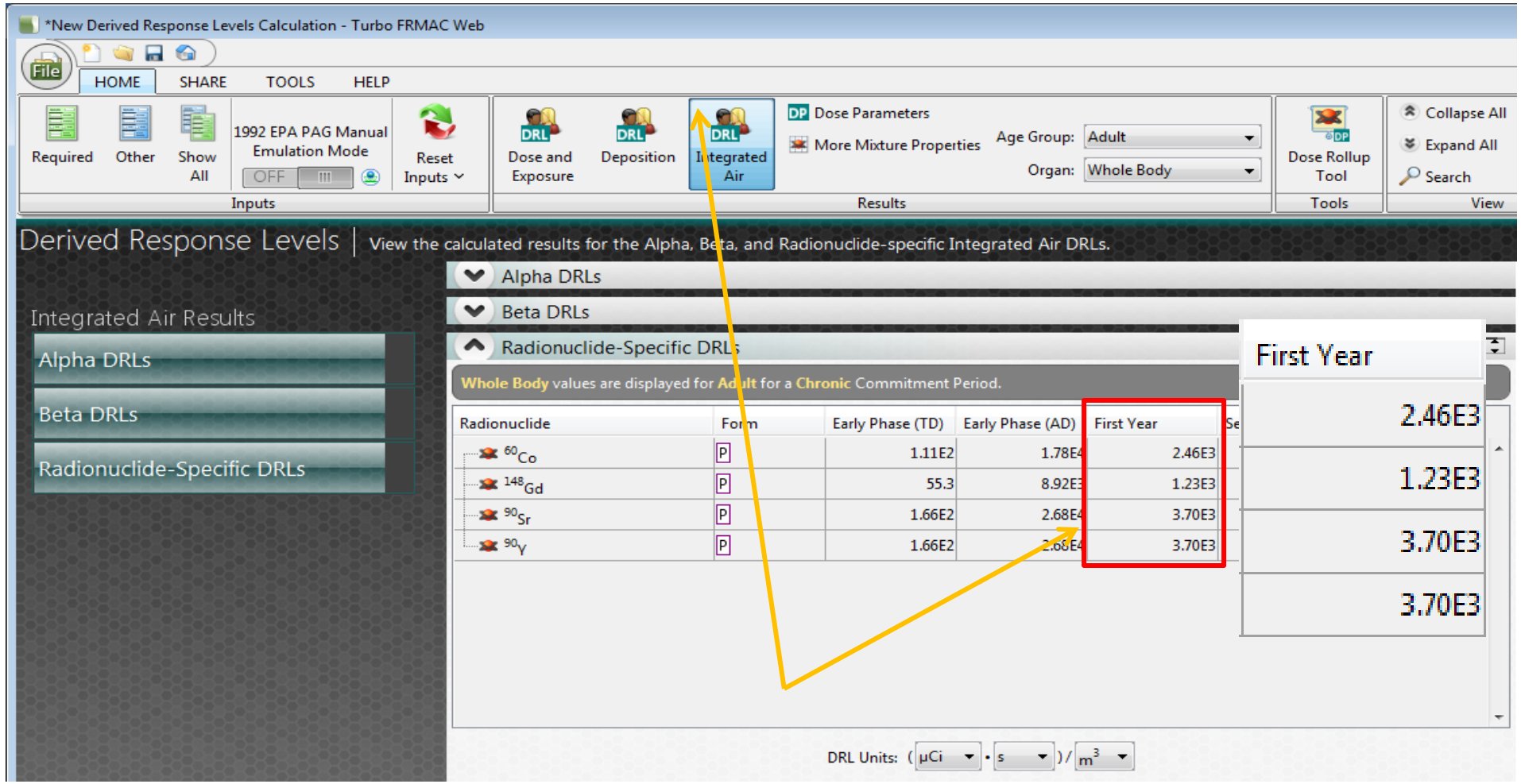
DOSE RATE/EXPOSURE RATE DRL

Select Dose and Exposure - Final Results Displayed



1ST YEAR INTEGRATED AIR CONCENTRATION DRL CREATED

Select Integrated Air - Final Results Displayed



SUMMARY OF RESULTS– DEPOSITION DRLS

None of the activities per area exceed the calculated DRLs. Therefore, Protective Actions in the 1st year may not be necessary

Radionuclide	Activity per Area ($\mu Ci/m^2$)	Deposition DRL ($\mu Ci/m^2$)
^{60}Co	2	7.36
^{148}Gd	1	3.69
^{90}Sr	3	11.08
^{90}Y [a]	3	11.09
[a] ^{90}Y included as a daughter in equilibrium		

SUMMARY OF RESULTS– INTEGRATED AIR ACTIVITY DRLS

None of the integrated air activities exceed the calculated DRLs. Therefore, Protective Actions in the 1st year may not be necessary

Radionuclide	Integrated Air Activity (µCi·s/m³)	Integrated Air DRL (µCi·s/m³)
^{60}Co	6.67E2	2.46E3
^{148}Gd	3.33E2	1.23E3
^{90}Sr	1.00E3	3.70E3
^{90}Y [a]	1.00E3	3.70E3
[a] ^{90}Y included as a daughter in equilibrium		

INGESTION CALCULATION CONCEPTS

INGESTION ASSESSMENT CONCEPTS

- Parent/Daughter Dose
  - All radionuclides present at consumption are treated as parents for ingestion calculations
  - Ingestion Dose Coefficients account for daughter ingrowth that occurs after consumption

- Average Annual Intake
  - Ingestion calculations are based on the average annual intake of all dietary components (including tap water used for drinking)
  - Calculations DO NOT apply to determining restrictions on Drinking Water – EPA has separate Drinking Water restrictions.

INGESTION ASSESSMENT CONCEPTS

- Age Groups
  - Annual intake varies by Age Group
  - ICRP provides Ingestion Dose Coefficients based on the following Age Groups: 3 months, 1 year, 5 years, 10 years, 15 years, Adult

- Fraction of Diet Contaminated
  - Assumed to be 0.3
  - Exceptions: ^{132}Te, ^{131}I, ^{133}I and ^{239}Np in the Infant (3-month and 1 year old) diet where it is assumed to be 1.0

INGESTION INTERVENTION LEVEL

An Ingestion Intervention Level is a radionuclide concentration in food that, when consumed, could result in an individual receiving an Ingestion Dose (to the most sensitive age group/organ) equal an FDA Ingestion PAG

Derived Intervention Levels (DILs) were recommended by the FDA in 1998 as the radionuclide activity concentration in food at which point protective actions should be considered. The FDA established DILs for a list

FDA DILS

Principle Radionuclide/Group	FDA DIL ($\mu Ci/kg_{wet}$)
^{90}Sr	4.3E-03
^{131}I	4.6E-03
$^{134}Cs + ^{137}Cs$	**3.2E-02**
^{134}Cs	2.5E-02
^{137}Cs	3.7E-02
$^{238}Pu + ^{239}Pu + ^{241}Am$	**5.4E-05**
^{238}Pu	6.8E-05
^{239}Pu	6.0E-05
^{241}Am	5.4E-05
$^{103}Ru + ^{106}Ru$	**(^{103}Ru/0.18) + (^{106}Ru/0.012) < 1**
^{103}Ru	1.8E-01
^{106}Ru	1.2E-02

Secondary Radionuclides	FDA DIL ($\mu Ci/kg_{wet}$)
^{89}Sr	3.8E-02
^{91}Y	3.2E-02
^{95}Zr	0.11
^{95}Nb	0.32
^{132}Te	0.12
^{129}I	1.5E-03
^{133}I	0.19
^{140}Ba	0.19
^{141}Ce	0.19
^{144}Ce	1.4E-02
^{237}Np	1.1E-04
^{239}Np	0.76
^{241}Pu	3.2E-03
^{242}Cm	5.1E-04
^{244}Cm	5.4E-05

HOW IS A INGESTION INTERVENTION LEVEL USED?

- A food must first be sampled and analyzed
- Radionuclide concentration in food is compared to an Ingestion Intervention Level (DIL or FIL)
- If the sample exceeds the Ingestion Intervention Level then consumption of the food may result in an Ingestion Dose greater than the FDA PAG

FRMAC INTERVENTION LEVELS

FRMAC has developed the FRMAC Intervention Level (FIL) to calculate values analogous to the FDA DILs for radionuclides not listed by the FDA

- FDA has directed FRMAC to use the DIL and applicable age group/organ for all FDA Radionuclides as listed in the FDA PAG Manual
- FRMAC will calculate FILs for all radionuclides not listed by the FDA

APPLYING INTERVENTION LEVELS

- Intervention Levels are applicable to foods as prepared for consumption or (generally) “wet”
- FDA allows FRMAC to exclude the 3-month old age group for Non-FDA Radionuclides because calculation assumptions are questionable for that age group
  - When the 3-month old is the limiting age group, discuss with the FDA representative on the A-Team
  - Determine the next most limiting age group and exclude the 3-month old

INGESTION INTERVENTION LEVEL ASSUMPTIONS

- FDA DILs apply to individual radionuclides or FDA-specified groups
- FRMAC FILs apply only to individual radionuclides
- Both DILs and FILs apply only during the first year after an incident
- Both are based on the most sensitive age group/organ determined from Dose Coefficients and Ingestion Rates
- DILs for FDA radionuclides use ICRP 56 and the National Radiological Protection Board (NRPB) GS7 publication
- FILs for non FDA-listed radionuclides use the ICRP 60+ dosimetry model
- Annual intake is adjusted to account for radioactive decay
  - DIL: Effective Days of Intake (EDI)
  - FIL: Integrated Decay

INGESTION DOSE

- The Dose from consumption of contaminated food based on measured radionuclide concentration
- Compared to the FDA PAGs to determine whether protective actions are warranted

INGESTION DOSE ASSUMPTIONS

Calculations take in to account:

- Radioactive decay
- Fraction of diet contaminated
- Daily food intake rate
- Consumption period (usually one year)

FDA has established Food PAGs, but does not provide method(s) for calculating Ingestion Dose

There is no specific guidance on the time period to use for calculating the Ingestion Dose, use one year as default

INGESTION DOSE FOOD GROUPS

Food Types fall into 4 groups *(shown with subgroups)*

1. Meat/Fish
   Beef, Pork, Poultry, Fin Fish, Shell Fish, Other Meat
2. Crop/Produce
   Leafy, Other Produce, Breads, Cereals, Other Grains, Exposed, Protected
3. Milk
   Fresh Cow's Milk, Other Dairy, Eggs
4. Beverages
   Tap Water, Water-Based Drinks, Soups, Other Beverages

INGESTION DOSE EXAMPLE

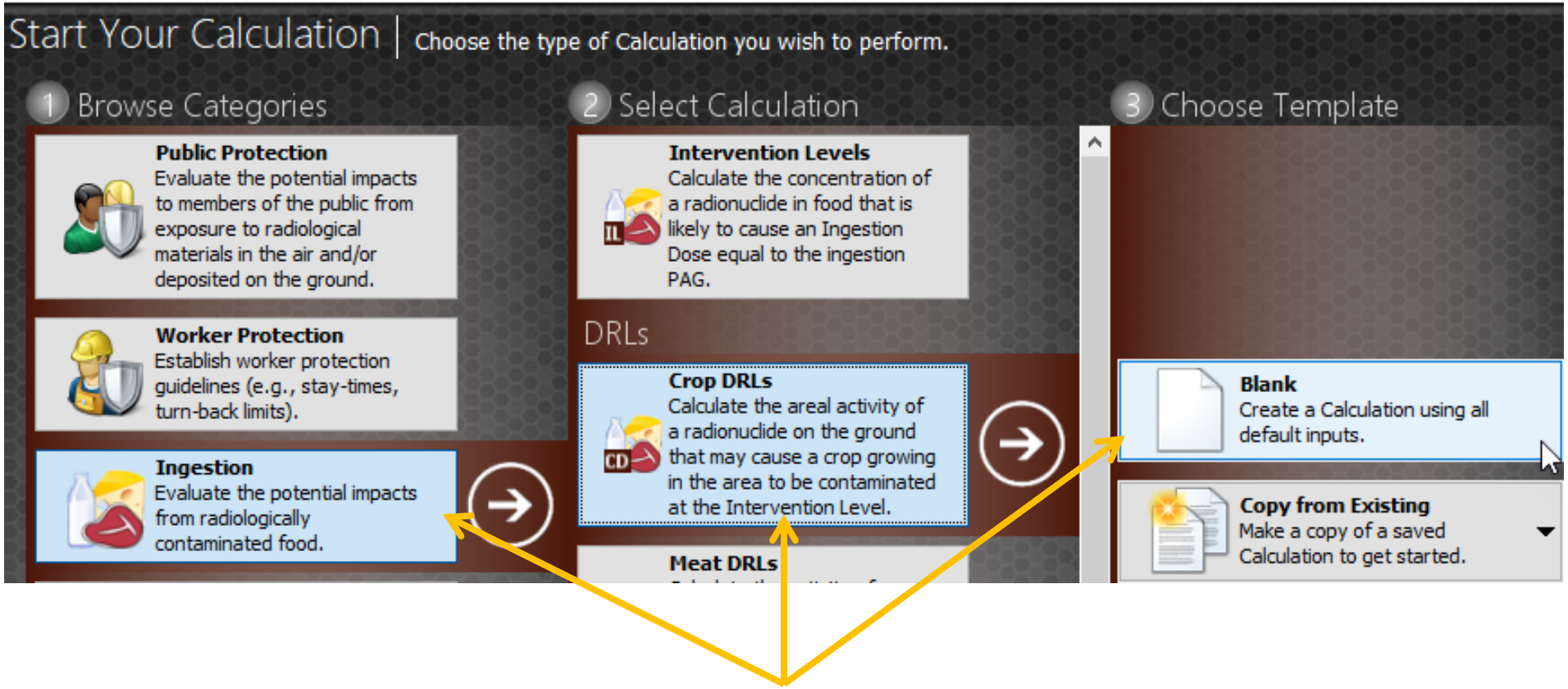
SETTING THE STAGE

Calculate the Crop Ingestion DRL for ^{60}Co in lettuce for an evaluation time of 7 days after deposition and a 90 day time to harvest

OPEN TURBO FRMAC

Select New Calculation

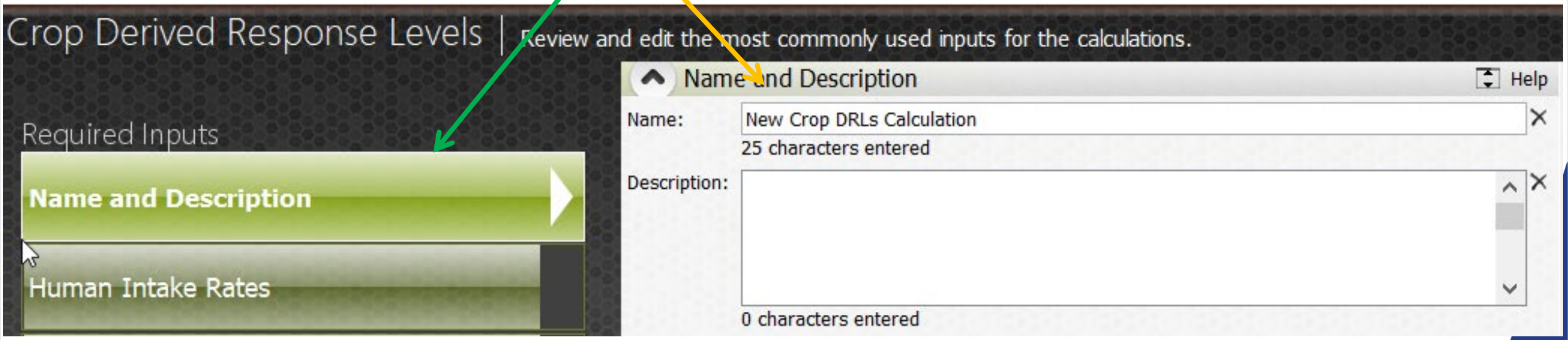
SELECT NEW CALCULATION



Select Ingestion, then Crop DRLs, then Blank

NAME AND DESCRIBE CALCULATION

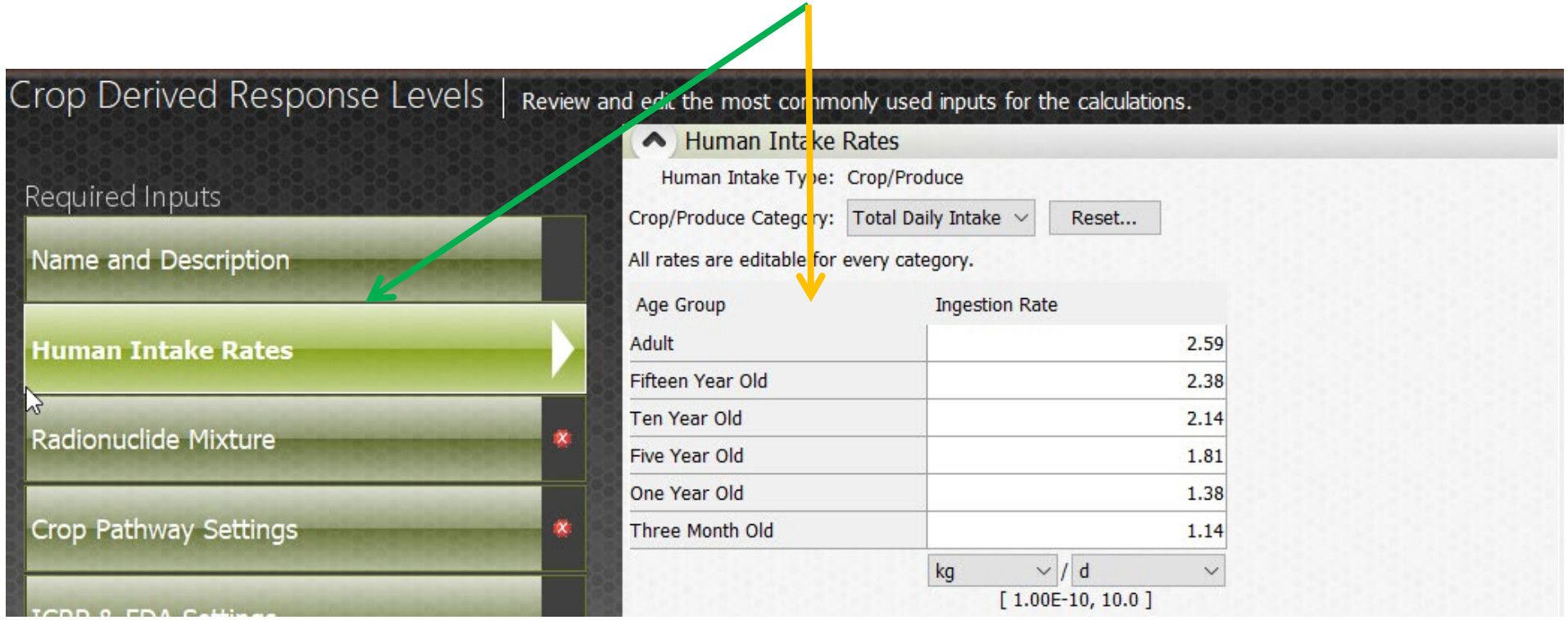
Click on Name and Description Button
Type in a Name and Description for the calculation



HUMAN INTAKE RATE

Click on Human Intake Rates Button

Default FDA Ingestion Rates are listed

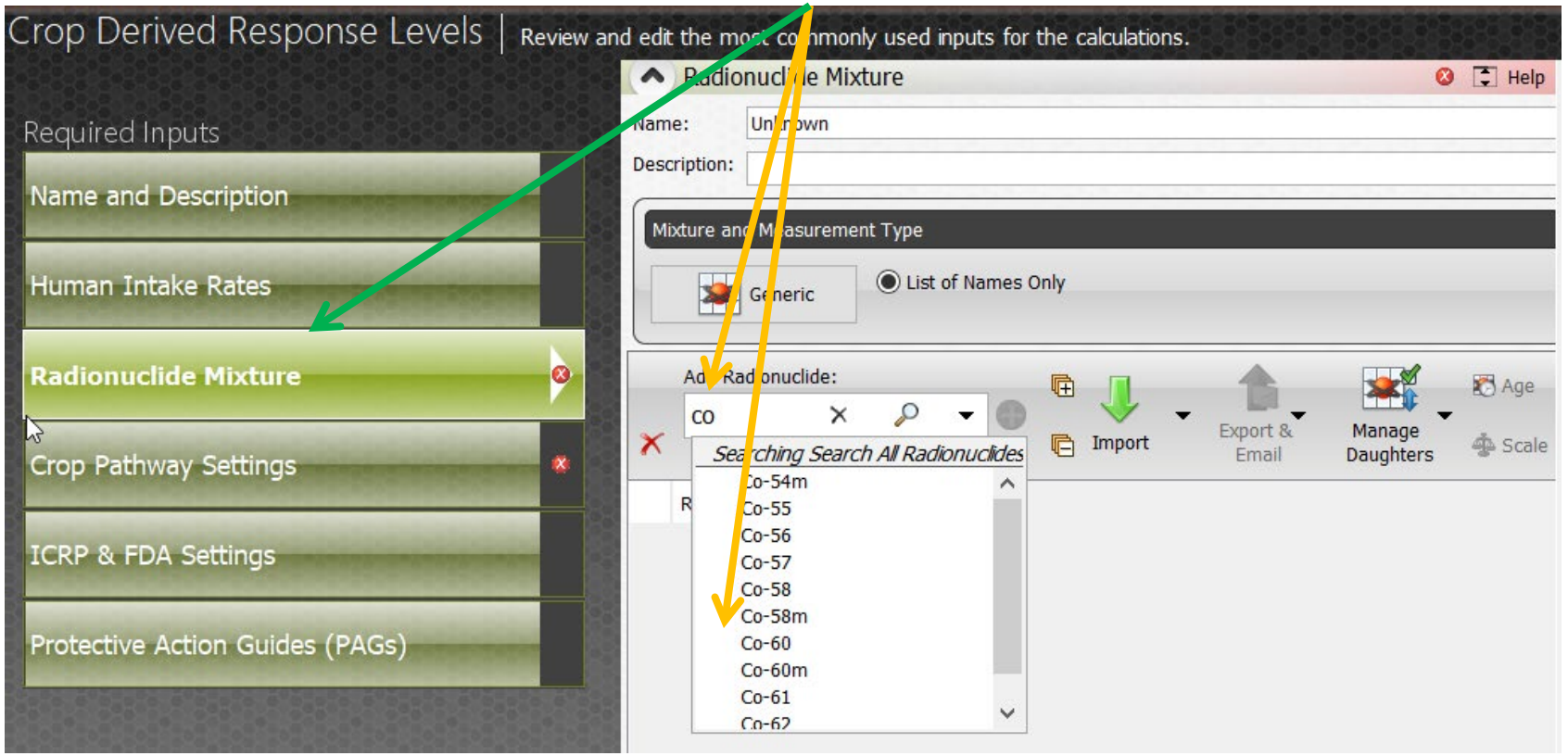


BUILD RADIONUCLIDE MIXTURE

Click on the Radionuclide Mixture Button

Click the Search box

Type in Co and select Co-60

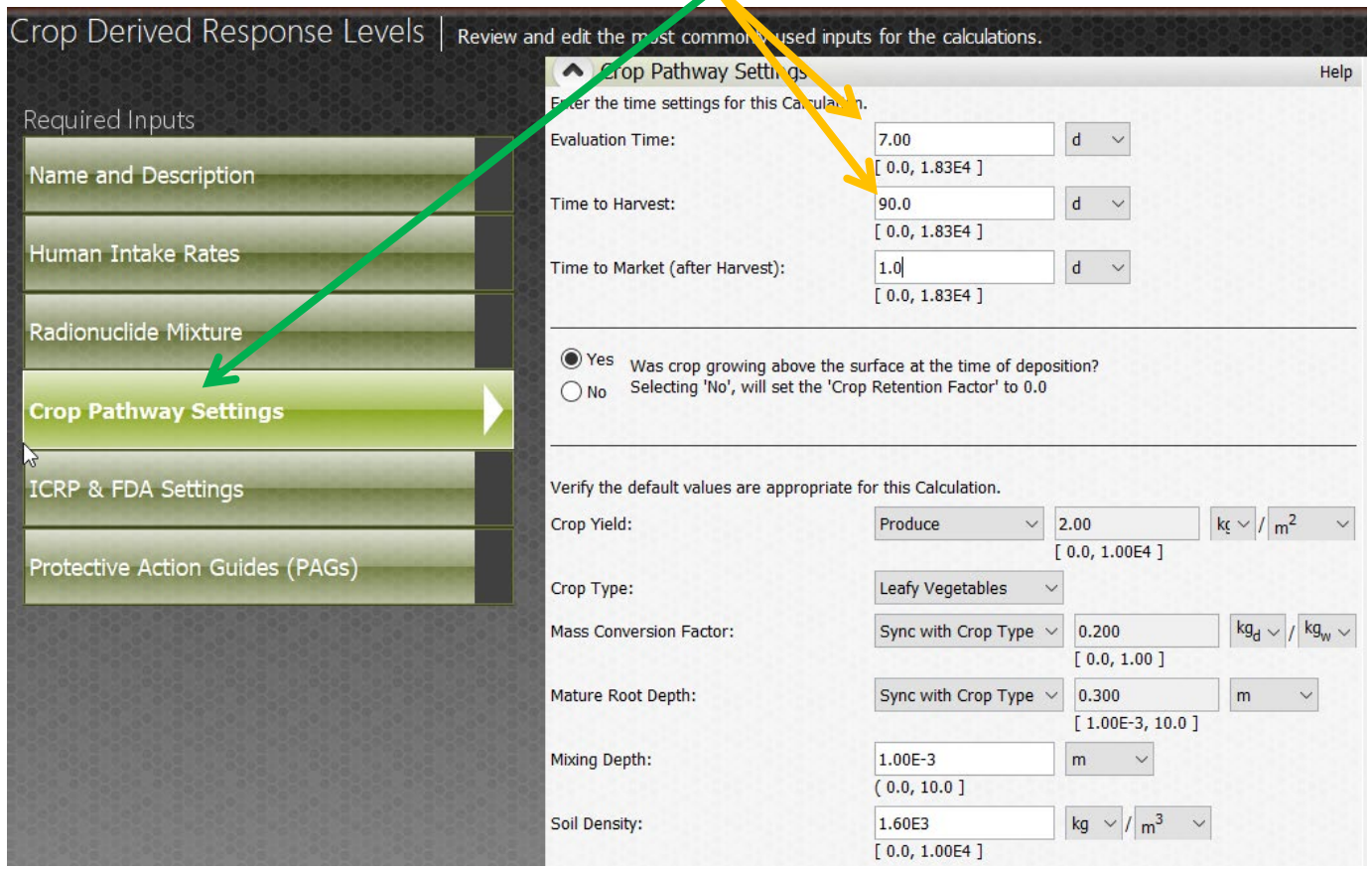


CROP PATHWAY SETTINGS

Click on the Crop Pathway Settings Button

Set Evaluation Time to 7 Days

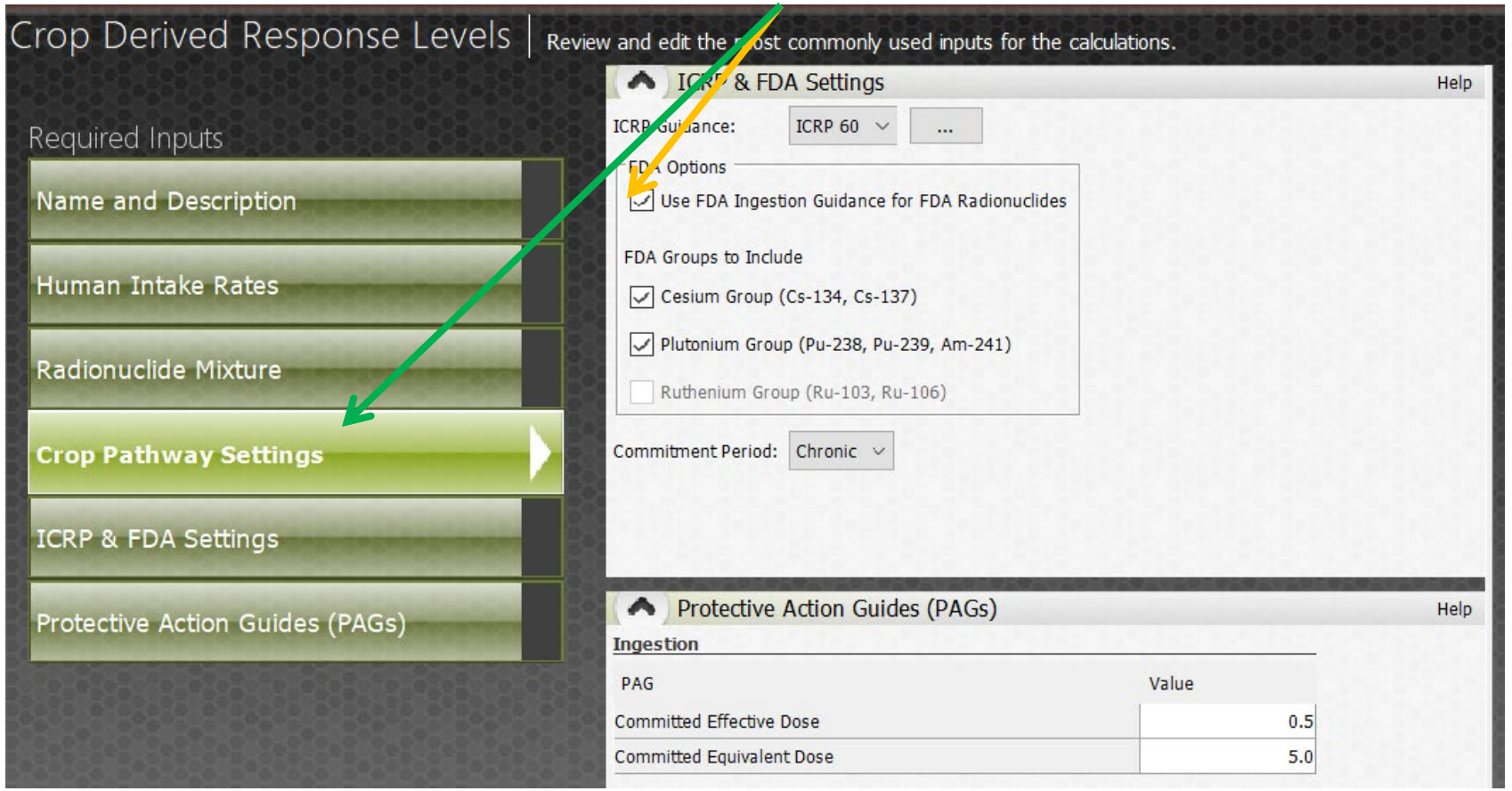
Set Time to Harvest to 90 Days



ICRP AND FDA SETTINGS

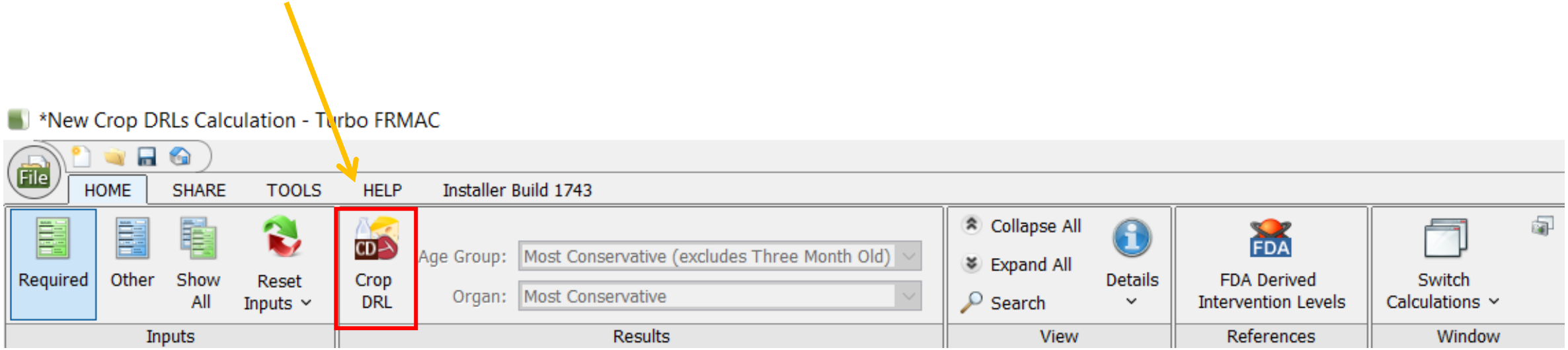
Click on the ICRP and FDA Settings Button

Notice the FDA Options box is checked



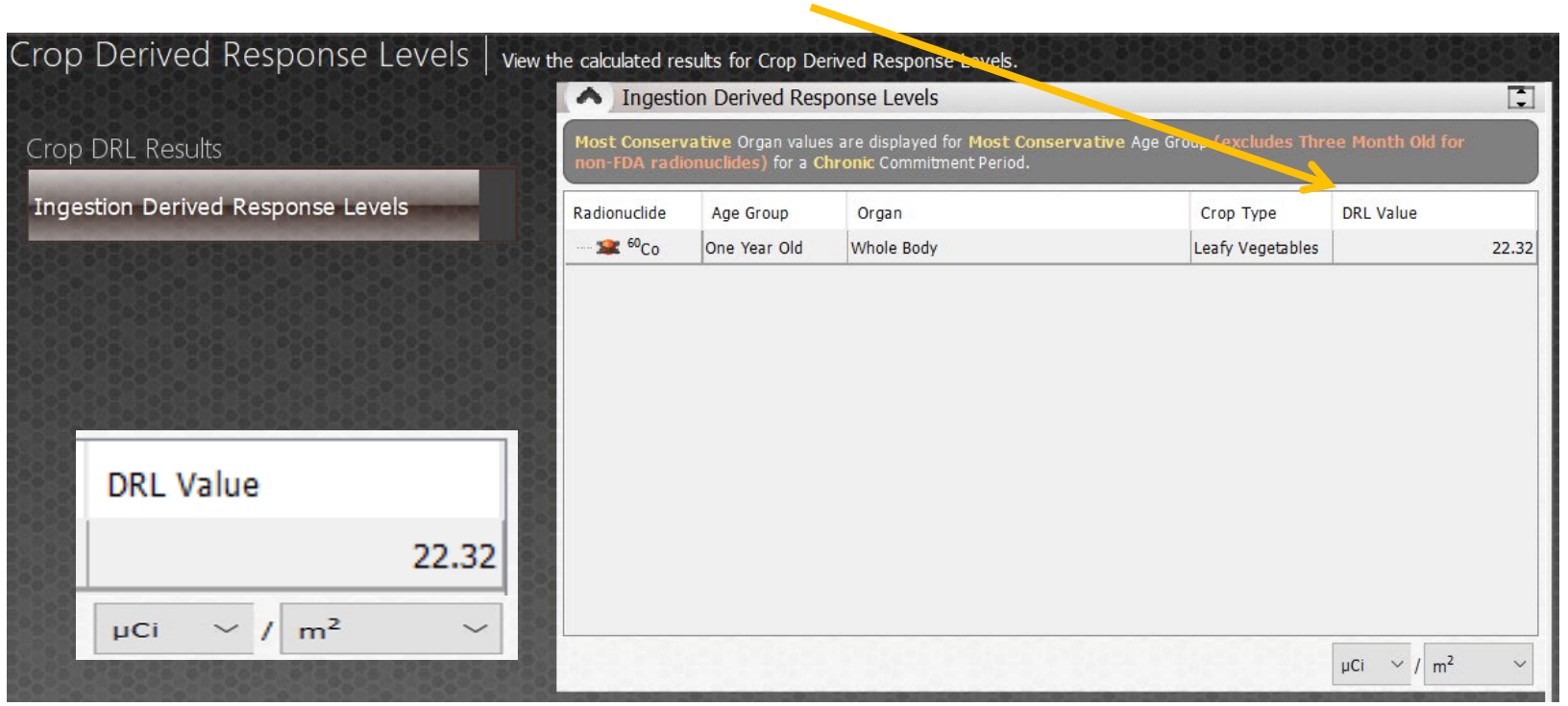
RUN CALCULATION

Click the Crop DRL button



NEW CROP DRL CREATED

Final Results displayed



WEB-BASED TRAINING OPPORTUNITIES

Nuclear Incident Response Self-Paced Learning Opportunities

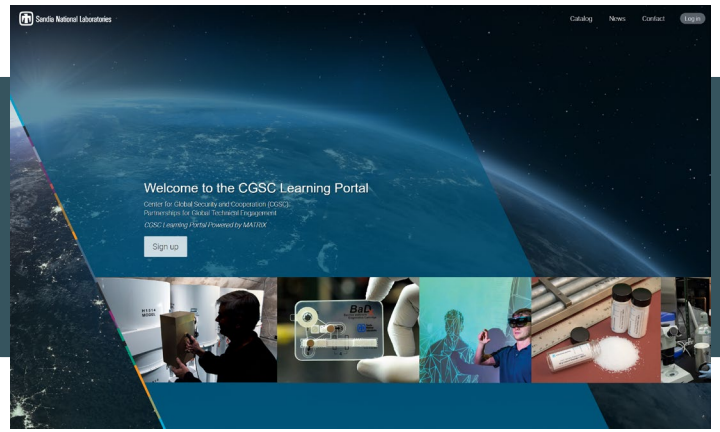
AS-100: Introduction to Assessment Science
24 ABHP CECs
- 22 module course covering FRMAC Assessment methods for public protection, worker protection, and ingestion pathway ***PNNS-KDXC***

Turbo FRMAC Advanced Methods
1 ABHP CEC each
- Administration of Potassium Iodide Derived Response Level Calculation ***OMXL-NMBV***
- Analytical Action Level Calculation ***HZAK-EWAX***

LA-050: Support Laboratory Briefing *CMOT-EKHS*
- What labs should expect when called to help FRMAC

Gamma Spectroscopy *ERXF-ZREQ*
- Detector Calibration Methods
- Sample Analysis
- Software Functions
- Mathematical Instrument Calibration
- True Coincidence Summing Corrections
- In-Situ Gamma Spectrometry

LA-075: Laboratory Data Reporting (2024)
- Detailed walkdown of data reporting in CBRNResponder



Sandia and partners have developed *free, online* training!
Learn more: https://snl.matrixlms.com/

Thank you!

Questions?

SUPPLEMENTAL SLIDES

ADMIN OF KI

The EPA has provided an Early Phase PAG for the issuance of KI

This method was developed to calculate Integrated Air, Deposition, Dose Rate and Exposure Rate DRLs to support decisions to administer KI in response to releases of iodine radionuclides

DRLs are calculated as shown in Equations 1.1-1 and 1.1-2 from Method 1.1 and Equation 1.2-1 from Method 1.2 and will not be covered here

This method differs from the standard DRL calculations in that only the dose to the thyroid from iodine radionuclides is included

EARLY PHASE PAGS

Protective Action Recommendation	PAG (Projected Dose)	Comments
Sheltering-in-place or Evacuation of the public[a]	1-5 rem over 4 days[b]	Evacuation (or, for some situations, sheltering-in-place) should be initiated when projected dose is 1 rem
Supplementary administration of prophylactic drugs – KI[c]	5 rem to child (1 Year Old) thyroid from iodine exposure[d]	KI is most effective if taken prior to exposure. May require approval of state medical officials (or in accordance with established emergency plans). FDA recommends that KI be administered to both children and adults at the lowest intervention threshold

[a] Should begin at 1 rem except when practical or safety considerations warrant using 5 rem; take whichever action (or combination of actions) that results in the lowest exposure for the majority of the population. Sheltering may begin at lower levels if advantageous.

[b] Calculated dose is the projected sum of the effective dose from external radiation exposure (i.e., groundshine) and the committed effective dose from inhaled radioactive material.

[c] Provides thyroid protection from radioactive iodines only.

[d] Thyroid equivalent dose

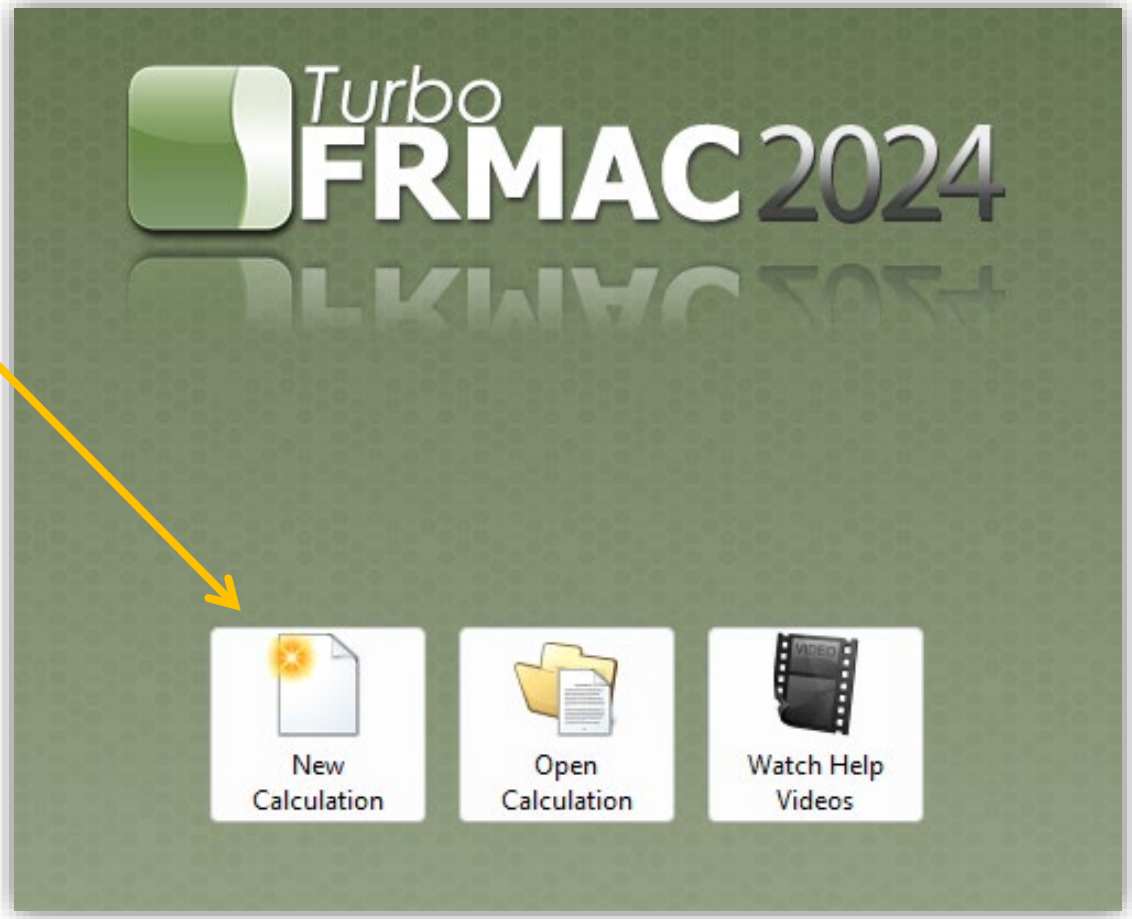
ASSUMPTIONS

- Receptor of interest is the 1 yr old child
- Organ of interest is the Thyroid
- Time Phase of interest is Early Phase Total Dose (TD) (0 – 96 hrs)
- Only considers the two inhalation pathways (Plume & Resuspension)
- Only considers the dose to the receptor's thyroid from iodine radionuclides
- Most likely release of iodines is from a Nuclear Power Plant (NPP)
- Accidental release of airborne iodine from a NPP is typically partitioned as follows in order to be consistent with NRC calculations

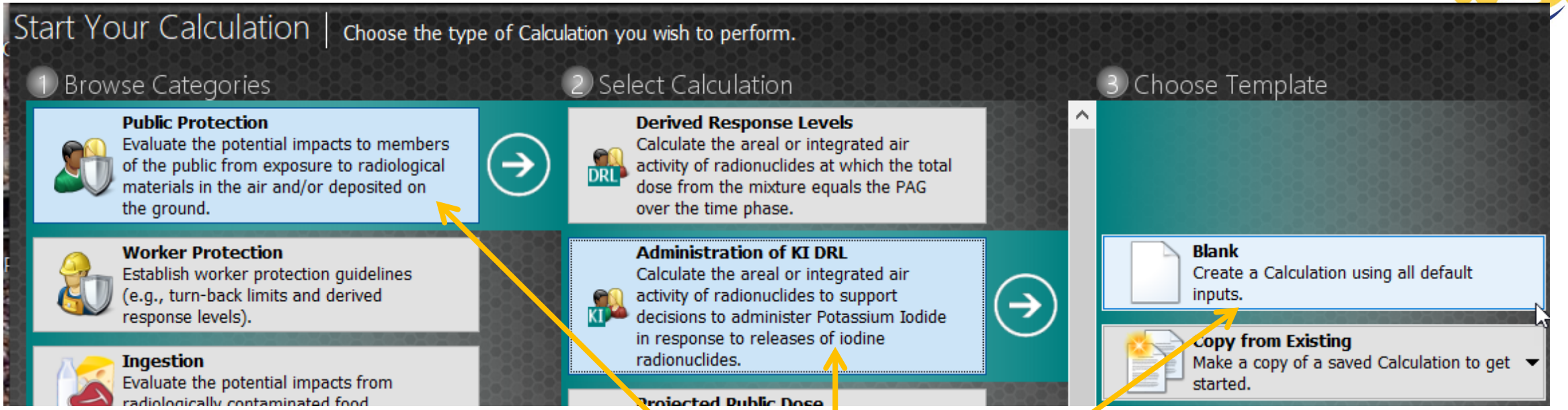
NOTE: DRLs may be calculated for any radionuclide present in the release, including non-iodine radionuclides. This can be useful when other radionuclides may be easier to detect than iodine radionuclides (e.g., Cs-137) and can be used as a "marker" to indicate how much iodine is present.

ADMIN OF KI EXAMPLE

Select New Calculation



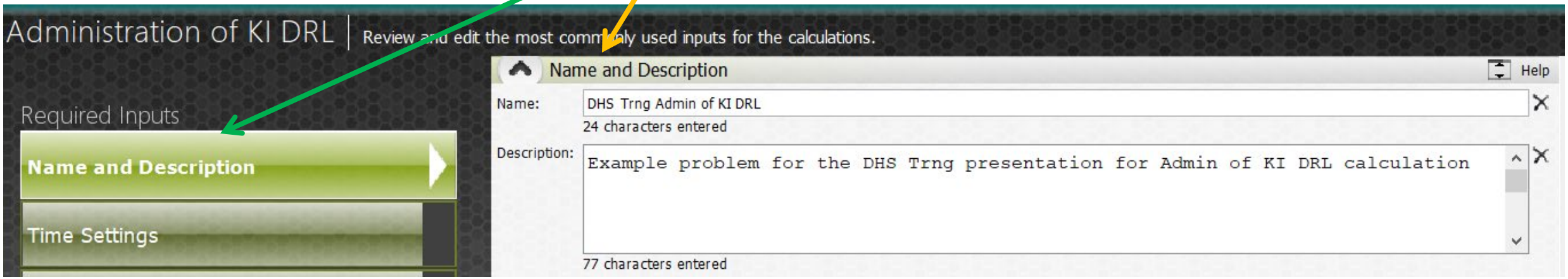
SELECT A NEW CALCULATION



Select Public Protection, then Administration of KI DRL, then Blank

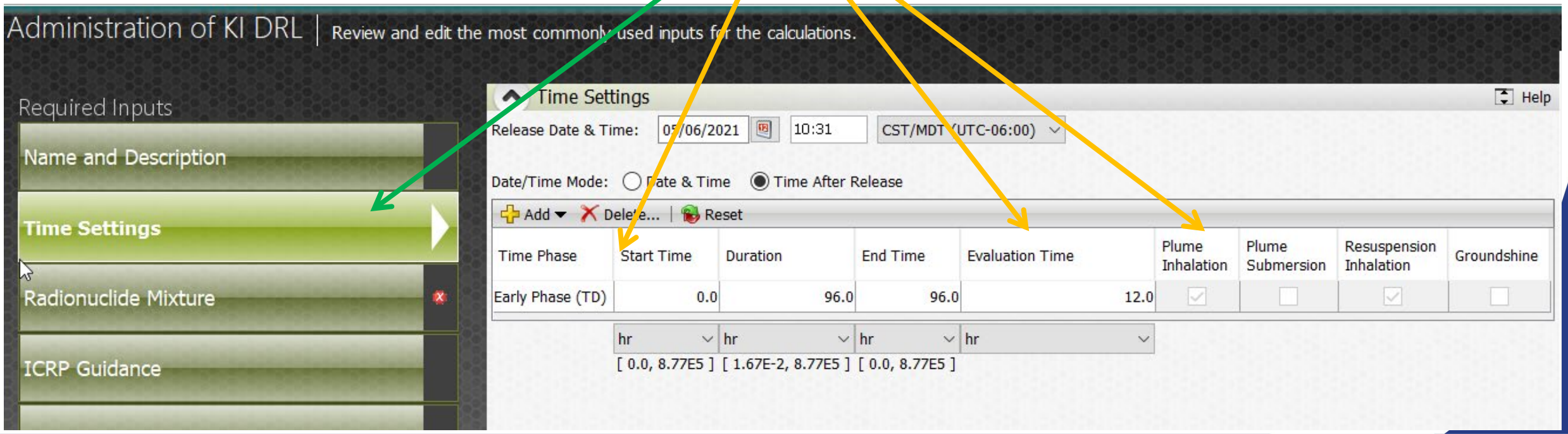
NAME AND DESCRIBE CALCULATION

Click on Name and Description Button
Type in a Name and Description for the calculation



VERIFY TIME PHASES AND EVALUATION TIME

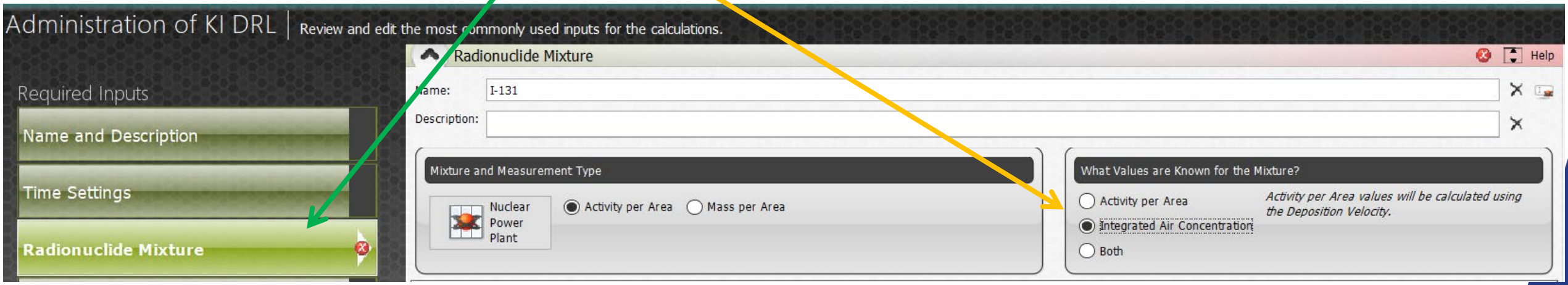
Click on Time Settings Button
Notice only one Time Phase is available
Verify Time Phases, Evaluation Time and Pathways are correct



BUILD RADIONUCLIDE MIXTURE

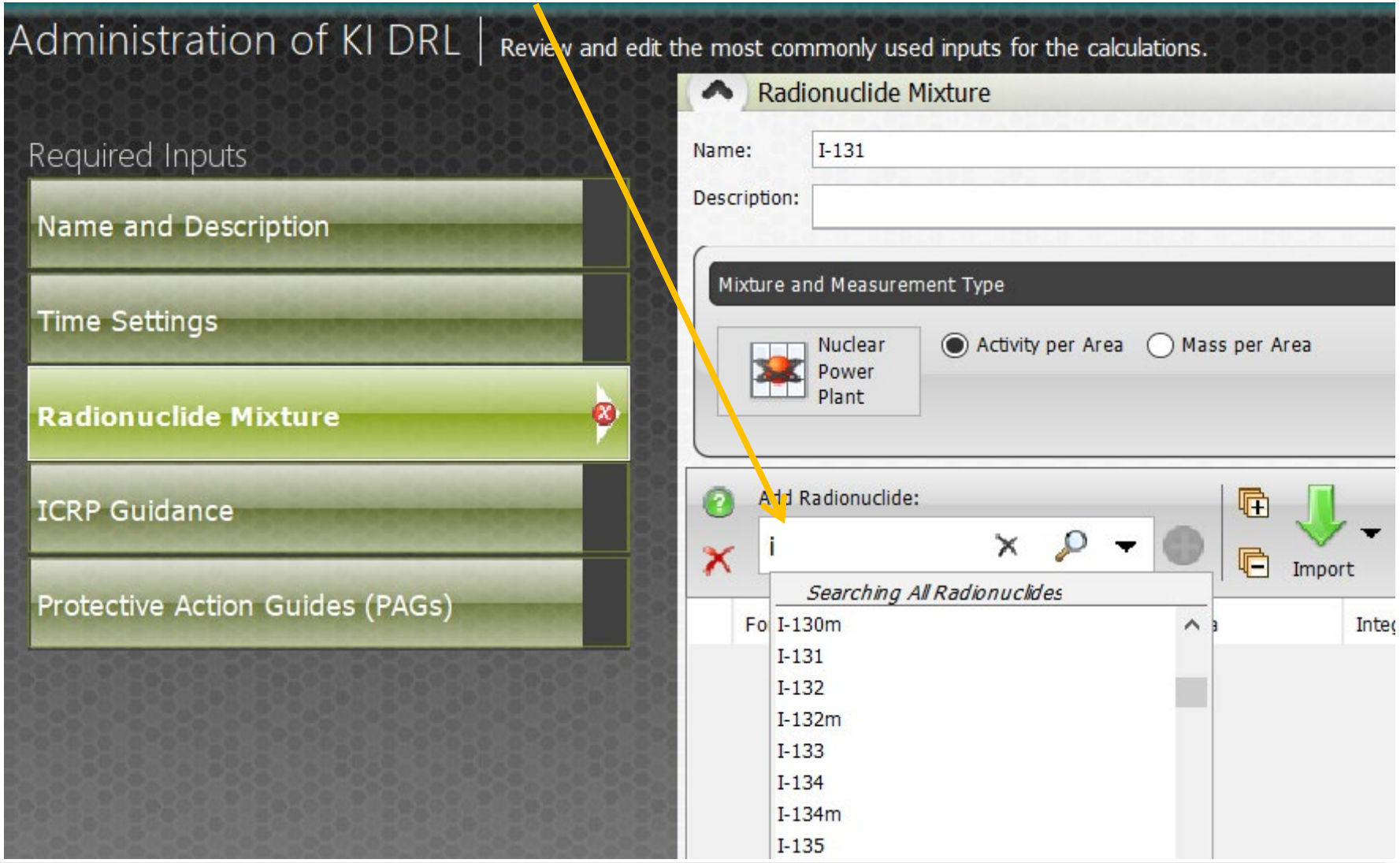
Click on Radionuclide Mixture Button

Click the Integrated Air Concentration button



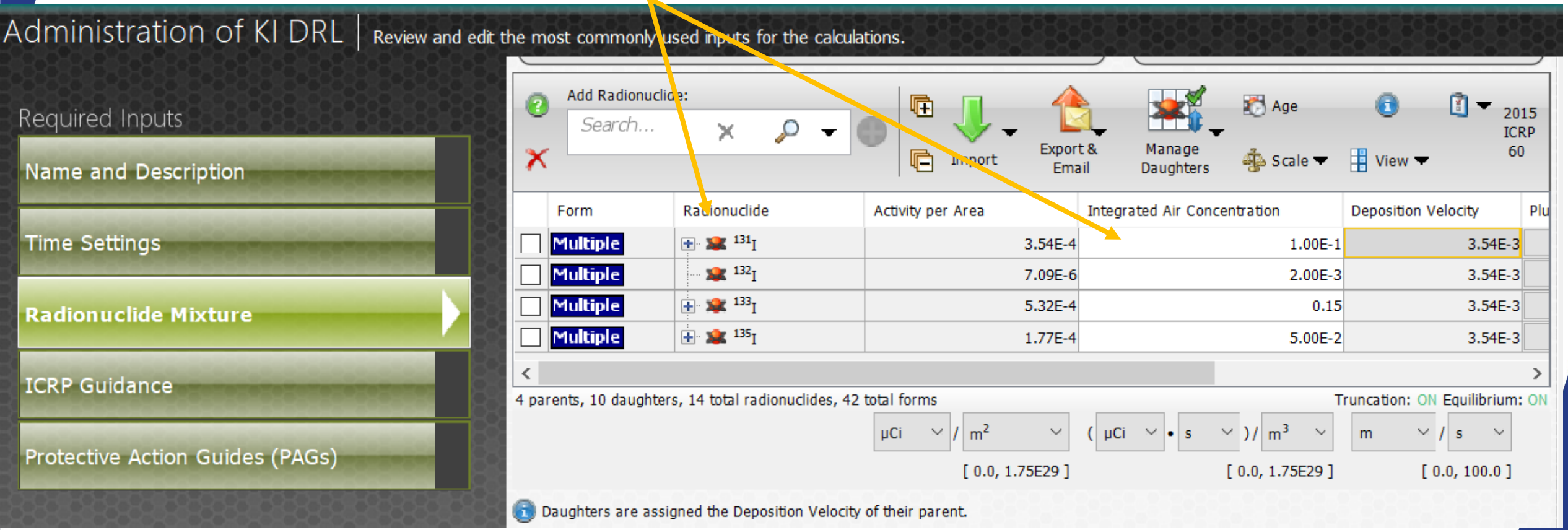
BUILD RADIONUCLIDE MIXTURE

Click on Search and begin to populate Radionuclides



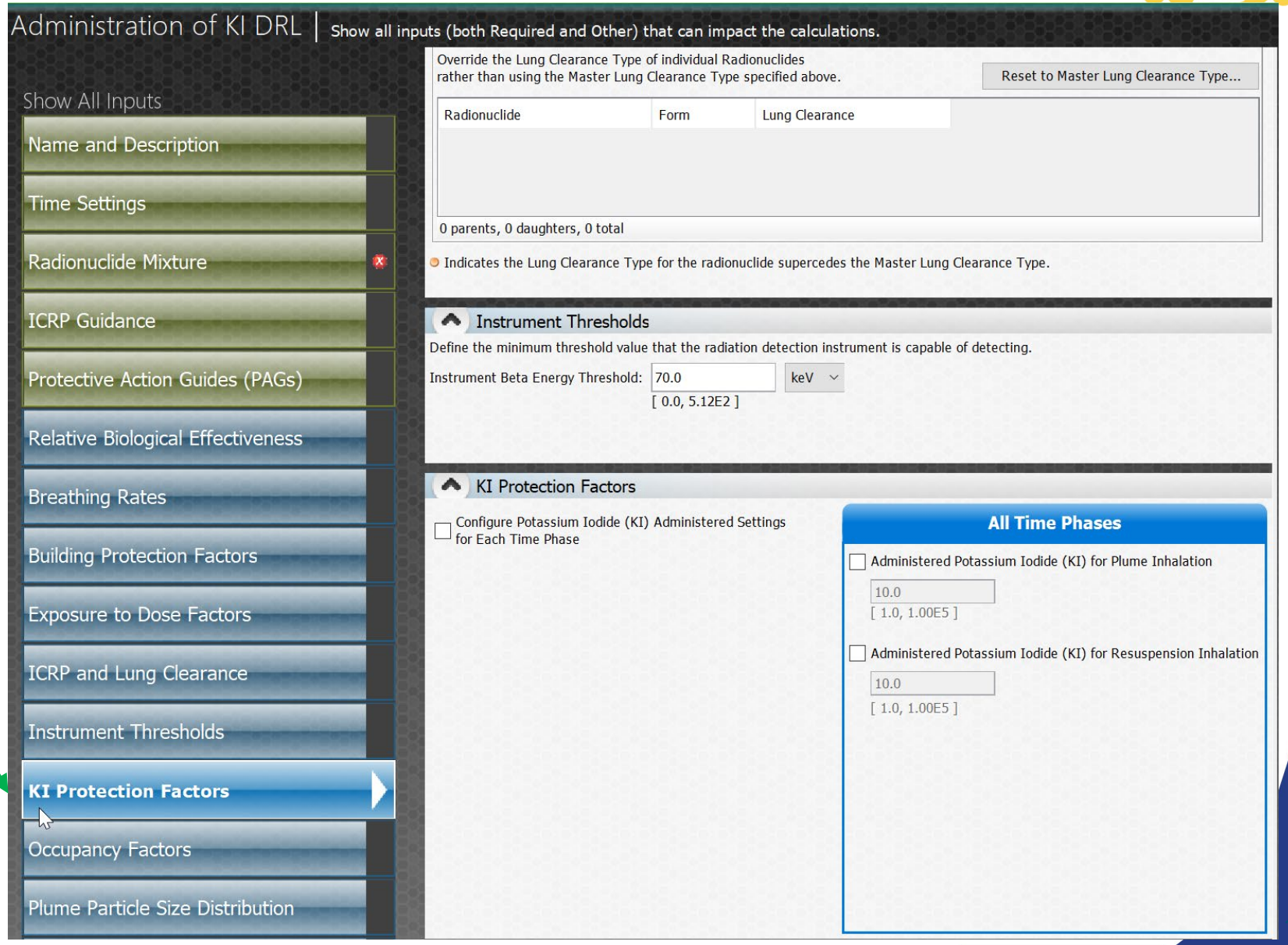
BUILD RADIONUCLIDE MIXTURE

Enter each Radionuclide in the mix and enter the Integrated Air Concentration



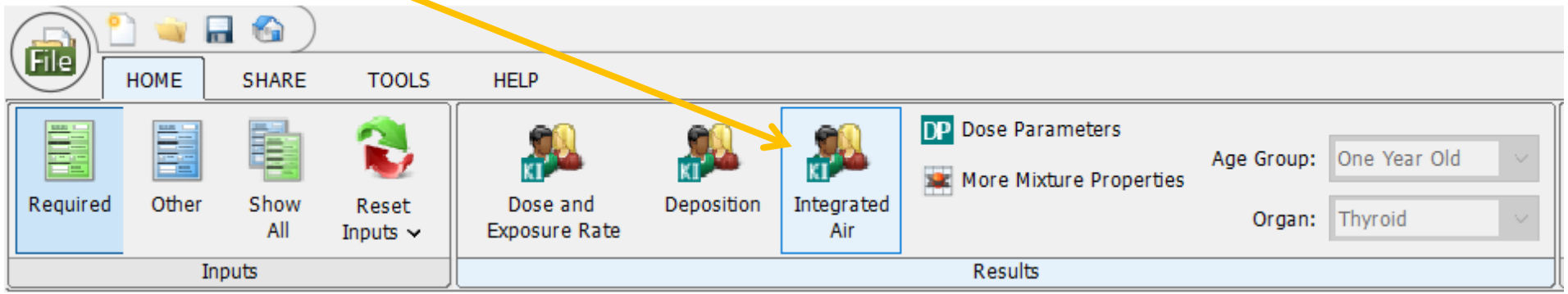
KI PROTECTION FACTORS

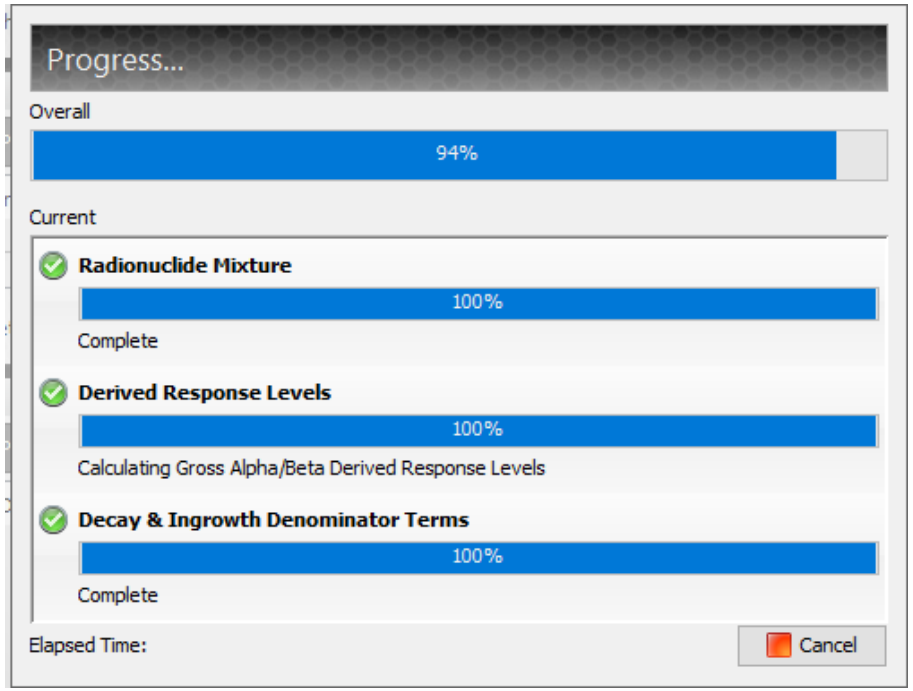
This calculation allows the user to add a protection factor for administration of KI



RUN CALCULATION

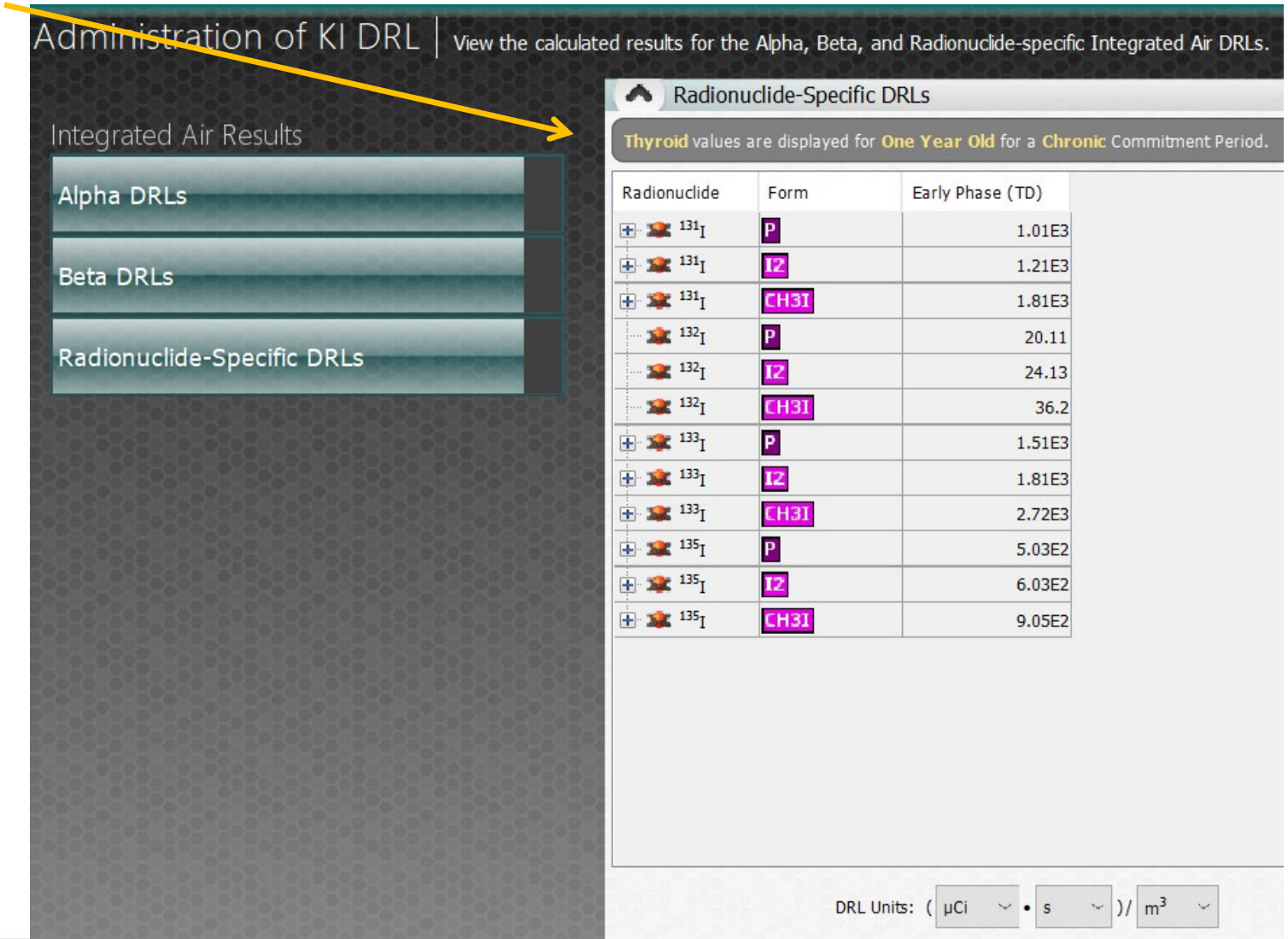
Click the Integrated Air button





NEW INTEGRATED AIR DRL CREATED

Final Results displayed



NEW INTEGRATED AIR DRL CREATED

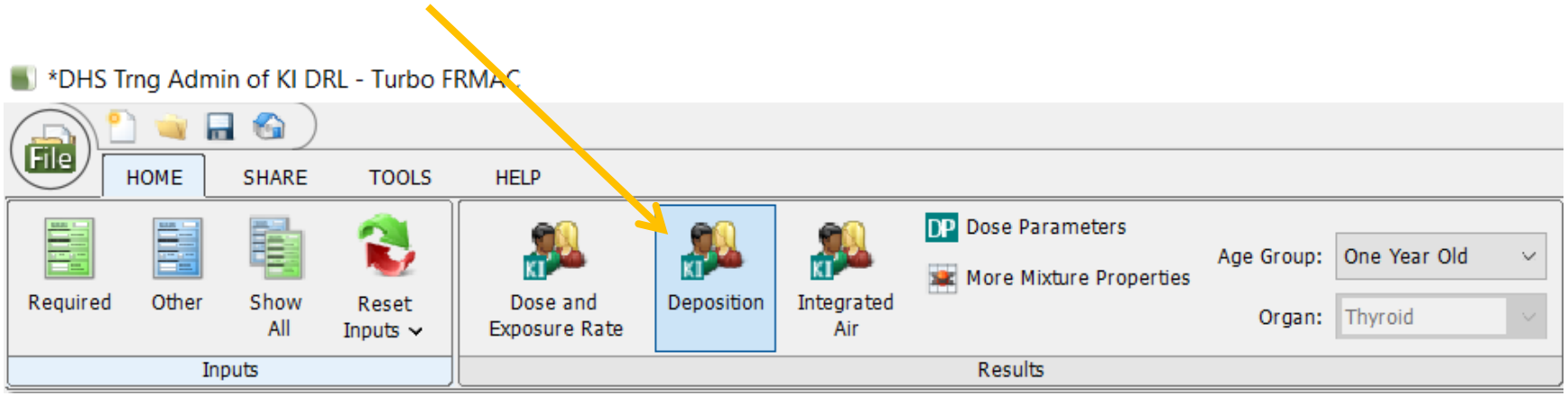
Final Results display DRLs for each of the different chemical/physical forms

Radionuclide	Form	Early Phase (TD)
^{131}I	P	1.01E3
^{131}I	I2	1.21E3
^{131}I	CH3I	1.81E3
^{132}I	P	20.11
^{132}I	I2	24.13
^{132}I	CH3I	36.2
^{133}I	P	1.51E3
^{133}I	I2	1.81E3
^{133}I	CH3I	2.72E3
^{135}I	P	5.03E2
^{135}I	I2	6.03E2
^{135}I	CH3I	9.05E2

DRL Units: (µCi • s)/ m^3

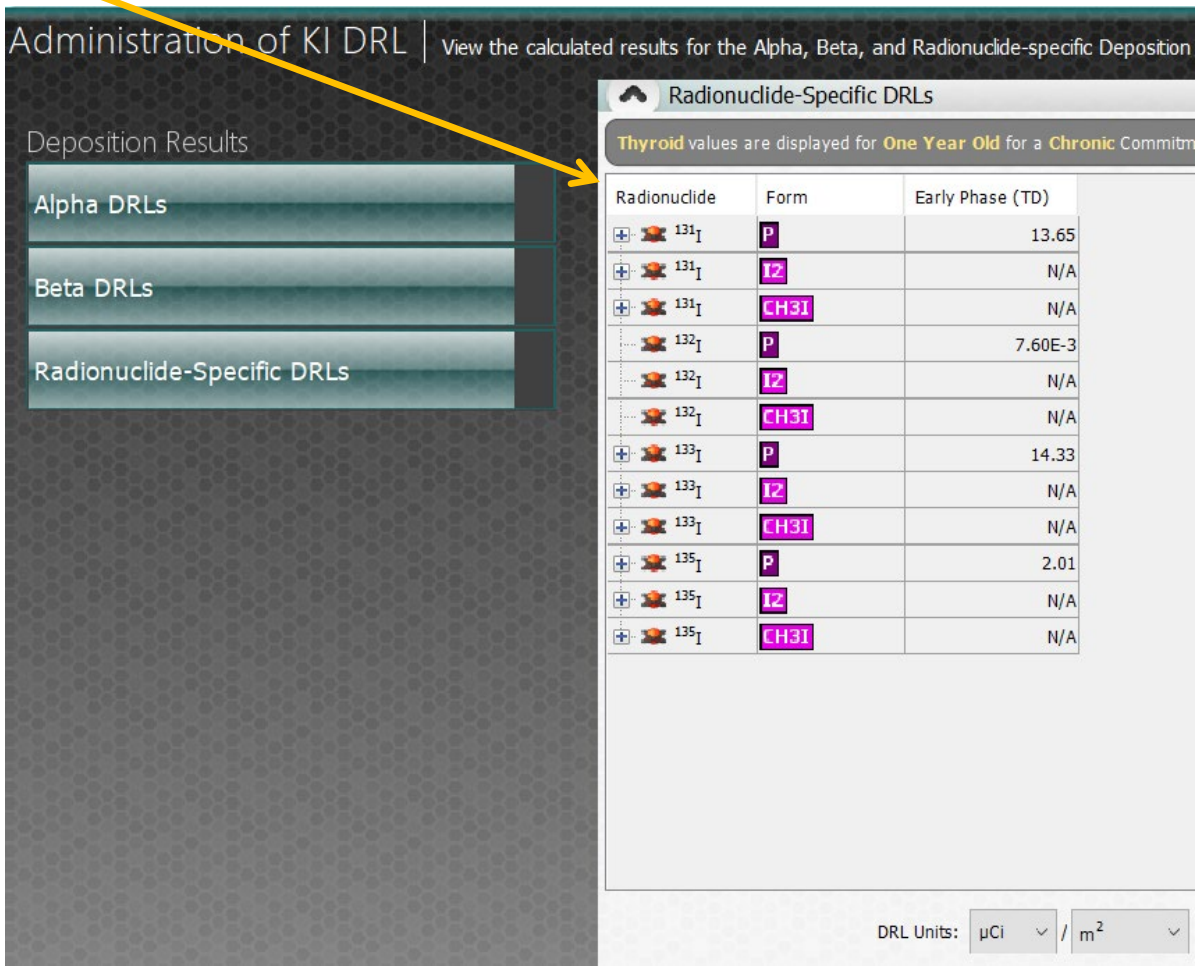
RUN CALCULATION

Click the Deposition button



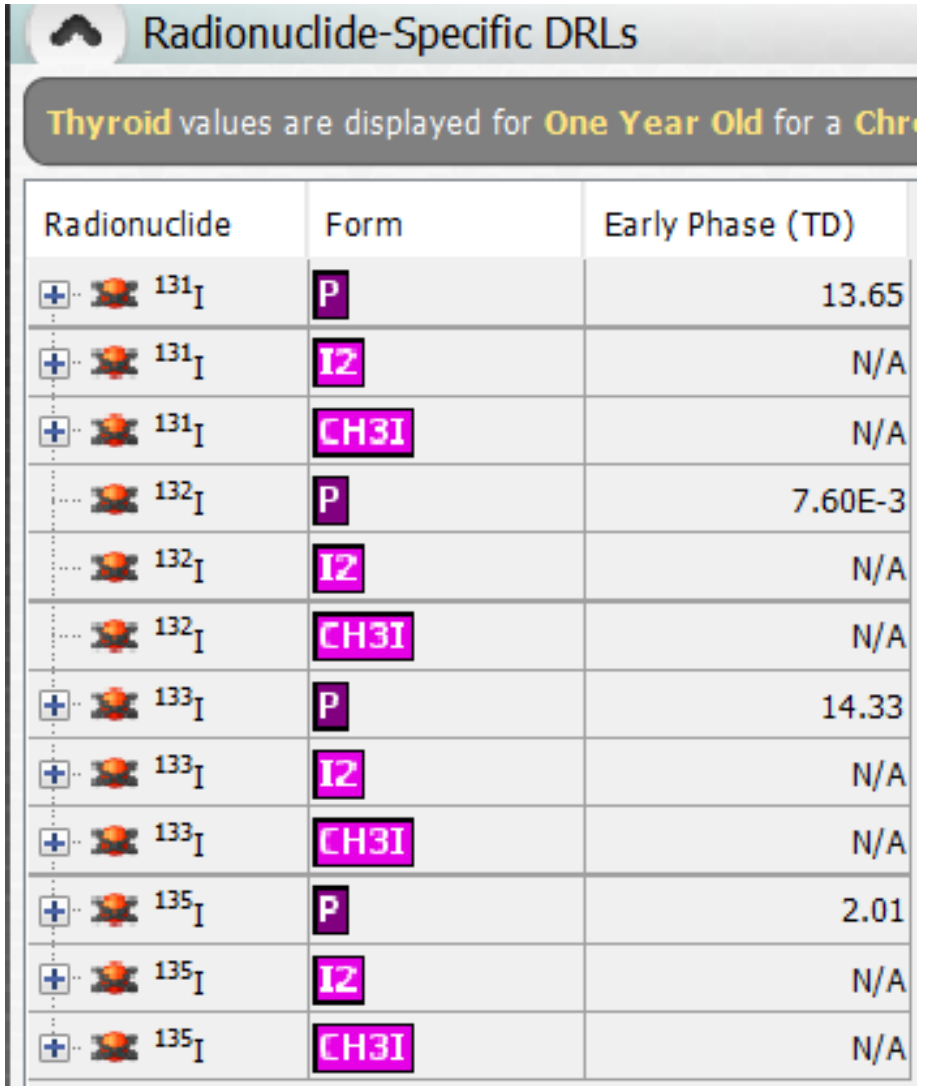
NEW DEPOSITION DRL CREATED

Final Results displayed



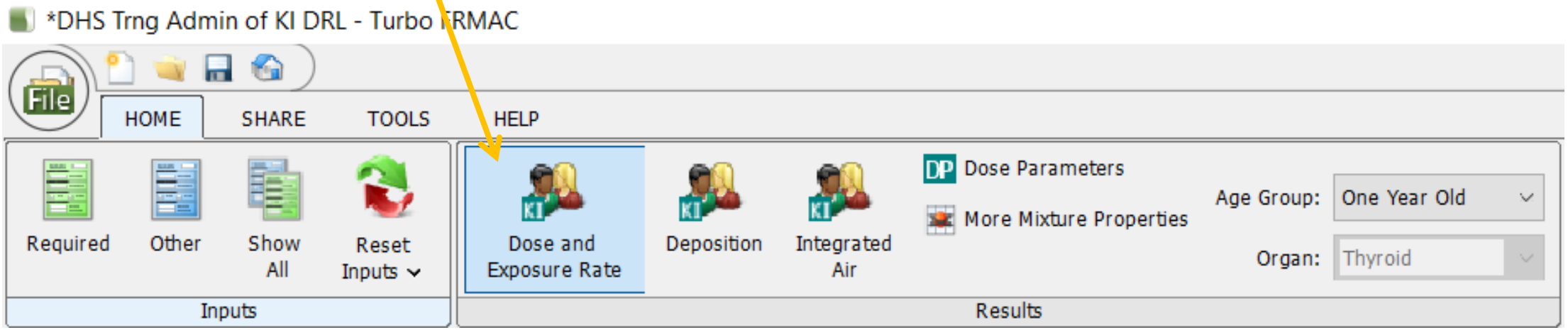
NEW DEPOSITION DRL CREATED

Final Results display DRLs but because the calculation is for Deposition, only the particulate form results are appropriate



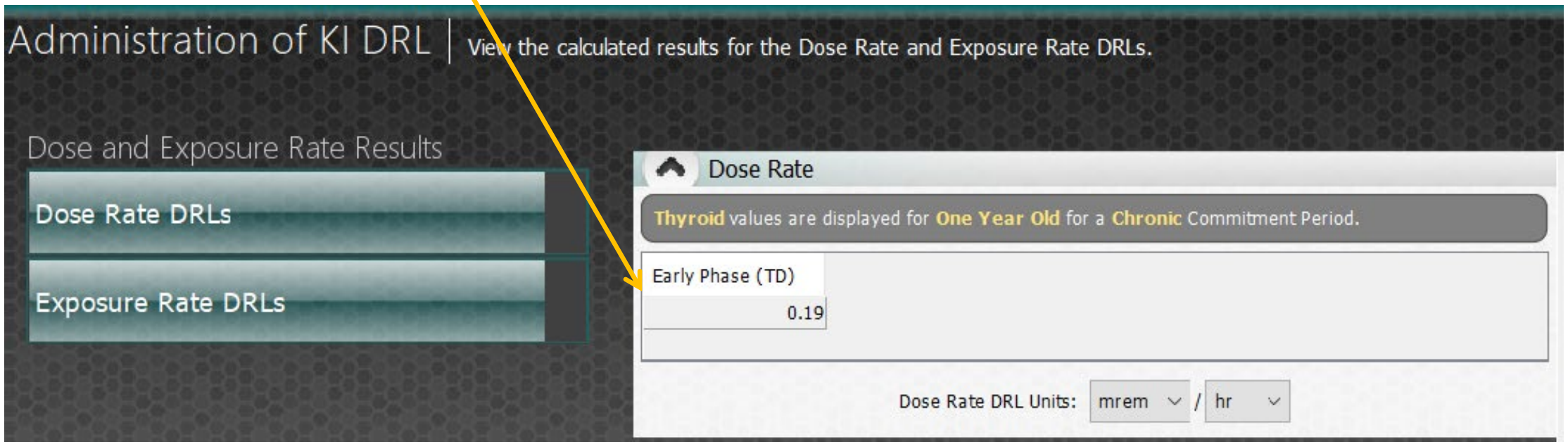
RUN CALCULATION

Click the Dose and Exposure Rate button



NEW DOSE AND EXPOSURE RATE DRL CREATED

Final Results displayed.



USING ADMINISTRATION OF KI DRLS

FOR DEMONSTRATION ONLY – NOT AN APPROVED NARAC PRODUCT

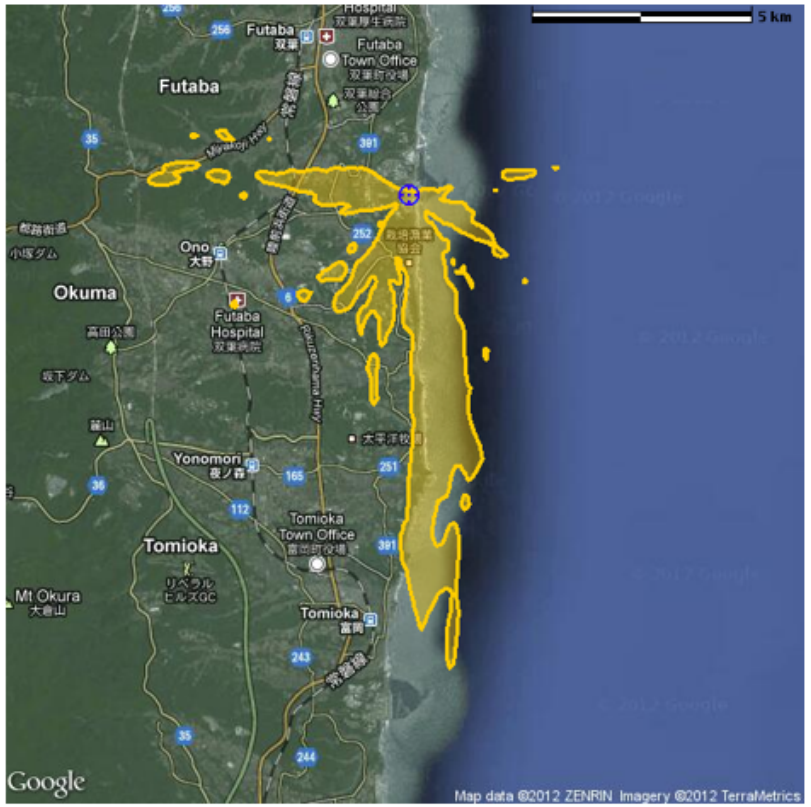
NOT APPROVED BY NARAC
NARAC
National Atmospheric Release Advisory Center

Automated Report: Testing
(37.4214,141.032)
NPP Release at 14 Mar 2011 06:00 UTC

Predicted Areas Warranting Administration of Potassium Iodide (KI)

Based on Current EPA Guidance (1992).

Applicable only if radioactive cloud is present or imminent



KI administration warranted to protect the adult thyroid. Exceeds 25 rem.

Notes:

- Prompt administration of KI is warranted for those located in the area indicated.
- The protective value of KI administration is time sensitive. If at all possible, administer KI before exposure to the radioactive cloud. Benefit diminishes rapidly after exposure to the cloud's radioiodine.
- Potassium Iodide only protects the thyroid from radioiodine. It has no protective value for other radionuclides or for any other organ.
- There are two different sources of guidance for the administration of KI in a radiation emergency: 1) the older EPA Protective Action Guide (PAG) Manual and 2) the newer FDA KI Guidance.
- This product employs the older guidance from the EPA Manual.

Assumptions:

- Areas shown are model predictions based on an estimated release of airborne radioactivity but not measurements.
- Plume Phase - Radioactive cloud may still be present or imminent.
- Dose predicted for maximally exposed adult. Includes dose from inhalation of contamination in the radioactive cloud and dose from inhalation of resuspended contaminated dust over first four days.

Briefing Product for Public Officials
Current: 18 Oct 2012 15:59 UTC
Check for updates

Technical Details: CMHT 702-794-1665
Advice & Recommendations: A-Team 770-488-7100

Beta rcE17332 rcC1

Not for Public Dissemination

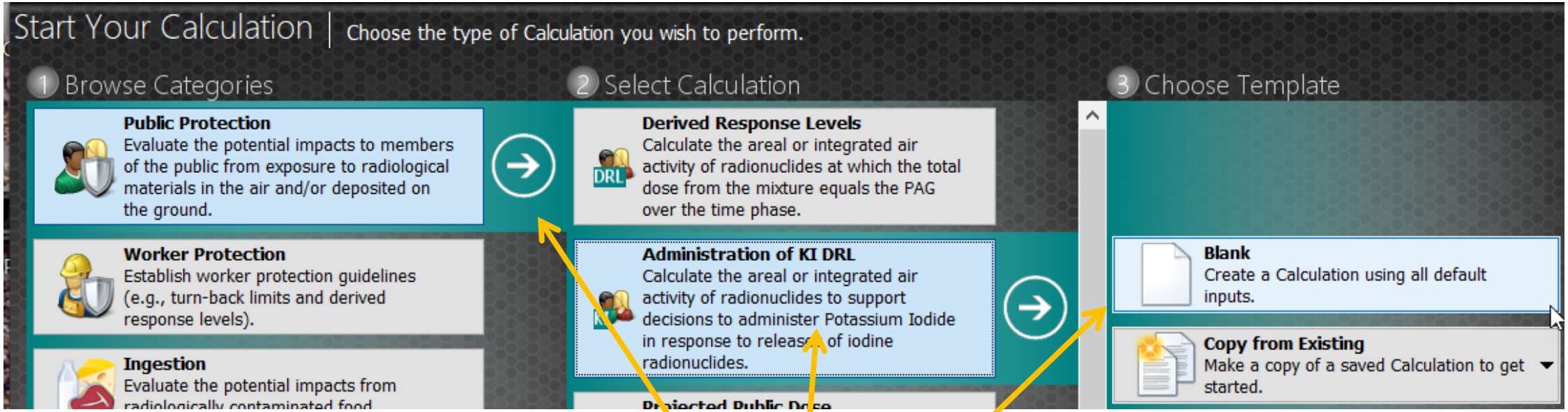
EXAMPLE PROBLEM

Calculate the KI Administration Deposition DRLs for the Early Phase (TD) Time Phase for the Mixture below with an Evaluation Time (t_n) of 72 hours and Airborne Partition as indicated

Radionuclide	Integrated Air Activity ($\mu Ci \cdot s/m^3$)
I-131	1.0E-01

Chemical/Physical Form	Airborne Partition
Particulate	0.75
I_2	0.20
CH_3I	0.05

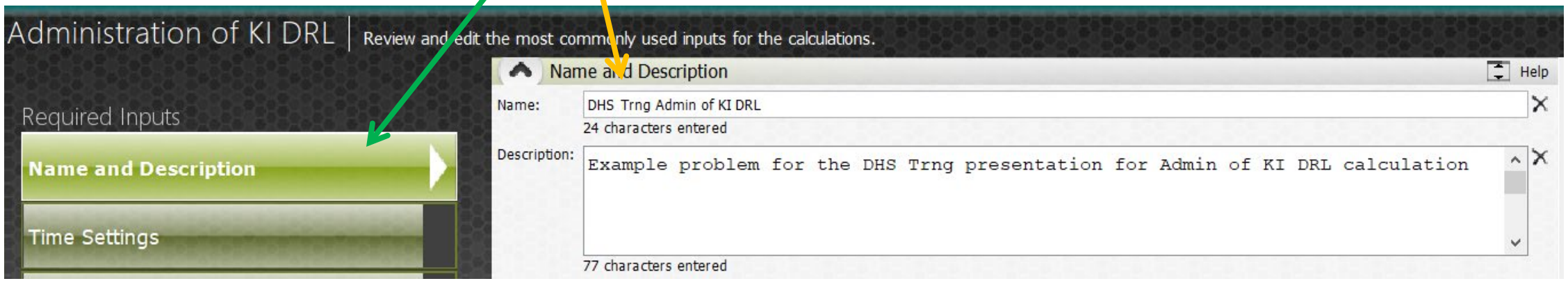
SELECT NEW CALCULATION



Select Public Protection, then Administration of KI DRL, then Blank

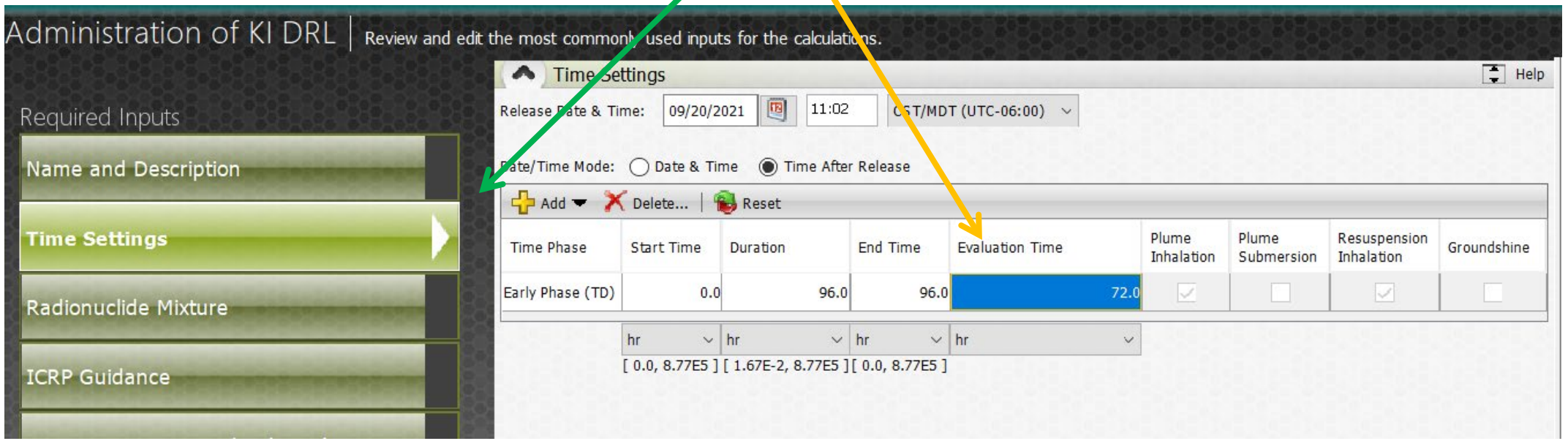
NAME AND DESCRIBE CALCULATION

Click on Name and Description Button
Type in a Name and Description for the calculation



VERIFY TIME PHASES AND EVALUATION TIME

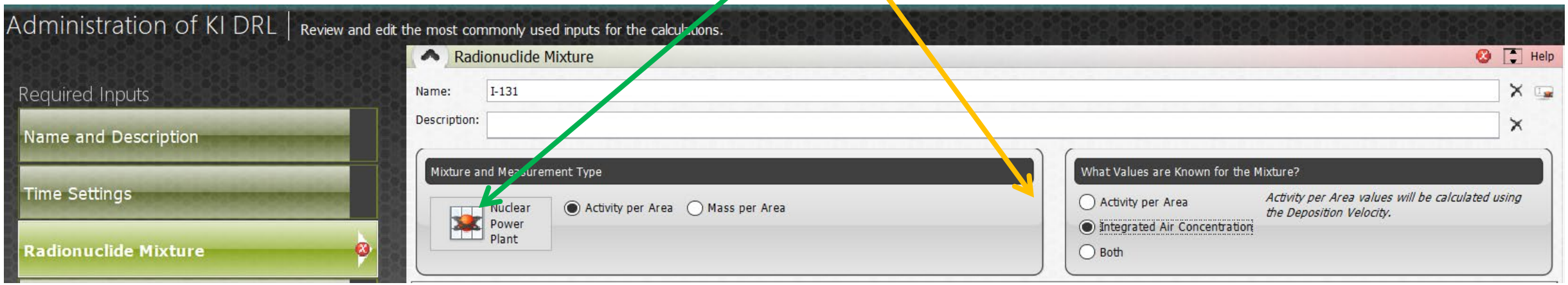
Click on Time Settings Button
Change Evaluation Time to 72 hr



BUILD RADIONUCLIDE MIXTURE

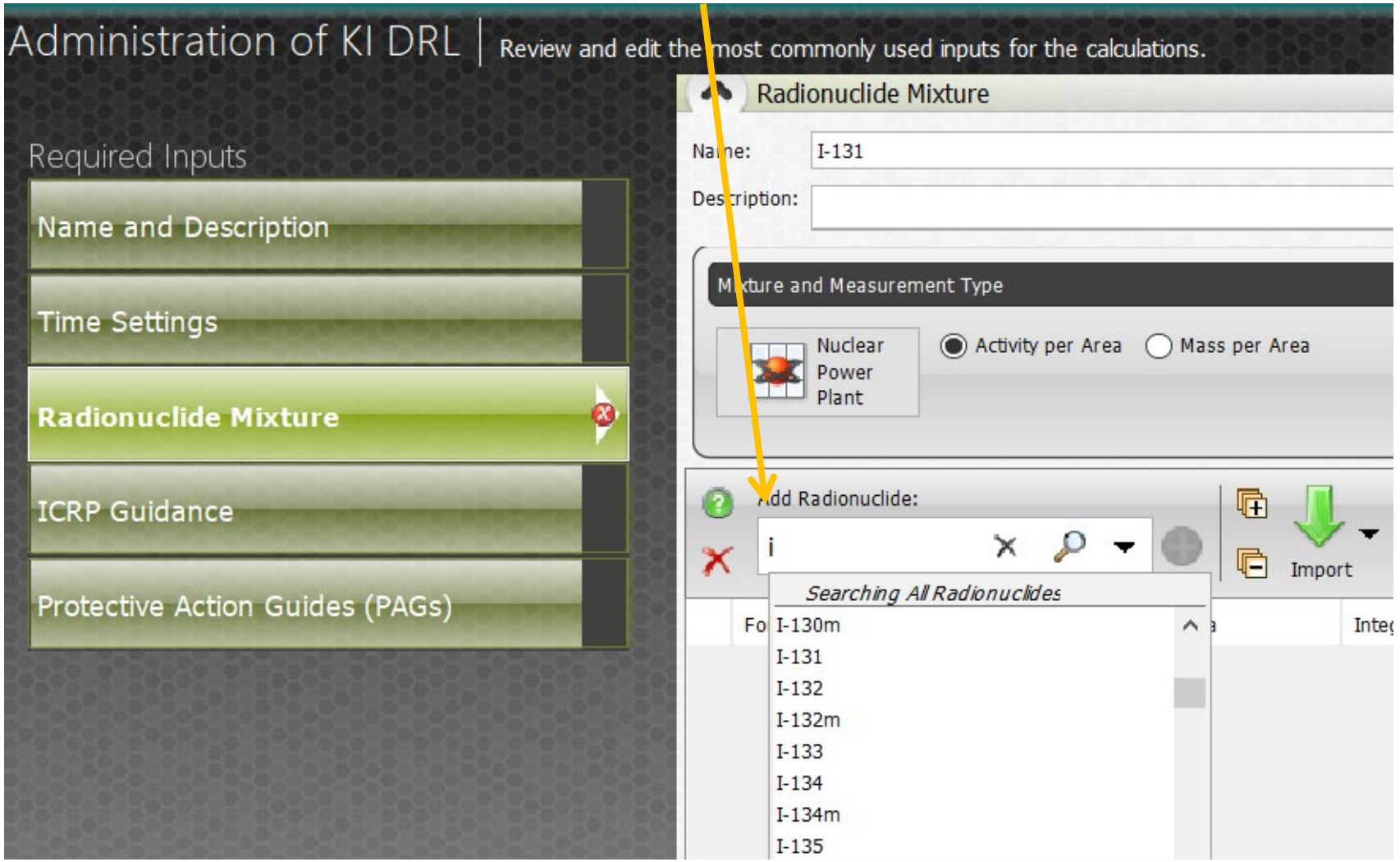
Click on Radionuclide Mixture Button

Click the Integrated Air Concentration button



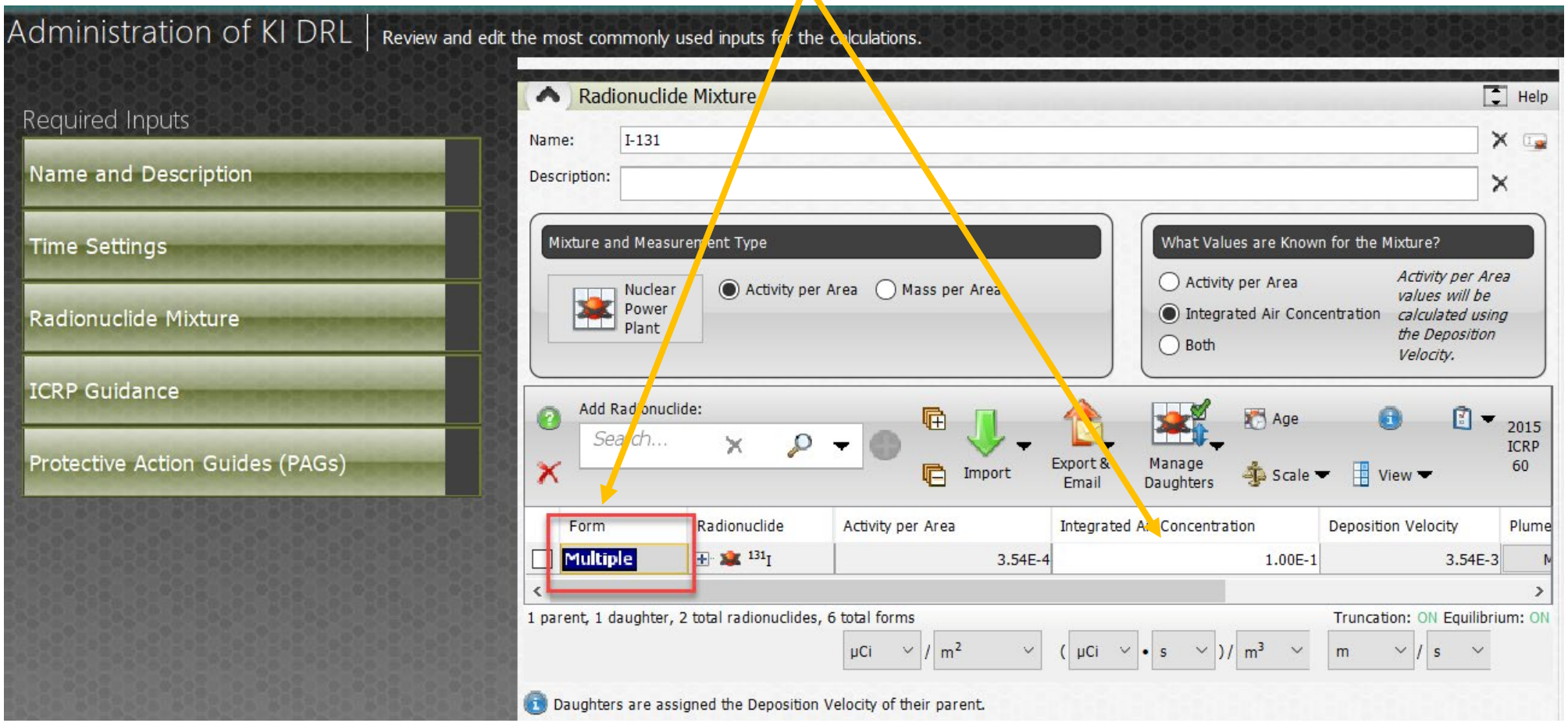
BUILD RADIONUCLIDE MIXTURE

Click on Search and begin to populate Radionuclides



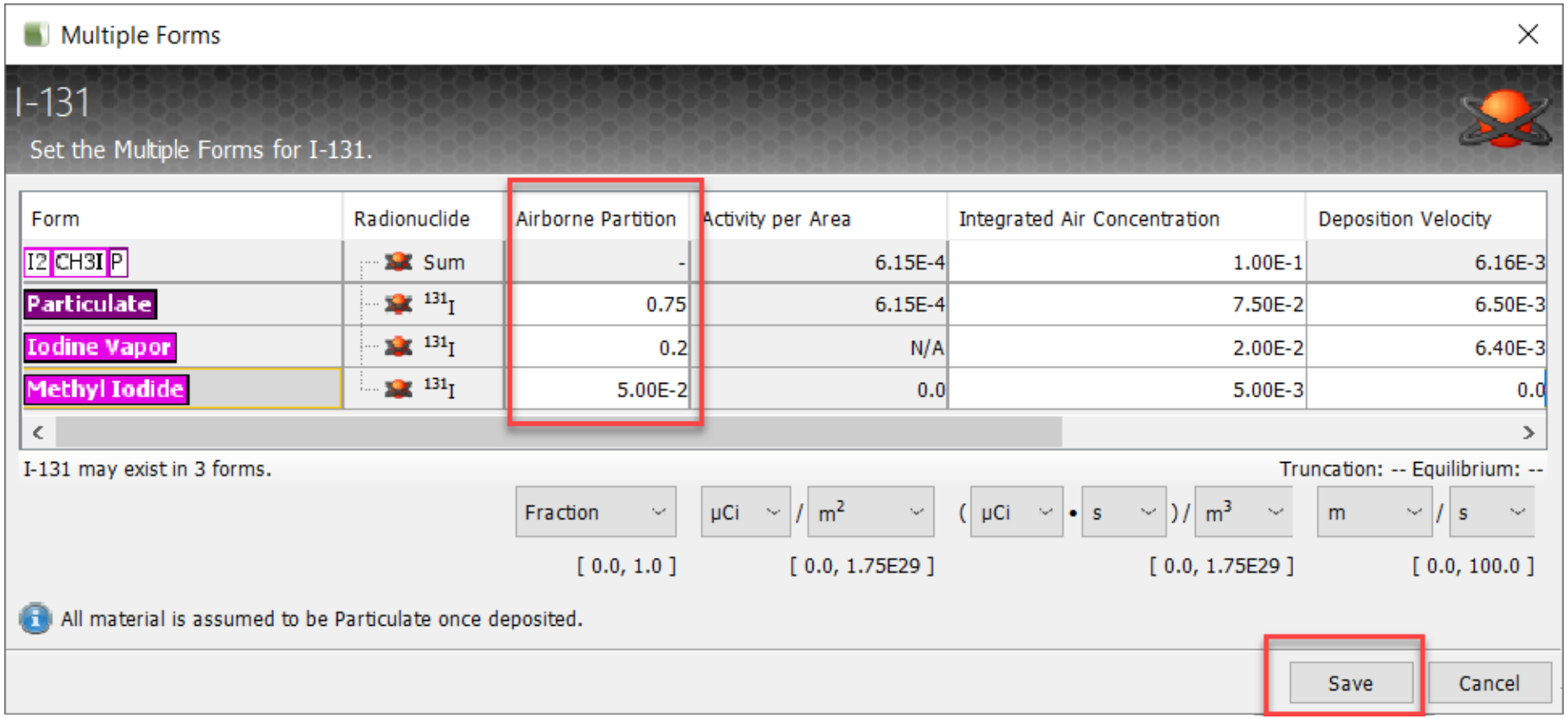
BUILD RADIONUCLIDE MIXTURE

Enter the Radionuclide and the Integrated Air Concentration
Notice the “Multiple” button under the Form column is highlighted – Double Click that button



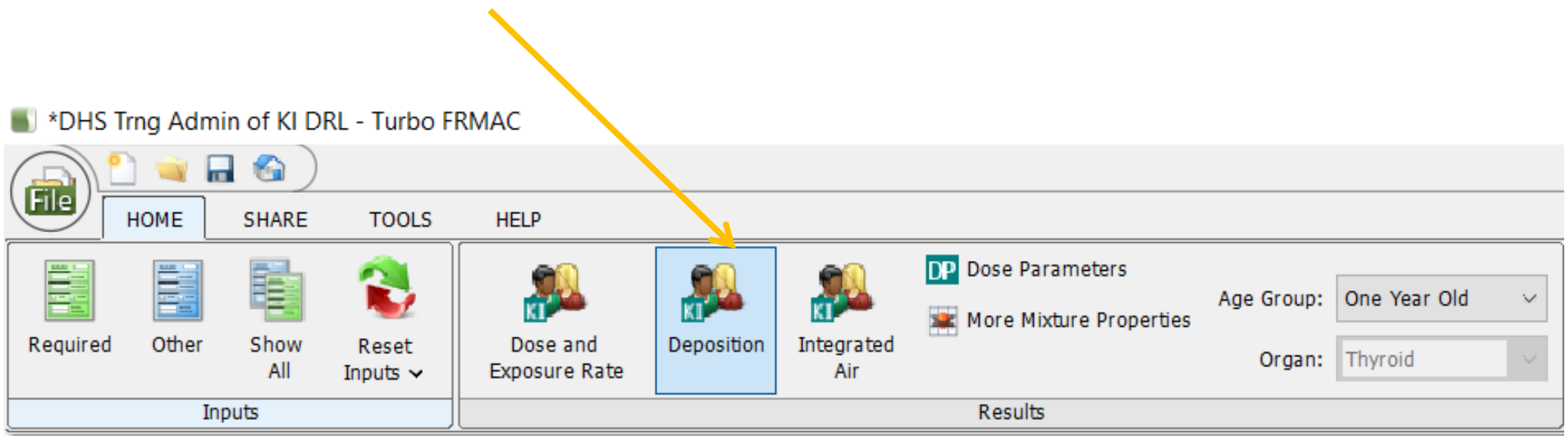
BUILD RADIONUCLIDE MIXTURE

A supplement box opens providing the user with the editable values for Airborne Partition
Change these as specified
Click Save with done



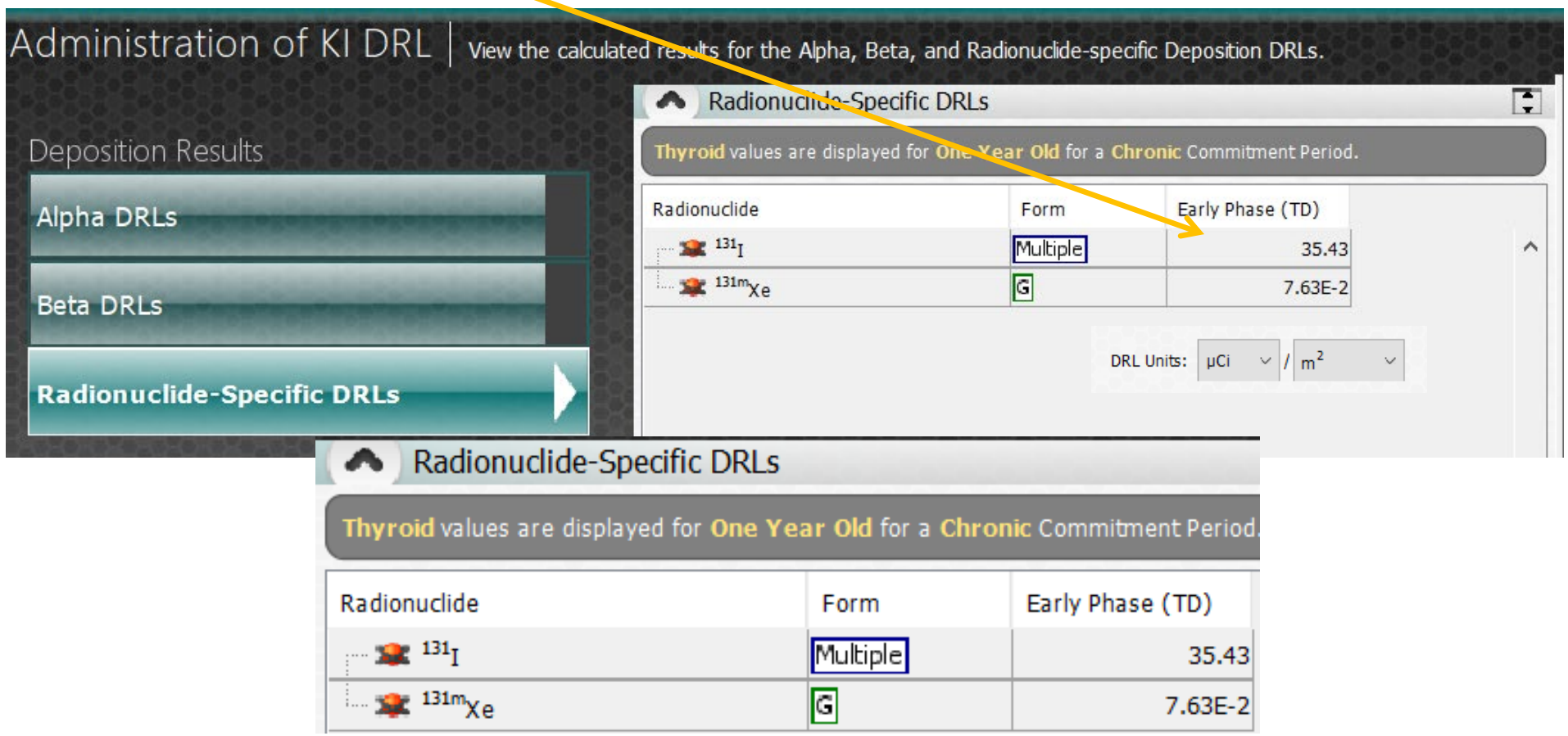
RUN CALCULATION

Click the Deposition button



NEW DEPOSITION DRL CREATED

Final Results displayed



INTERPRETING THE RESULTS

A Deposition DRL of 35.43 µCi/m^2 measured at 72 hrs after the release indicates that the Protective Action Guide (PAG) of 5 rem to the 1 yr old thyroid for the Early Phase (TD) time phase is met or exceeded

This data would provide the Decision Makers the information needed to take some protective action such as issuance of KI and advise as to administration

Also this data is provided to NARAC for plotting on a map to determine the potential impacted area that protective actions should be implemented