U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

RAMP
RADIATION PROTECTION COMPUTER CODE
ANALYSIS AND MAINTENANCE PROGRAM

RASCAL TRAINING

RASCAL for novice users

Session start – 0930 EDT

Sound Check

You should hear some music playing. If not, try these options…

- For computer audio:
  - Make sure your speaker is turned up, you won't need a mic
  - Or, try phoning in (see below)
- For calling in using a phone:
  - Click the ^ next to mute on the bottom left of the Zoom control bar,
  - Then click "switch to phone audio" and dial in with the pop-up info
  - Chat the host if you still have a problem.

Quick Overview

Presenters: George & Jeff

Additional Support: Stephanie & Ed

Participants

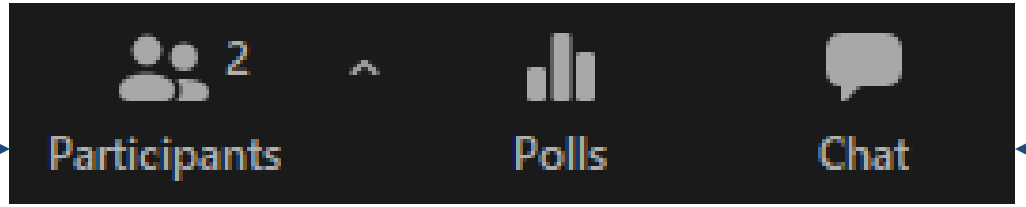
Click this button to open the Participants pane. From here, you can give us feedback, like raising your hand, go slower, or yes/no.

Polls

We'll be using polls a few times throughout these sessions. The poll will pop up automatically. This button only shows up when we have a poll running.

Chat

You are muted by default; please stay muted unless asked to unmute. To ask questions or request help send a chat to George Athey (Host) or Jeff Kowalczik.



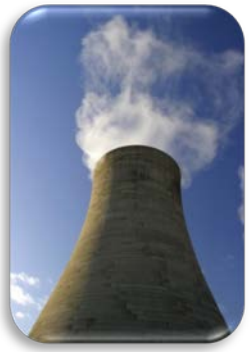
RASCAL Slide

- Every time we ask you to use RASCAL, you'll see one of these blue slides.
- It will include information needed to complete the steps.
- Polls will be used to ask about the problem and make sure everyone is finished.

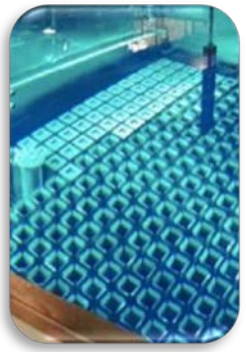
Quick Poll

Just so we know the audience, we're going to ask a few poll questions to understand your knowledge base.

TECHNOLOGY REVIEW, IF NEEDED



Nuclear Power Plant



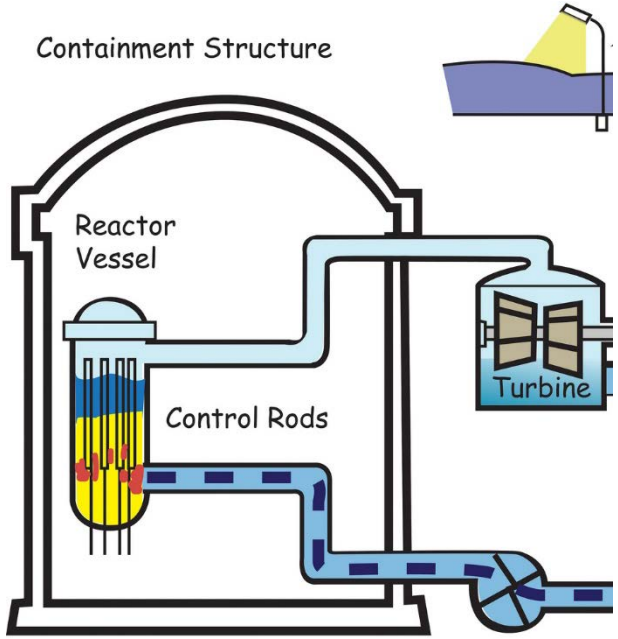
Spent Fuel

Fuel Cycle

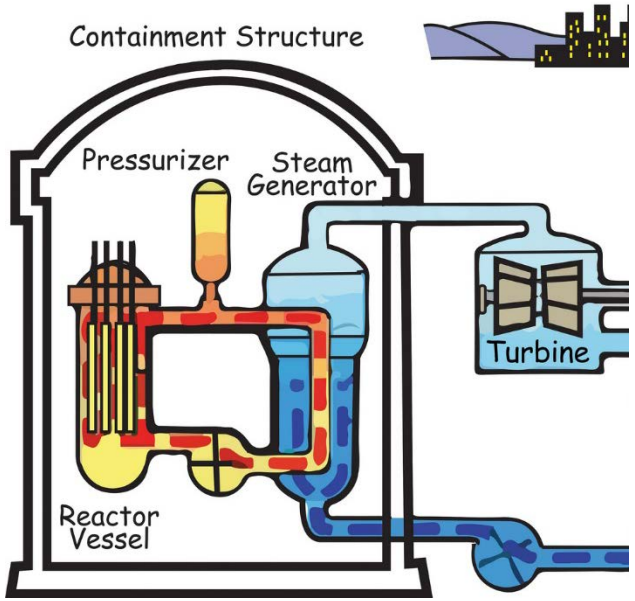
Other Material

Reactor Types

Core inside reactor vessel creates heat, steam is created (main loop in BWR, secondary loop in PWR), steam turns turbine, which produces electricity



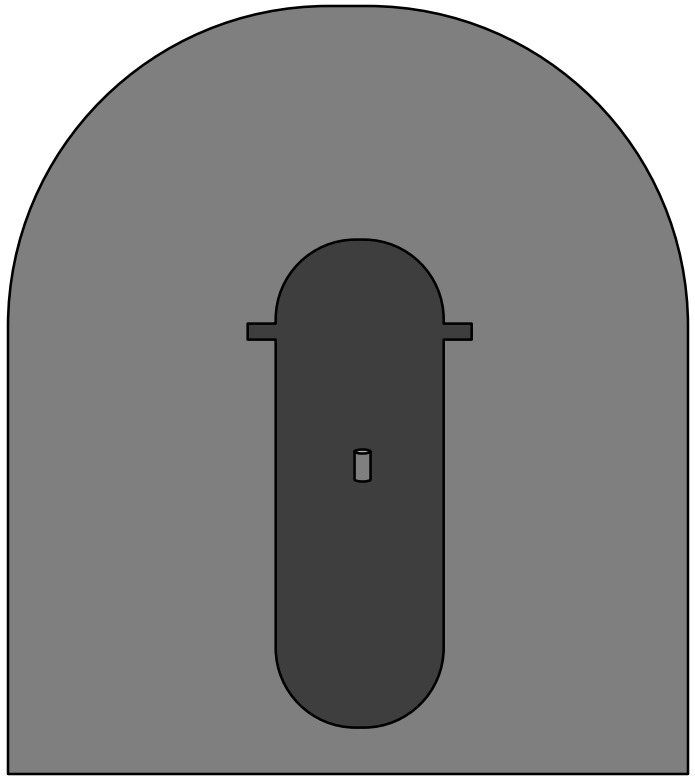
Boiling Water Reactor (BWR)



Pressurized Water Reactor (PWR)

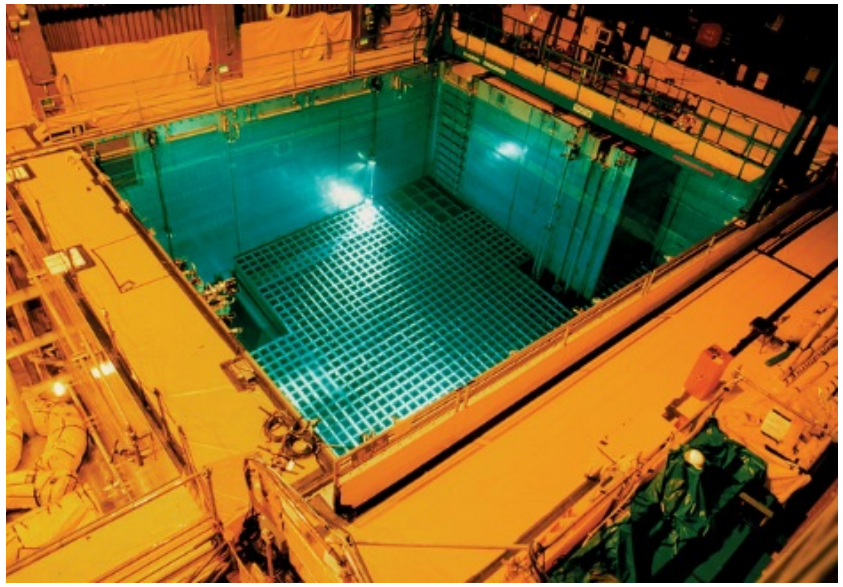
LARGE RELEASES WILL COME FROM MAJOR FUEL DAMAGE, ONLY CAUSED FROM LACK OF COOLING

- No heat removal leads to fuel cladding failure and fuel melt
- Eventual RCS overpressure / leakage
- Possible containment overpressure / leakage



Spent Fuel

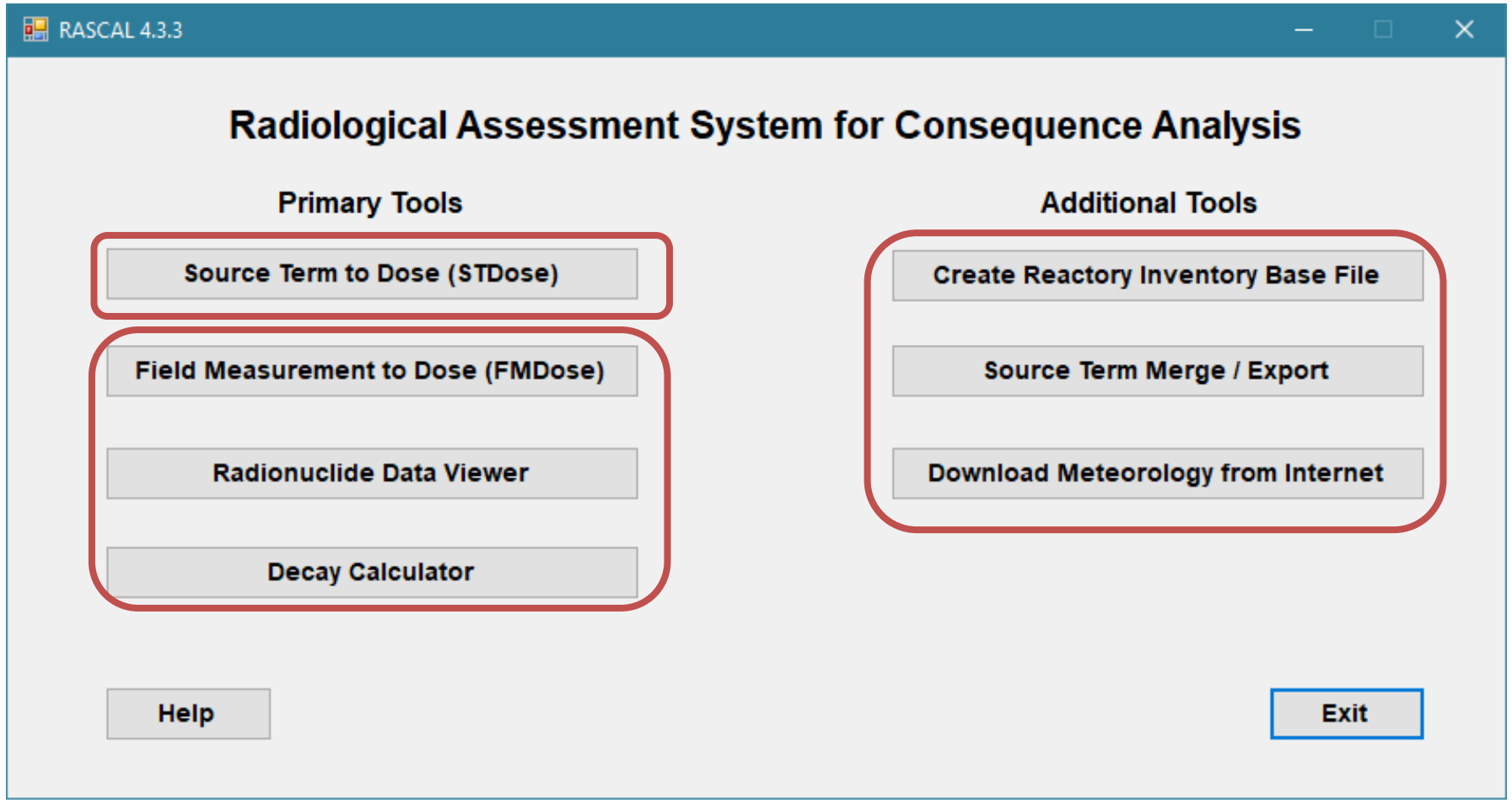
- **Every 12-24 months, a fraction of reactor core is replaced and moved to a pool to cool.**
- **5-10 years later, cooler fuel moved to dry cask**



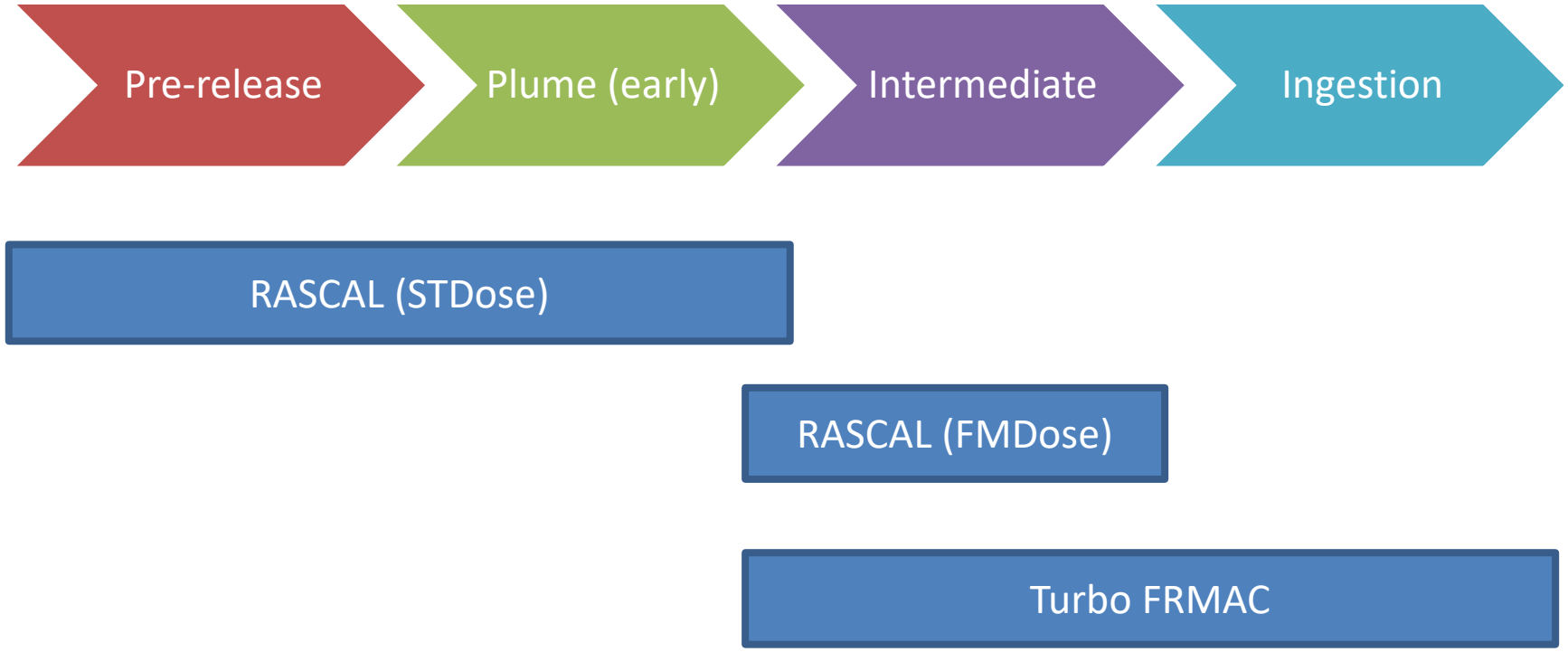
Fuel Cycle

- Fuel cycle facilities convert, enrich, and fabricate mined material into reactor fuel
- RASCAL Supports these accident types:
  - UF_6 Cylinders
  - Criticality
  - Fire/Explosions involving Uranium Oxide

There are 4 primary tools and 3 additional tools on the RASCAL Home Page.

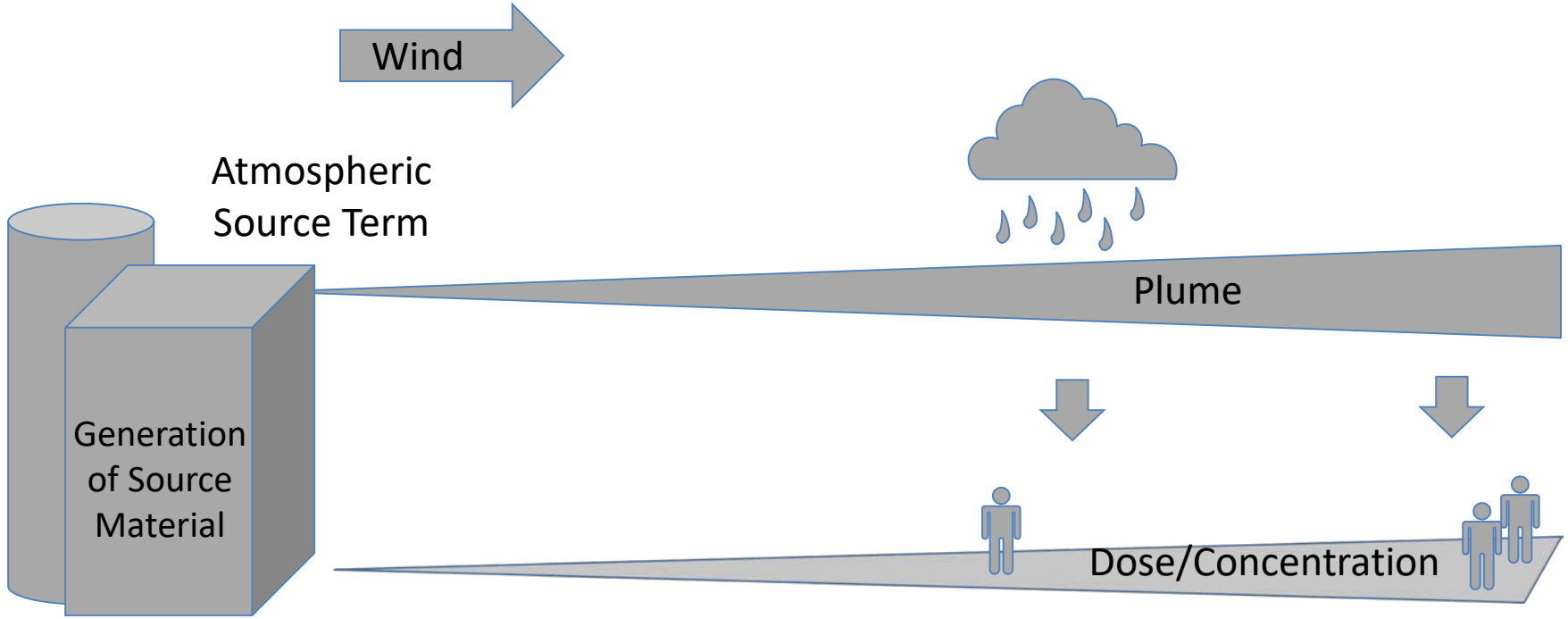


WHERE DOES RASCAL FIT IN THE PHASES OF A RADIOLOGICAL EMERGENCY?



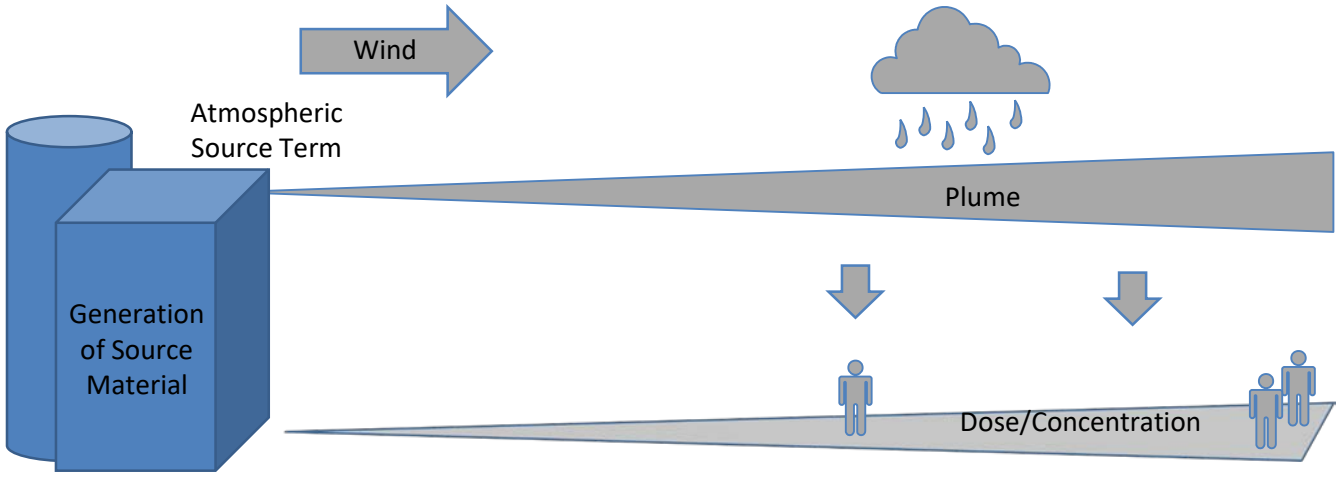
Our Training Will Focus on STDose

Source Term to Dose module creates an atmospheric source term, processes weather data, and calculates doses



RASCAL Defines Atmospheric Source Term

- Determines radionuclides available for release
  - May be single nuclide or complex core damage
  - Time-dependent isotopes and activity
- Source material may be filtered, reduced, or decayed

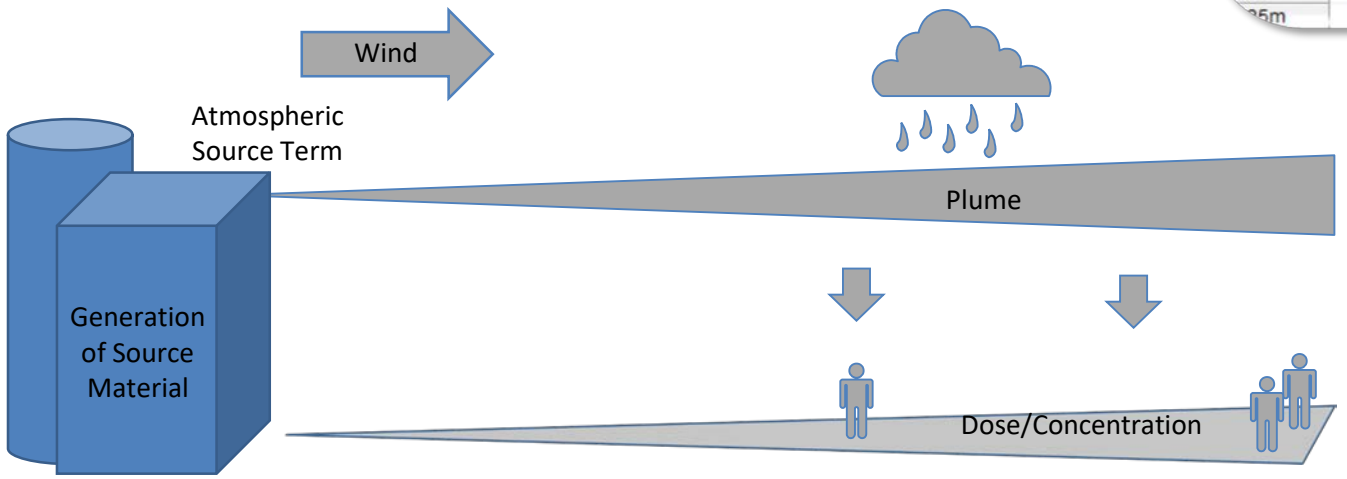


Result is Radionuclides Released to Environment Over Time (Atmospheric Source Term)

Isotopic activity over time (15 min)

ity (Ci) released to atmosphere (by nuclide and time step)

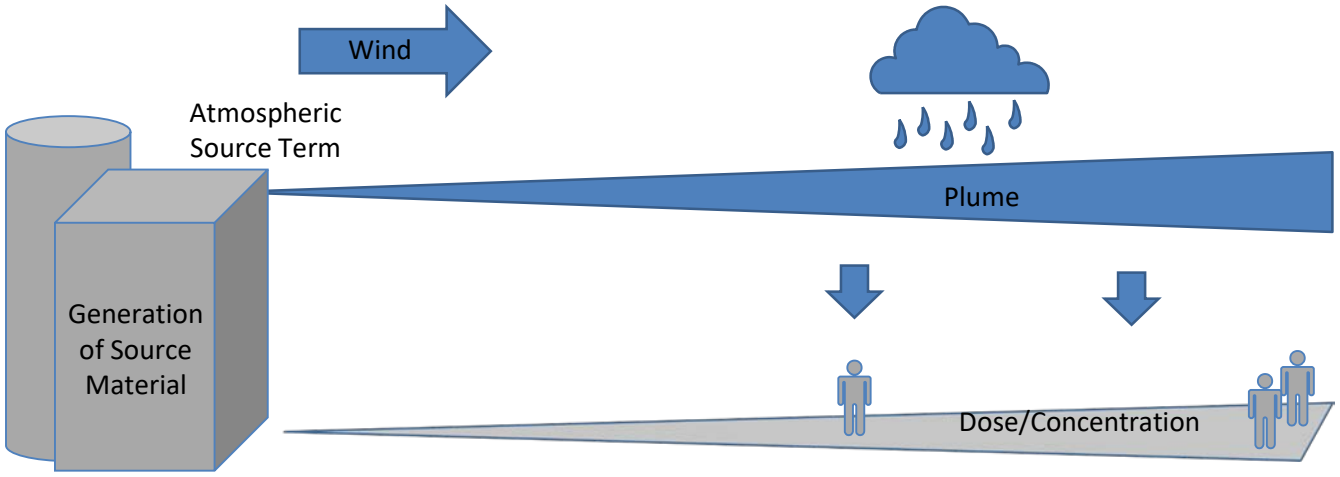
Interval	2016/02/02	2016/02/02	2016/02/02	2016/02/02	2016/02/02	2016/02/02	2016/02/02	20
Start	00:00	00:15	00:30	00:45	01:00	01:15	01:30	01:
Am-241	0.00E+00	0.00E+00	4.62E-10	1.46E-09	2.75E-09	4.17E-09	5.63E-09	
Ba-139	0.00E+00	0.00E+00	5.62E+00	8.62E+00	9.99E+00	1.04E+01	1.02E+01	1
Ba-140	0.00E+00	0.00E+00	7.25E+00	1.26E+01	1.66E+01	1.95E+01	2.17E+01	3
Ce-141	0.00E+00	0.00E+00	1.67E-01	2.92E-01	3.83E-01	4.51E-01	5.01E-01	1
Ce-143	0.00E+00	0.00E+00	1.51E-01	2.61E-01	3.42E-01	4.01E-01	4.43E-01	1
Ce-144*	0.00E+00	0.00E+00	1.35E-01	2.35E-01	3.09E-01	3.64E-01	4.04E-01	1
Cm-242	0.00E+00	0.00E+00	1.71E-03	2.97E-03	3.91E-03	4.60E-03	5.11E-03	
Cs-134	3.62E+00	6.30E+00	1.16E+01	1.56E+01	1.85E+01	2.07E+01	2.23E+01	2
Cs-136	1.48E+00	2.57E+00	4.73E+00	6.35E+00	7.53E+00	8.41E+00	9.09E+00	9
Cs-137*	2.50E+00	4.36E+00	8.05E+00	1.08E+01	1.28E+01	1.43E+01	1.54E+01	1
Cs-138	0.00E+00	1.73E+01	3.76E+01	5.65E+01	6.04E+01	5.41E+01	4.37E+01	3
I-131	2.65E+01	4.60E+01	1.05E+02	1.49E+02	1.81E+02	2.05E+02	2.23E+02	2
I-132	3.84E+01	6.49E+01	1.49E+02	2.07E+02	2.49E+02	2.81E+02	3.05E+02	2
I-133	5.37E+01	9.27E+01	2.11E+02	2.95E+02	3.57E+02	4.01E+02	4.32E+02	4
I-134	5.92E+01	8.46E+01	1.58E+02	1.85E+02	1.85E+02	1.72E+02	1.53E+02	1
I-135	5.13E+01	8.70E+01	1.94E+02	2.67E+02	3.18E+02	3.50E+02	3.71E+02	3
Kr-83m	4.08E+00	7.43E+00	3.14E+01	5.10E+01	6.69E+01	7.94E+01	8.91E+01	8
Kr-85	2.89E-01	5.78E-01	2.69E+00	4.81E+00	6.91E+00	9.00E+00	1.12E+01	
85m	8.25E+00	1.58E+01	7.11E+01	1.22E+02	1.69E+02	2.12E+02	2.52E+02	



Atmospheric Source Term is Moved using ATD Models

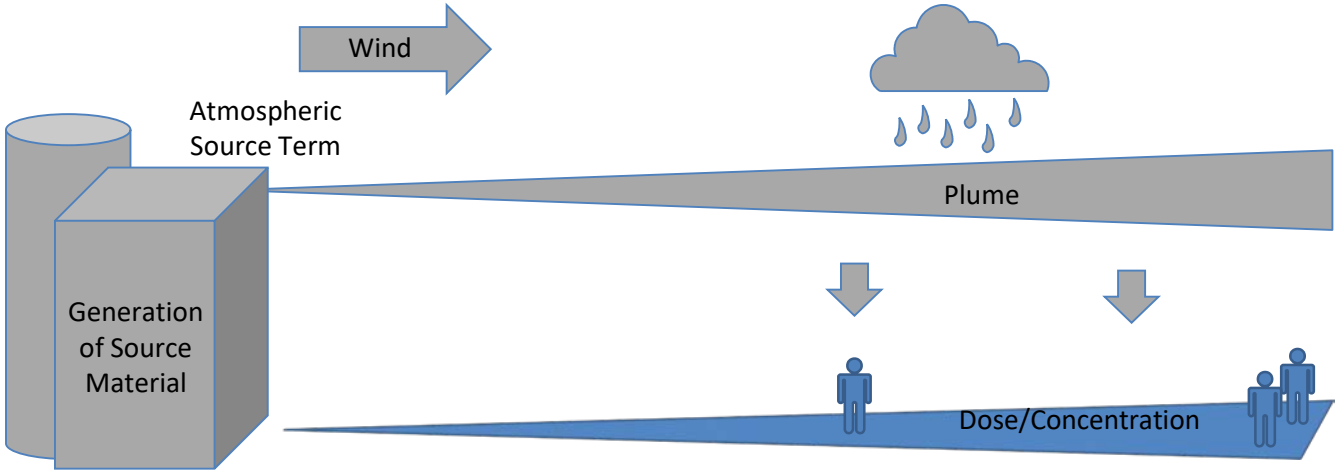
Atmospheric Transport and Dispersion Models

- **Transport material based on weather conditions**
- **Track material to where it falls/washes on ground**
- **Accounts for dry/wet processes and particle size**

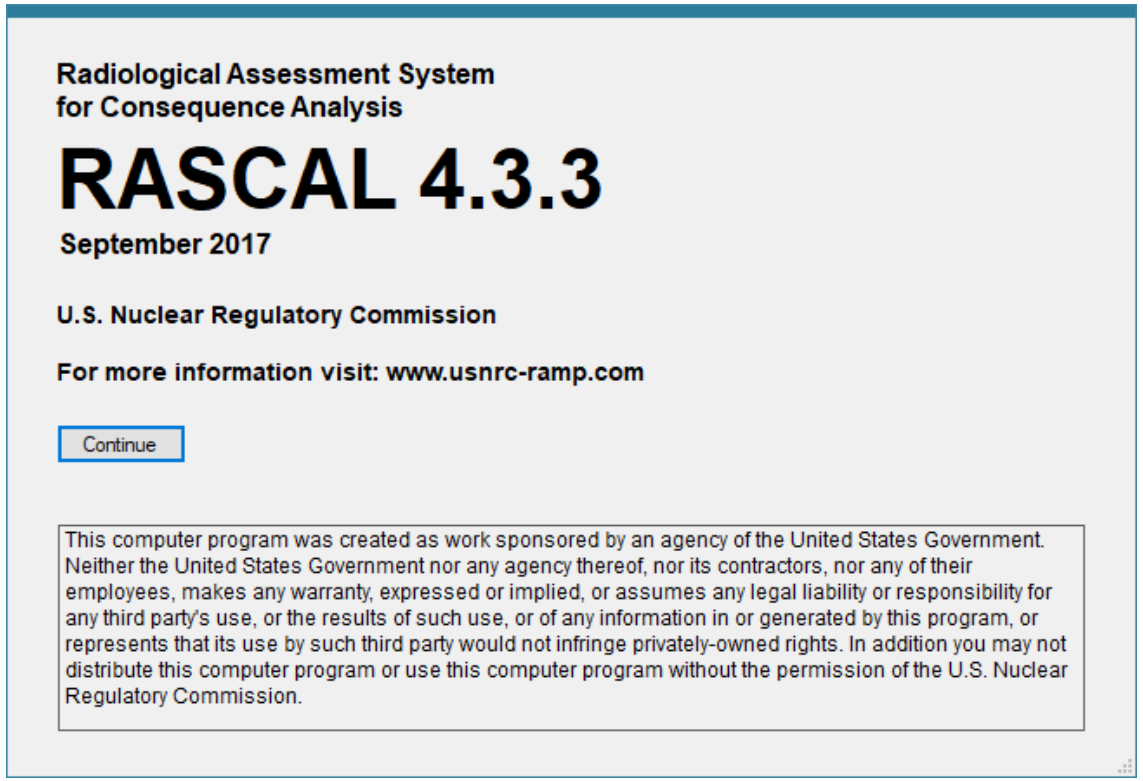


Final Calculations Provide Doses and Concentrations over Calculation Area

- Dose calculation accounts for multiple pathways
  - External (Groundshine + cloudshine)
  - Internal (Inhalation + ~~ingestion)~~
- Results includes other display/calculation options

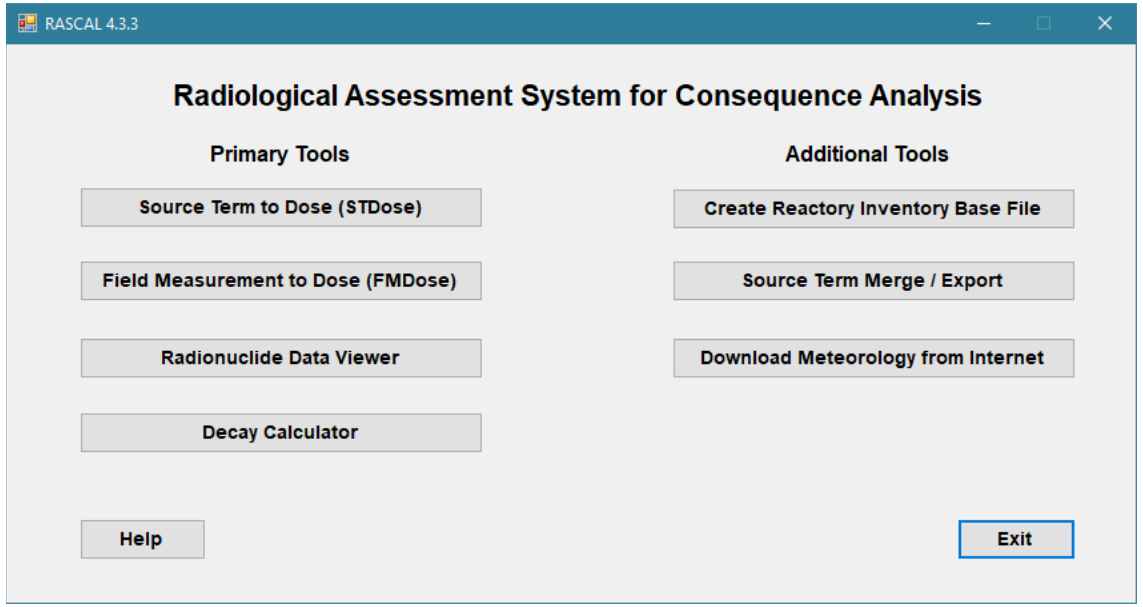


WALKTHROUGH



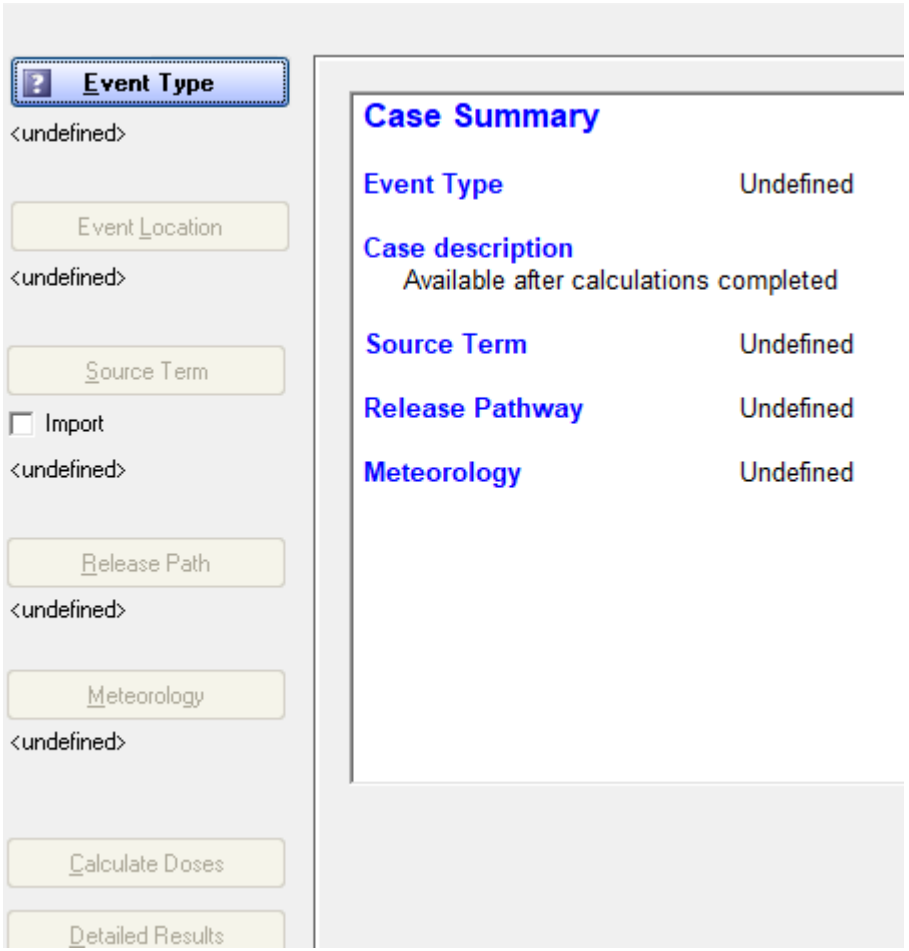
- Let's step through a RASCAL run together
  - No need for you to click along with us
  - After each few discussion slides, we'll give you an opportunity to click through RASCAL (with the blue RASCAL slide)
- We'll start by opening RASCAL

SELECT STDOSE



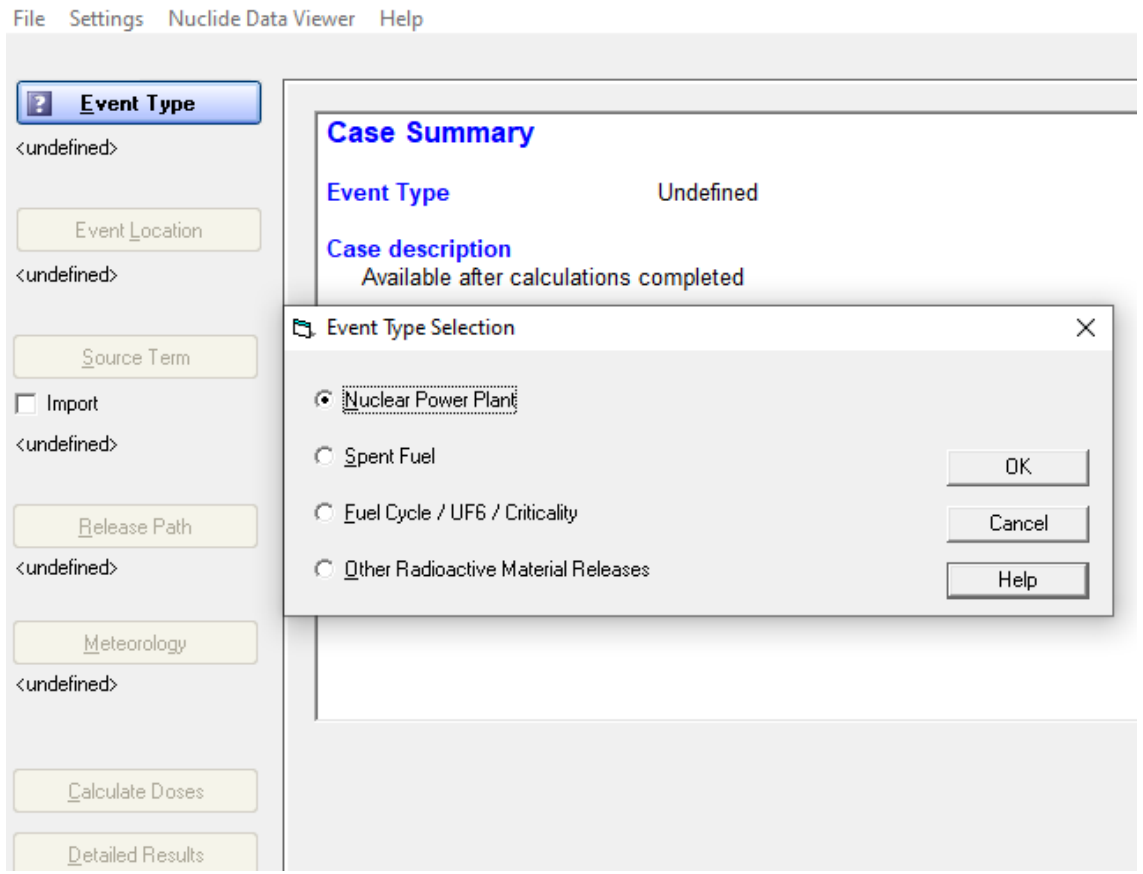
Most of what you will be using RASCAL for (dose assessment) will be done with Source Term to Dose (STDose).

USING STDOSE



- Input information on the buttons on left, from top to bottom
  - Meteorology can be input once a location is selected
- Translate available data into RASCAL inputs
  - Some data is “static”; enter once
  - Some data is “dynamic” and changes with time as more communications is established and as conditions evolve

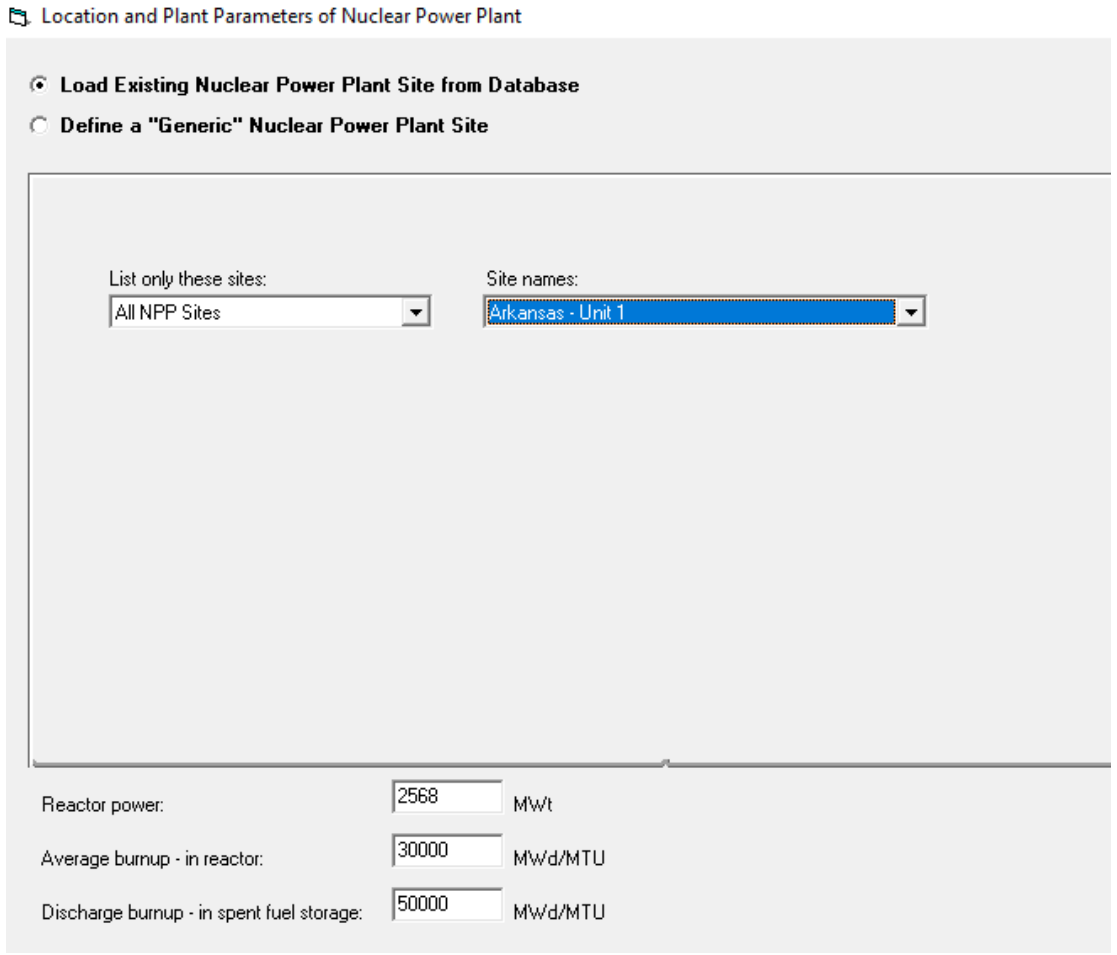
START BY CLICKING EVENT TYPE



RASCAL breaks up locations and models into 4 types:

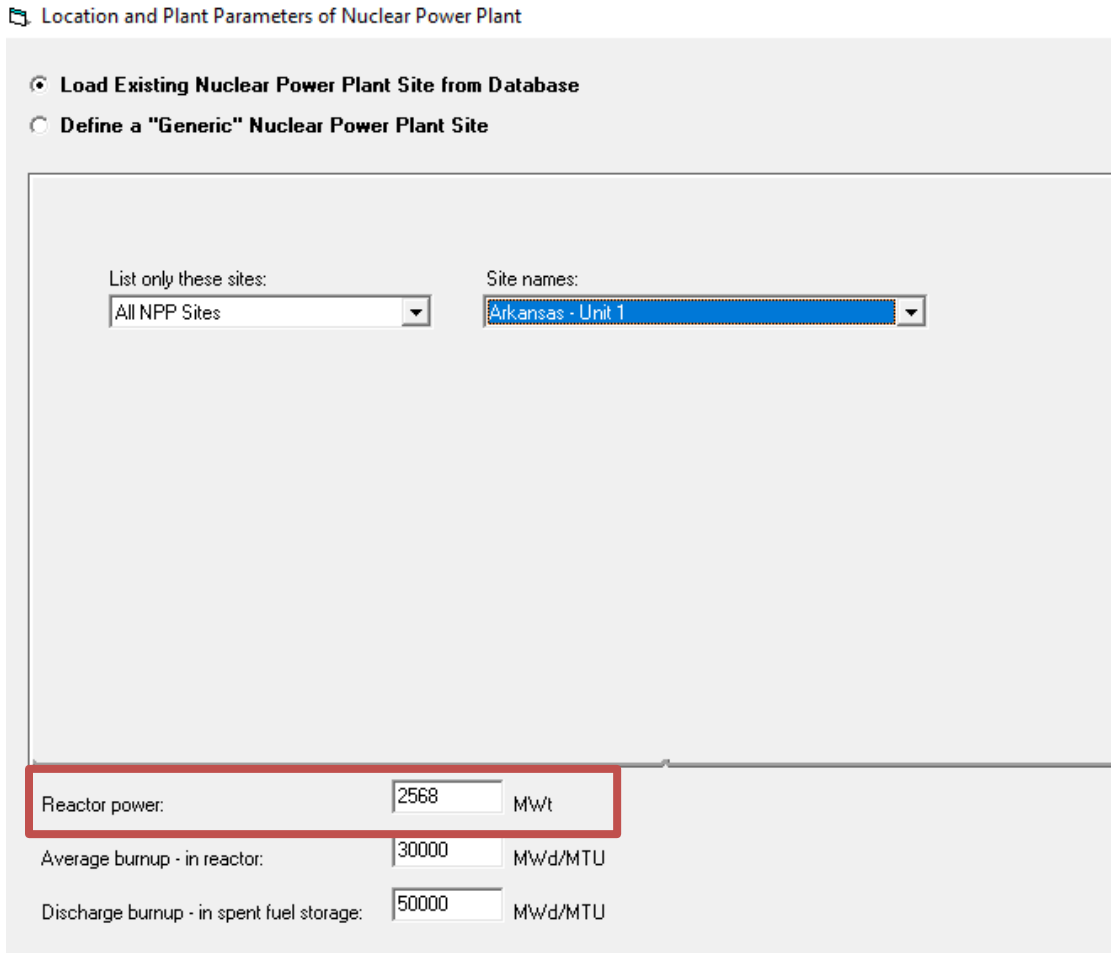
- NPP
- Spent Fuel
- Fuel Cycle
- Other/Materials

Next, Click Event Location



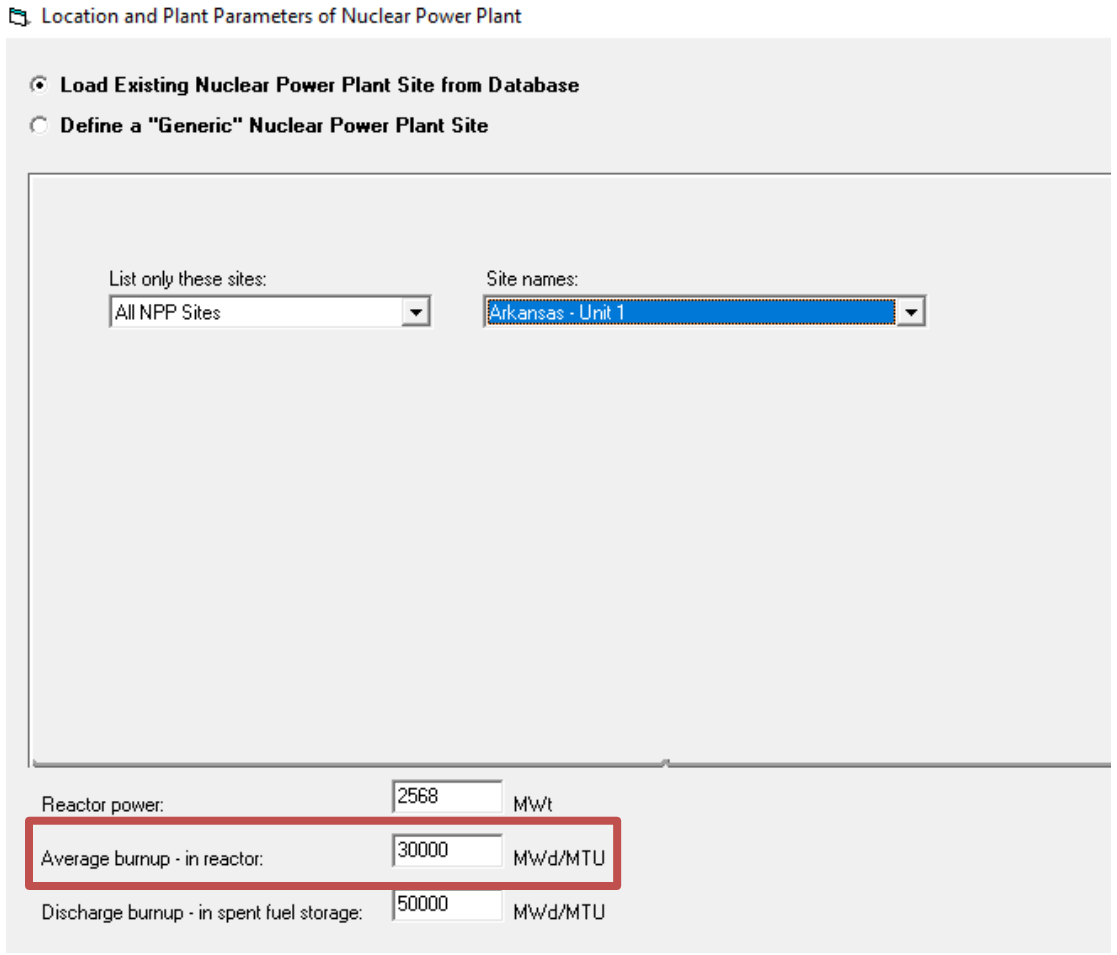
- Select from a list of predefined sites
  - All U.S. facilities (NPPs, Fuel Cycle, Materials)
  - International NPPs including: Mexico, South Africa, Taiwan, and UAE
- Or, define a custom site
  - Need Latitude/Longitude coordinates
  - Does not build in roughness or topography

At the Bottom of Location, Check Reactor Power



- Units of megawatts thermal (MWt) and is a direct measure of the energy produced by fission. This number is used by the model to determine the fission product inventory in the core.
- The facility database contains the power level at which the reactor is allowed to operate.
- Since reactors generally try to operate at 100% power, this value should rarely be changed.

Also Check Burnup



- Fuel burnup has units of megawatt-days per metric ton of uranium (MWd/MTU) and is a measure of how much fission energy has been produced by the fuel elements that are currently in the core.
- RASCAL uses burnup to adjust core inventory for long-lived radionuclides in the core fuel. A mid-life core value is used as default instead of site-specific values
- If you have a burnup value – use it, otherwise the default is OK.

Your Turn to Use RASCAL

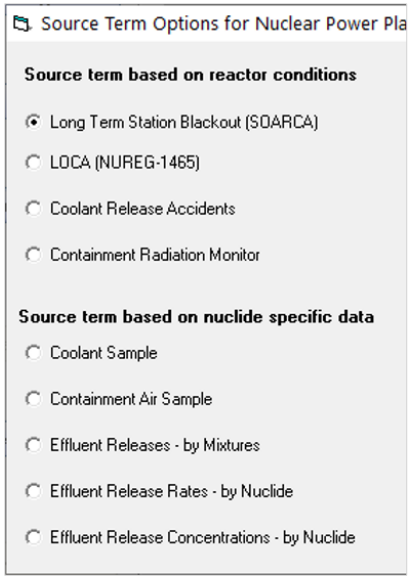
- Start the RASCAL program & select STDose
- Click Event Type
  - Select Nuclear Power Plant
  - Click OK
- Click Event Location
  - Select Beaver Valley, Unit 1
  - Click OK

- Answer the Zoom Poll that pops up shortly

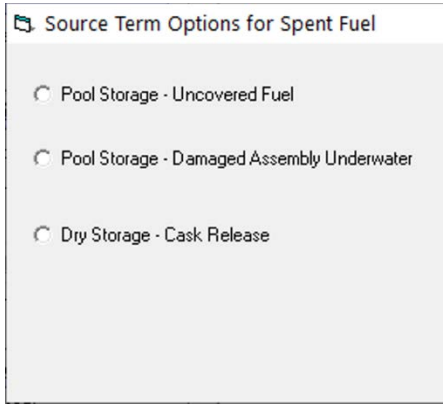
Source Term

- Source term models calculate material that can be released
- Pick the best model; may have multiple options
- Available choices depend on Event Type

Nuclear Power Plant

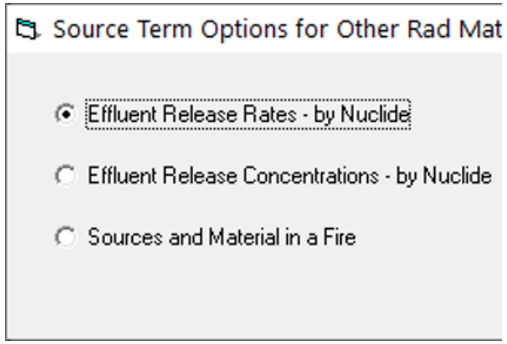


Spent Fuel



Fuel Cycle

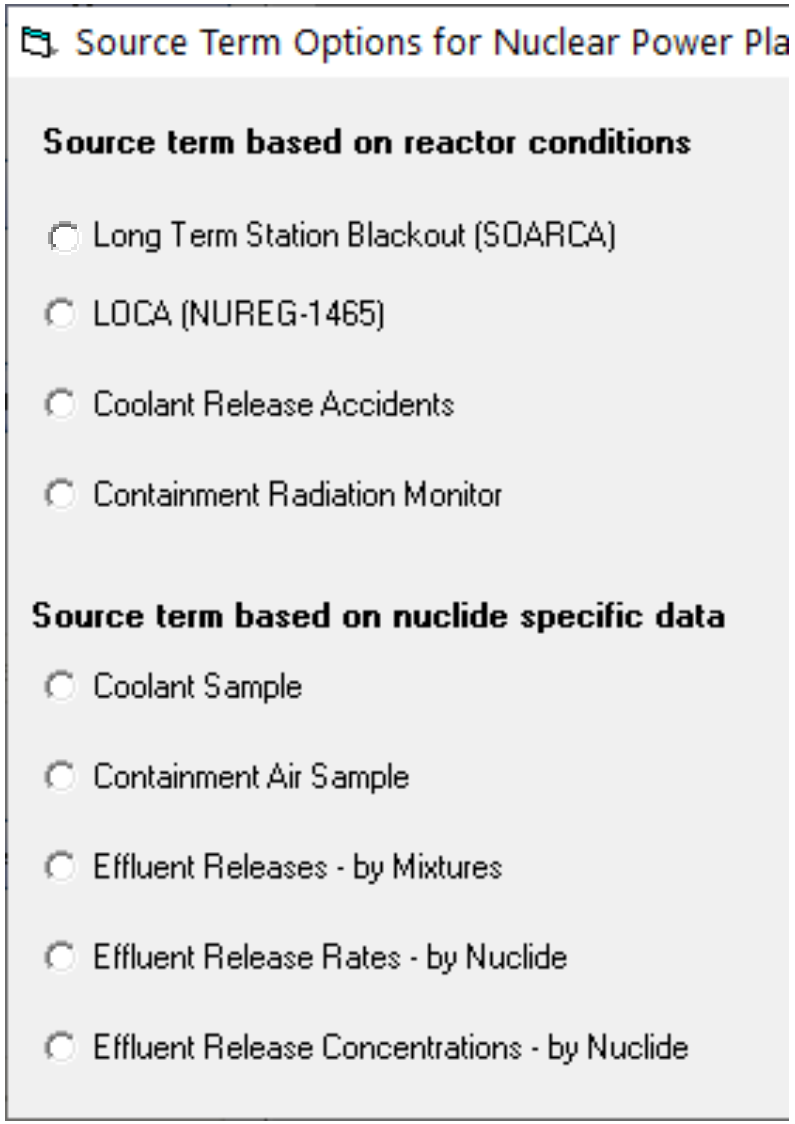
Other Materials



Event Type

Source Term

NUCLEAR POWER PLANT



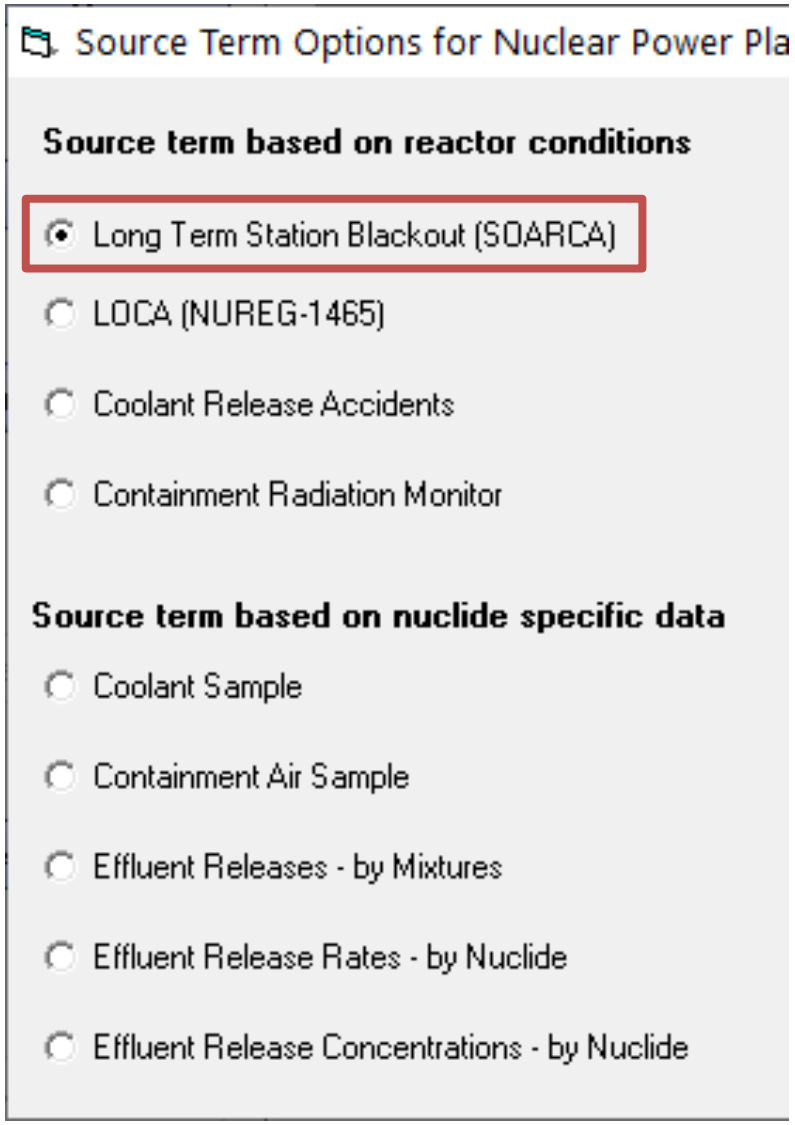
RASCAL has 9 nuclear power plant source term options:

- 4 based on reactor condition models
- 5 based on nuclide measurements

Event Type

NUCLEAR POWER PLANT

Source Term



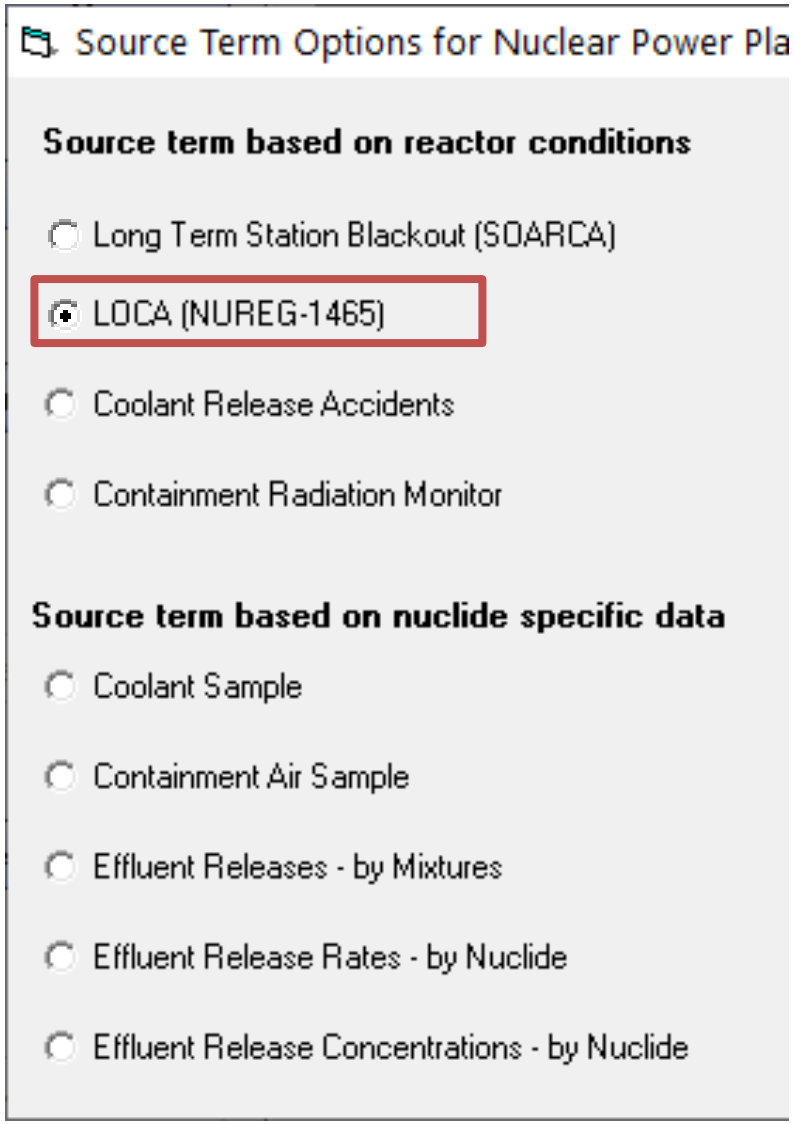
Long Term Station Blackout

- Without onsite & offsite AC power and other cooling methods, could lead to core melt
- User inputs event timing

Event Type

NUCLEAR POWER PLANT

Source Term



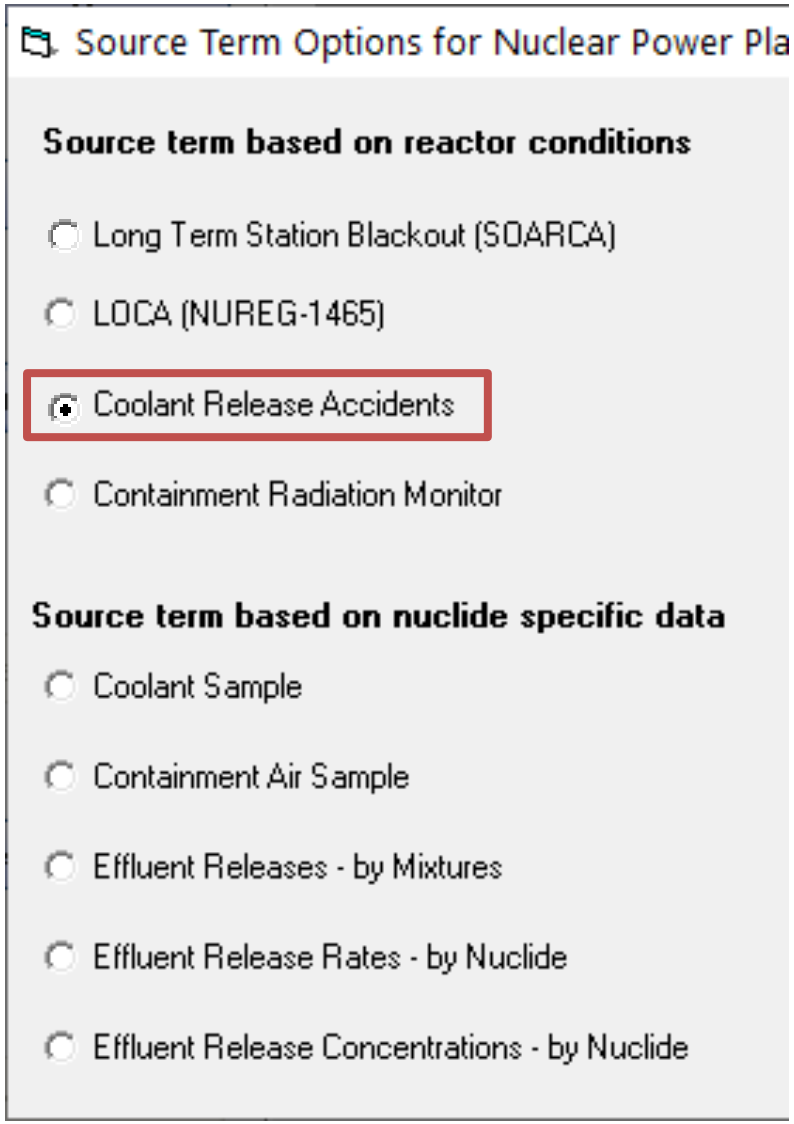
Loss of Coolant Accident (LOCA)

- Loss of reactor coolant, leads to core uncovery and fuel melt
- User inputs event timing

Event Type

NUCLEAR POWER PLANT

Source Term



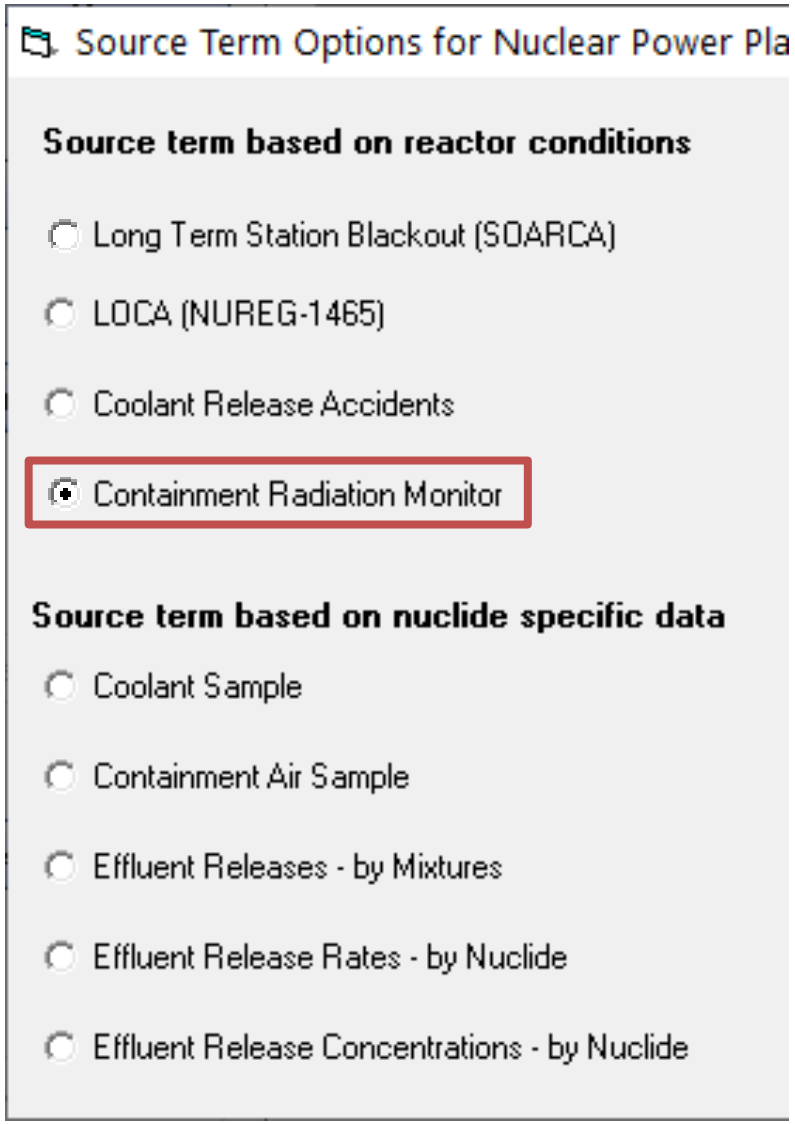
Coolant Release Accident

- Loss of reactor coolant where only coolant is released, no core melt expected
- Very small releases

Event Type

NUCLEAR POWER PLANT

Source Term



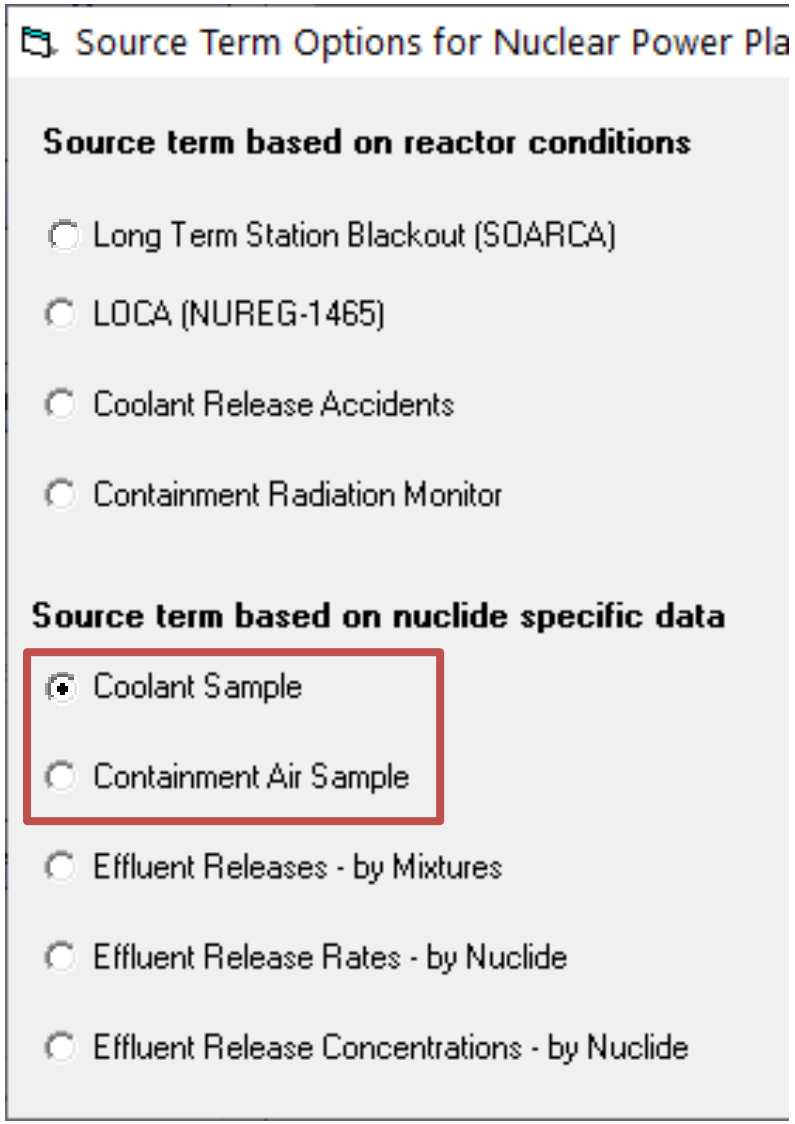
Containment Radiation Monitor

- Estimates core damage based on containment rad monitor

Event Type

Source Term

NUCLEAR POWER PLANT



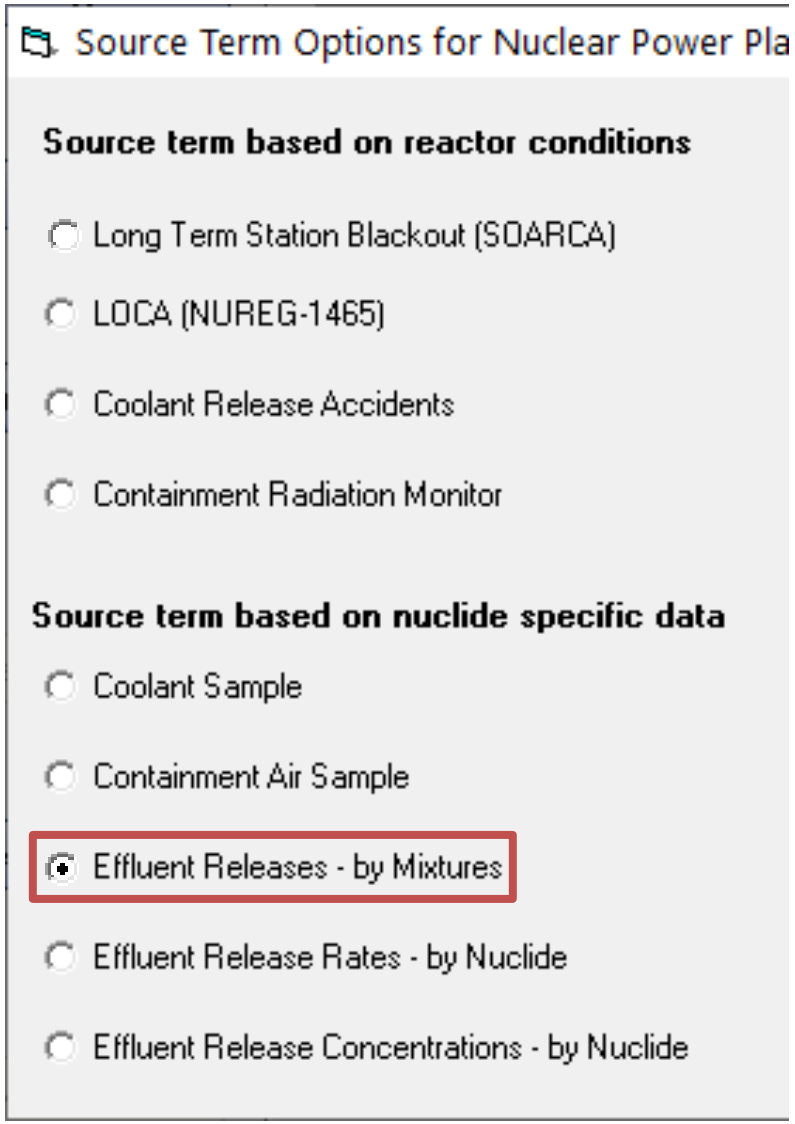
Coolant or Containment Air Sample

- User inputs entire source term by nuclide
- RASCAL does not extrapolate source term from subset of nuclides
- Not expected to have data during event

Event Type

NUCLEAR POWER PLANT

Source Term



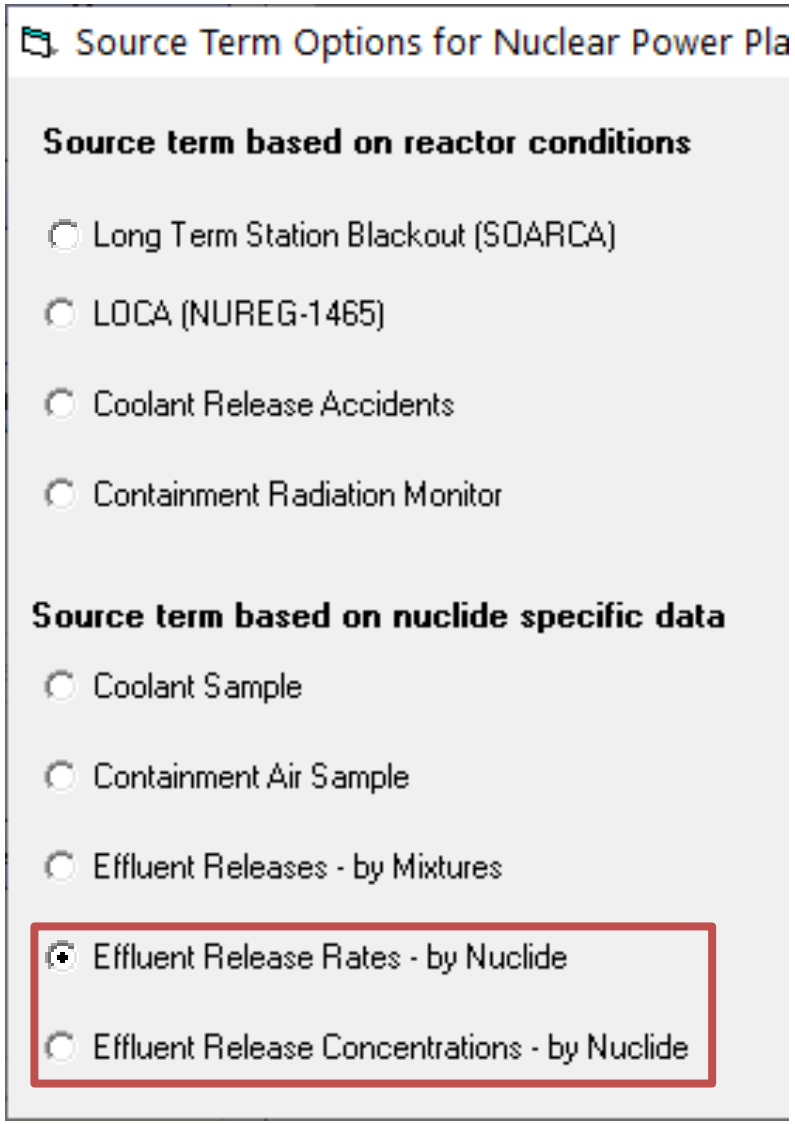
Effluent Releases - Mixtures

- User inputs activity rates of:
  - Noble Gas
  - Iodines
  - Particulates
- RASCAL fractionates by nuclide based on core inventory
- Often based on utility conversion or calculation

Event Type

NUCLEAR POWER PLANT

Source Term



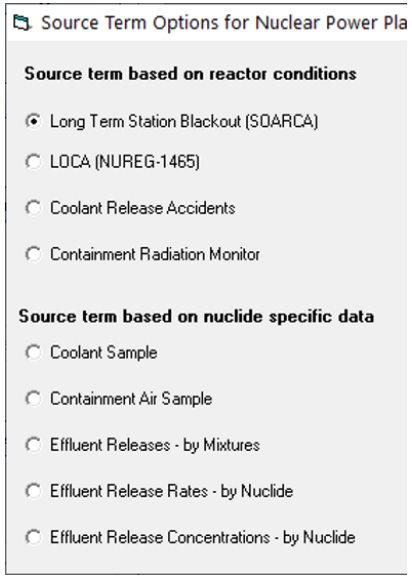
Effluent Release Rates/Concentration

- User inputs entire atmospheric source term by nuclide
- RASCAL does not extrapolate source term from subset of nuclides
- Can be used to manually define source term, including small/custom releases

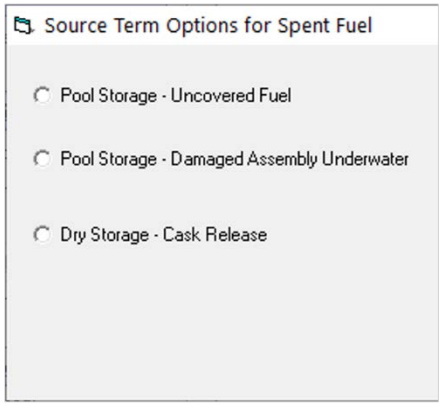
Source Term

- Source term models calculate material that can be released
- Pick the best model; may have multiple options
- Available choices depend on Event Type

Nuclear Power Plant

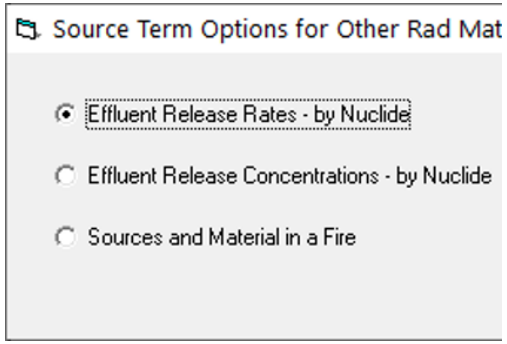


Spent Fuel



Fuel Cycle

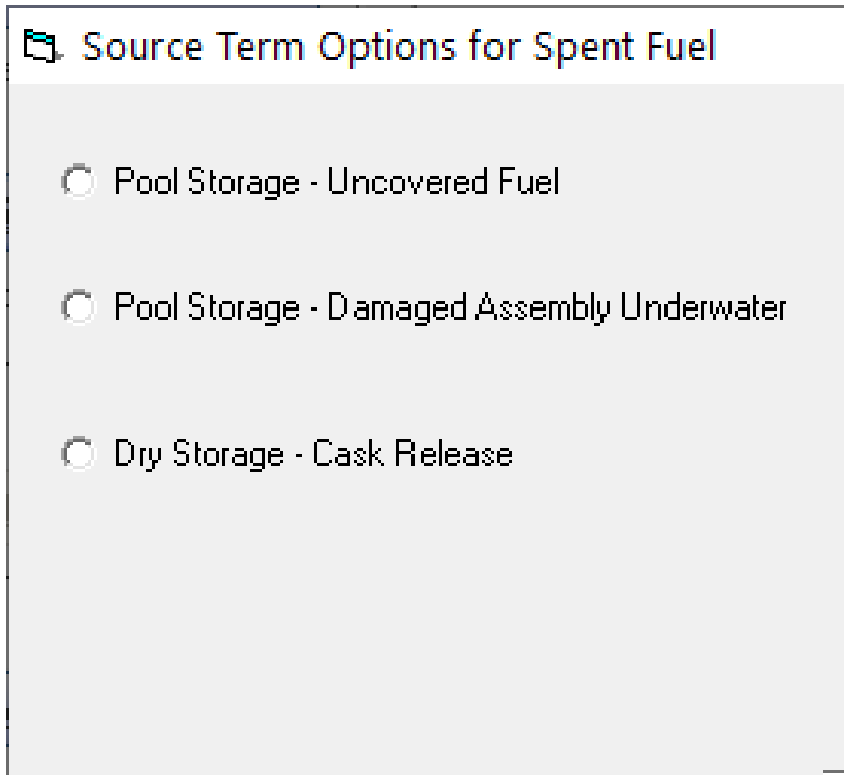
Other Materials



Event Type

SPENT FUEL

Source Term



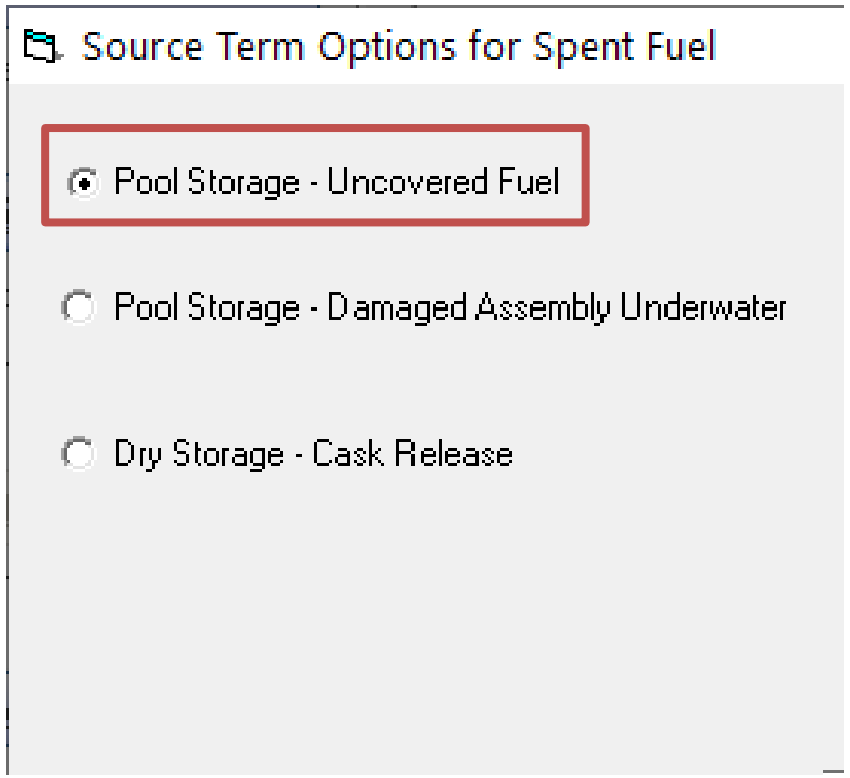
For Spent Fuel, RASCAL has 3 source term options

- Includes both pool and dry storage
- Sites are collocated with NPPs

Event Type

SPENT FUEL

Source Term



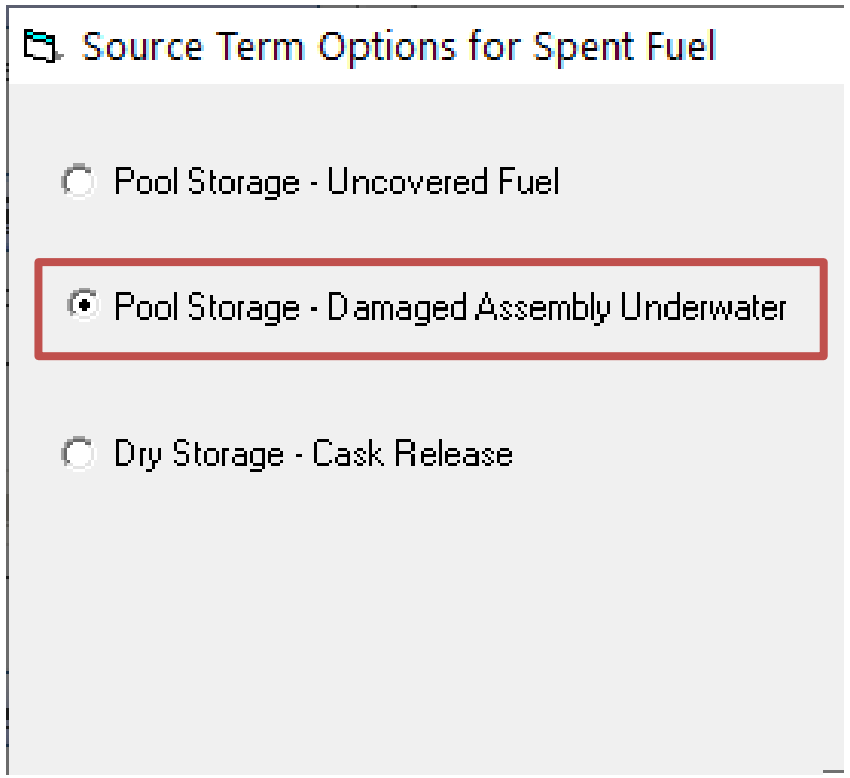
Pool - Uncovered Fuel

- Models clad/zirconium fire whether possible or not
- User inputs fuel pool inventory and fire start/end times

Event Type

SPENT FUEL

Source Term



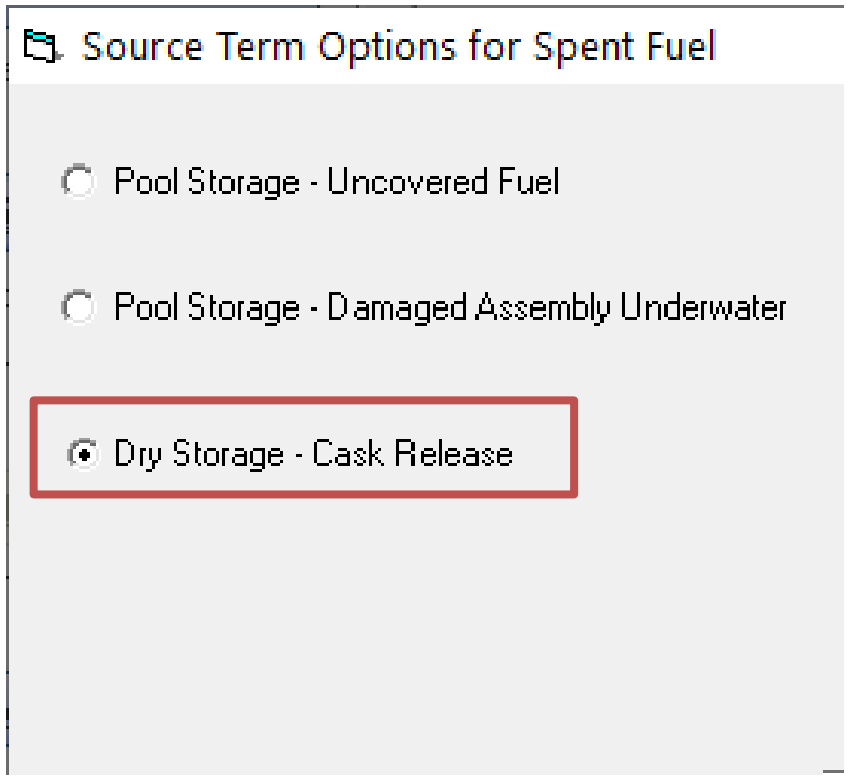
Pool - Damaged Underwater

- For fuel handling accidents
- Very small releases
- User inputs amount of fuel damaged

Event Type

SPENT FUEL

Source Term



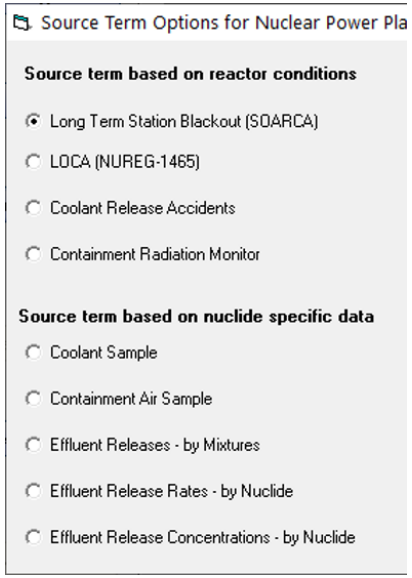
Dry - Cask Release

- 4 damage options
- Small to zero release
- User defines inventory of fuel and damage type

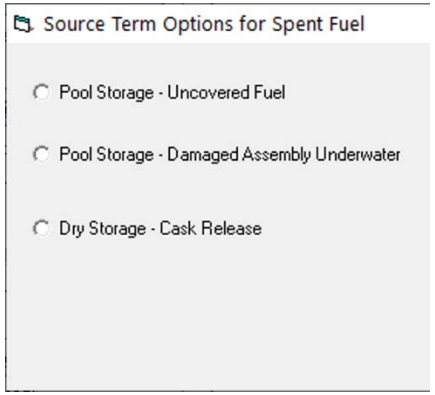
Source Term

- Source term models calculate material that can be released
- Pick the best model; may have multiple options
- Available choices depend on Event Type

Nuclear Power Plant

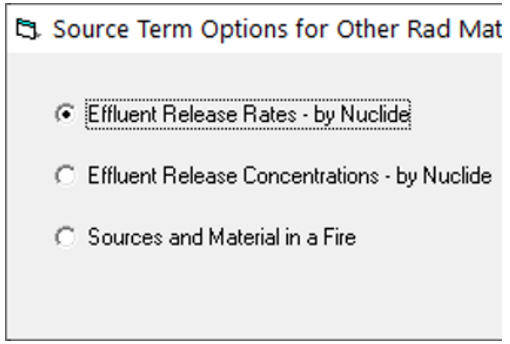


Spent Fuel



Fuel Cycle

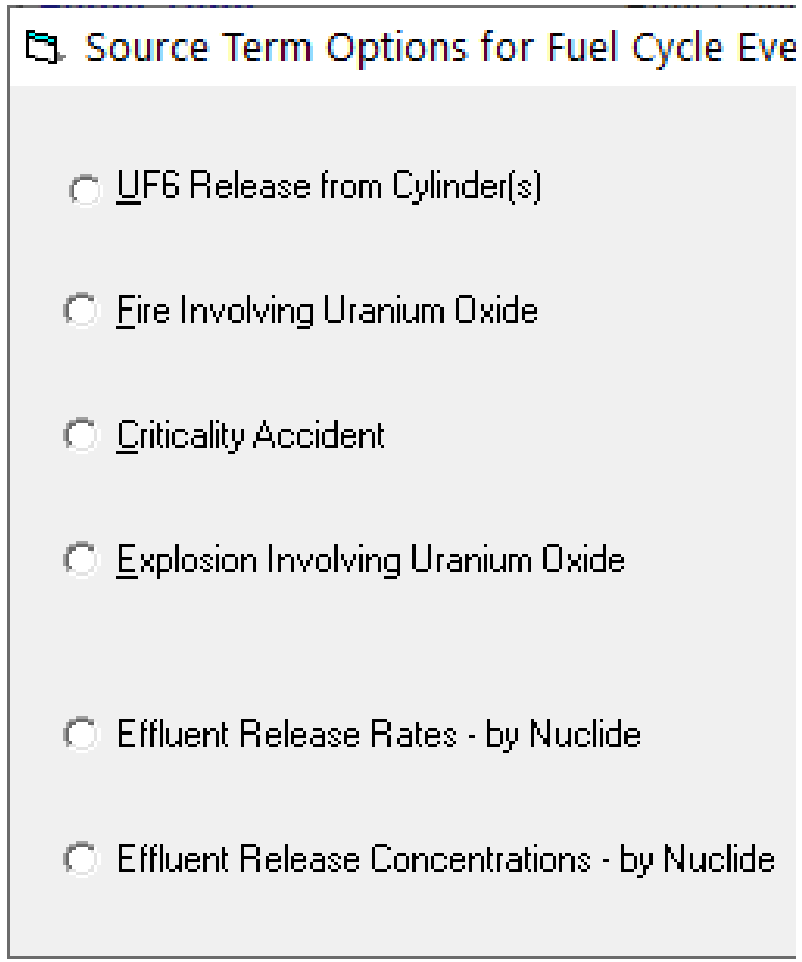
Other Materials



Event Type

FUEL CYCLE

Source Term

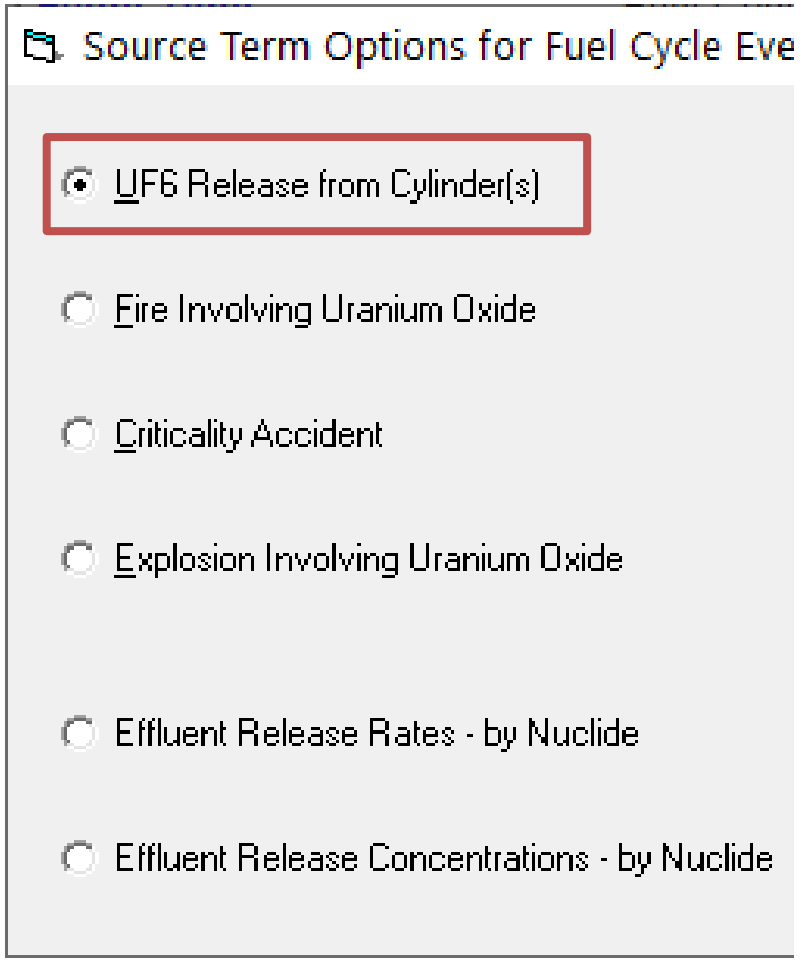


- RASCAL can model certain events from fuel fabrication facilities

Event Type

FUEL CYCLE

Source Term



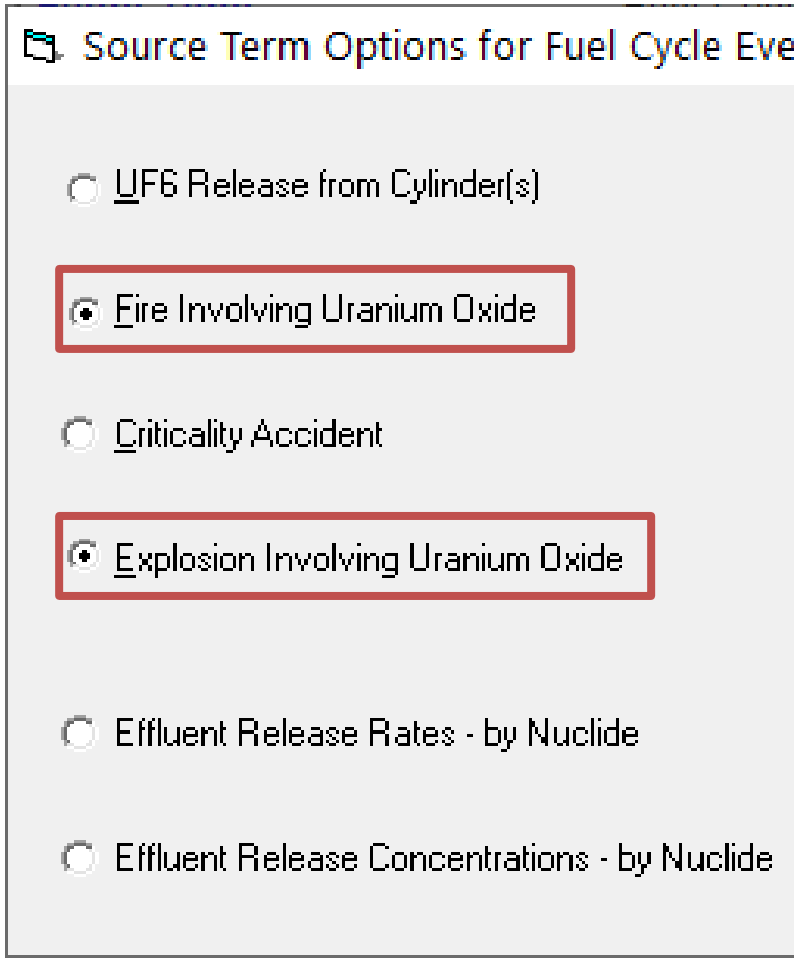
UF6 Release from Cylinder

- Gaseous UF6 released
- Special plume model with chemical conversion process
- More chemically dangerous than radiological

Event Type

FUEL CYCLE

Source Term



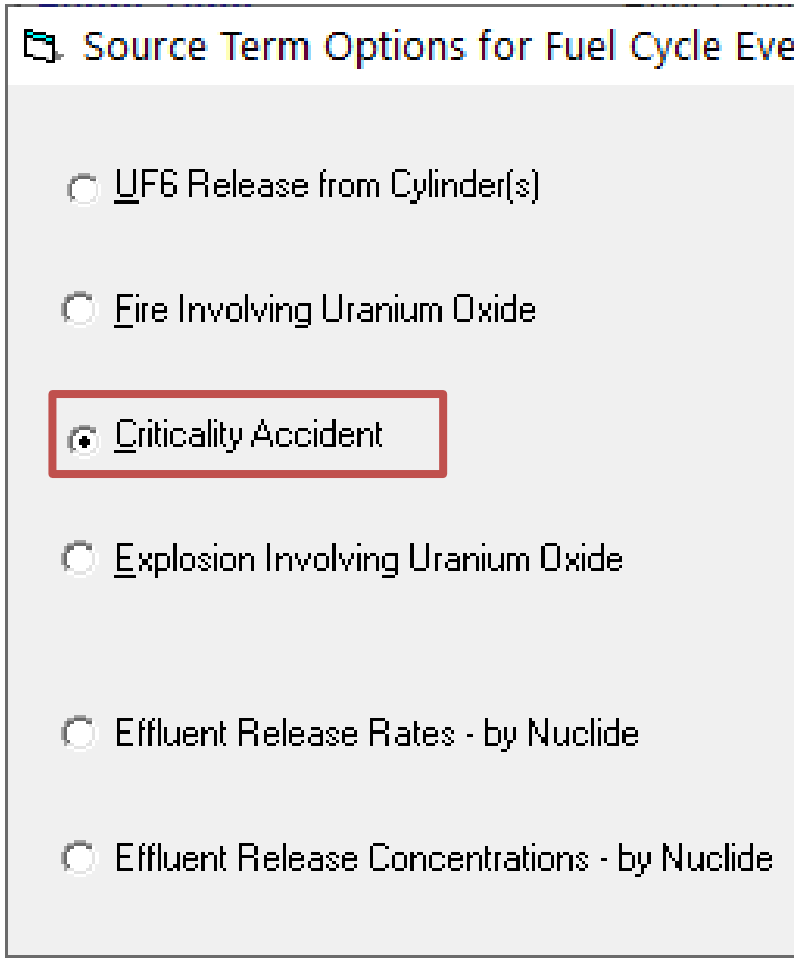
Fire or Explosion involving Uranium Oxide

- Small amounts of material put into atmosphere from event
- User inputs material at risk and release fractions / rates

Event Type

FUEL CYCLE

Source Term



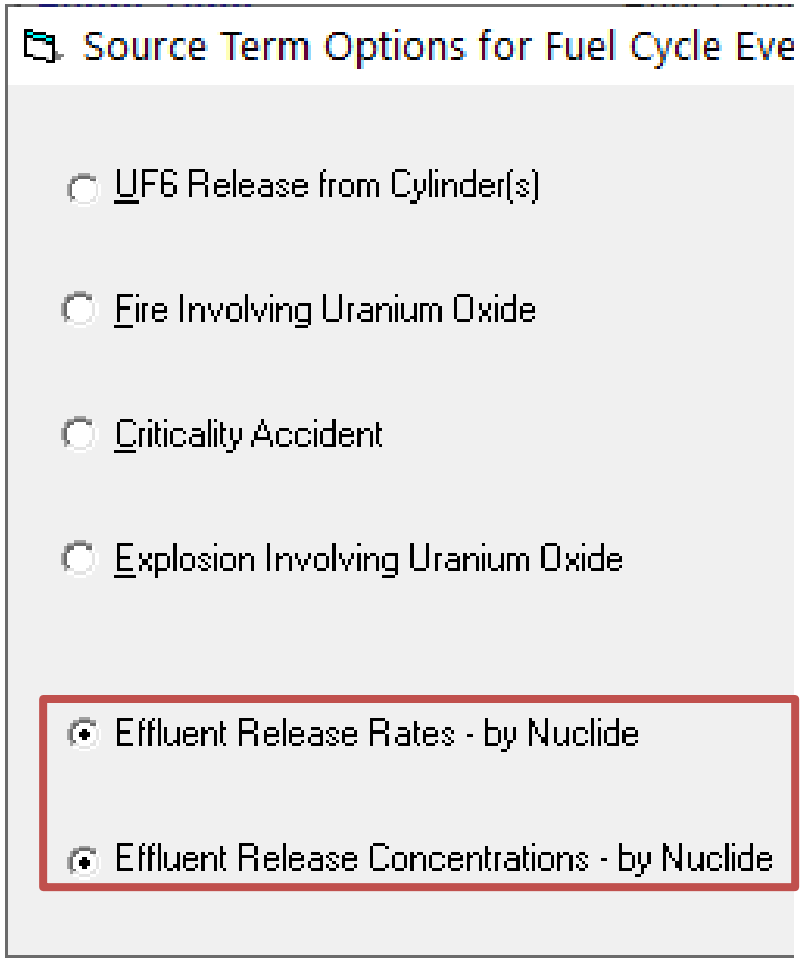
Criticality

- Mainly focused on direct shine from criticality event
  - Very small amount of activated material put into atmosphere

Event Type

FUEL CYCLE

Source Term



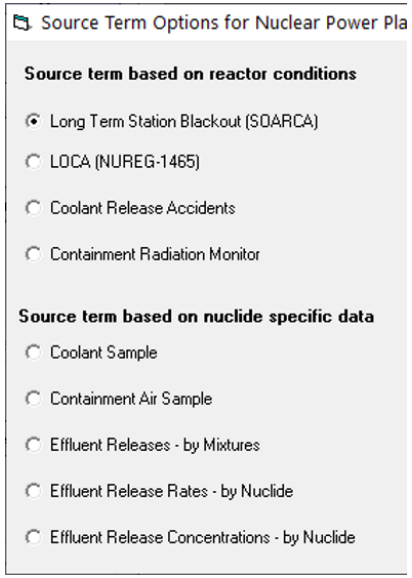
Effluent Release Rates/Concentration

- User inputs entire atmospheric source term by nuclide
- RASCAL does not extrapolate source term from subset of nuclides
- Can be used to manually define source term, including small/custom releases

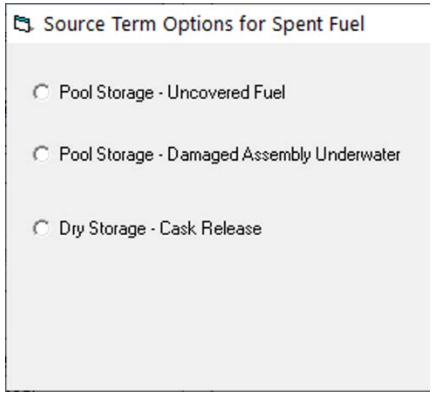
Source Term

- Source term models calculate material that can be released
- Pick the best model; may have multiple options
- Available choices depend on Event Type

Nuclear Power Plant

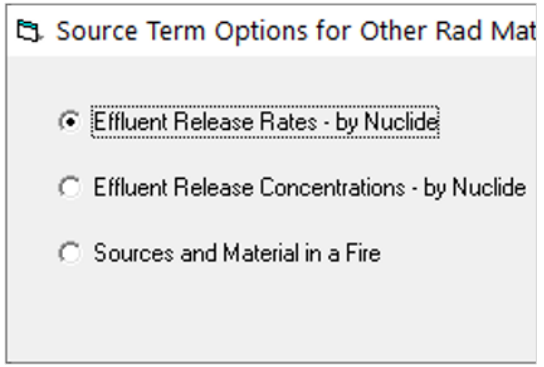


Spent Fuel

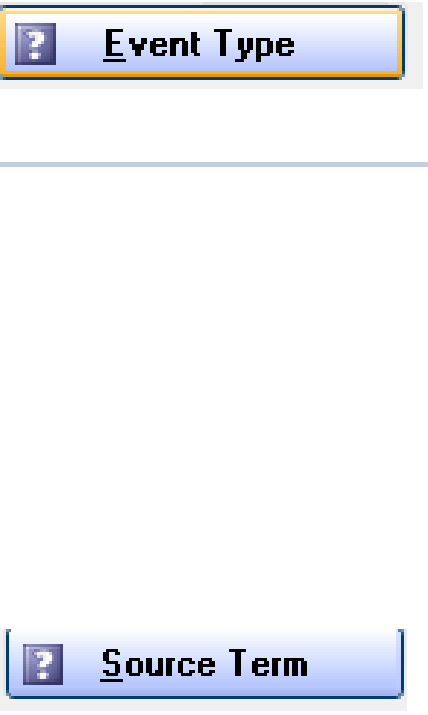


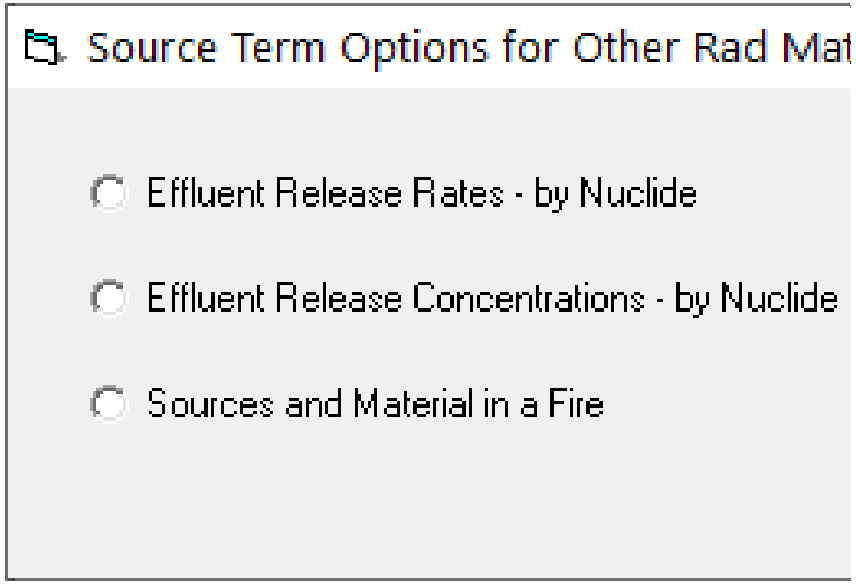
Fuel Cycle

Other Materials



Other Materials Locations



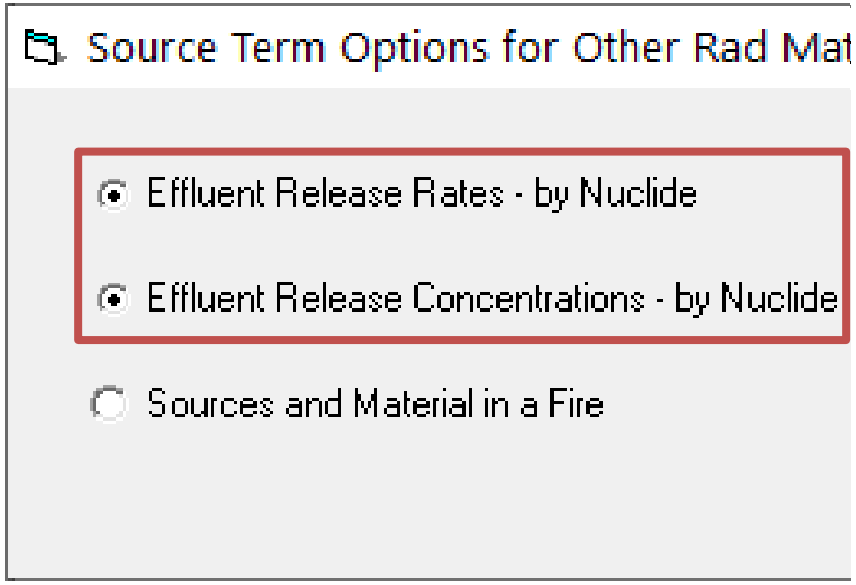


- RASCAL also has 3 “other” materials options
- Useful for modeling transportation accidents, lab accidents, etc.
- All models still focus on atmospheric releases
  - Liquid releases (like spills and leaks) are not modeled in RASCAL

Event Type

Other Materials Locations

Source Term



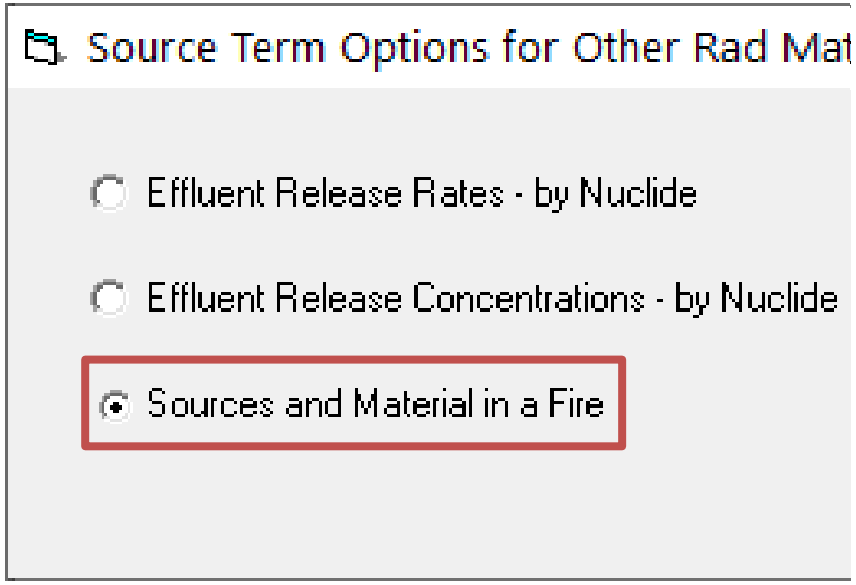
Effluent Release Rates/Concentration

- User inputs entire atmospheric source term by nuclide
- RASCAL does not extrapolate source term from subset of nuclides
- Can be used to manually define source term, including small/custom releases

Event Type

OTHER MATERIALS LOCATIONS

Source Term



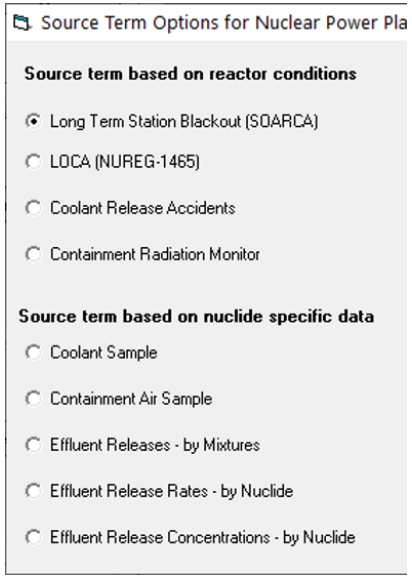
Sources and Material in a Fire

- Small amounts of material put into atmosphere from a fire
- User inputs material at risk and release fractions / rates

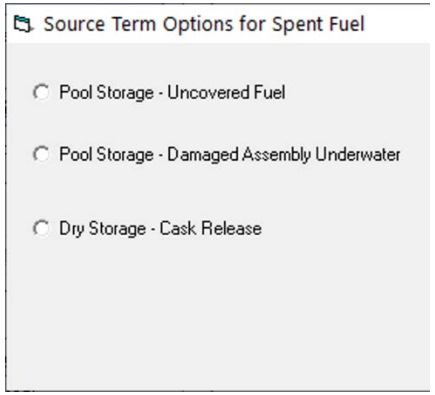
Source Term

- Source term models calculate material that can be released
- Pick the best model; may have multiple options
- Available choices depend on Event Type

Nuclear Power Plant

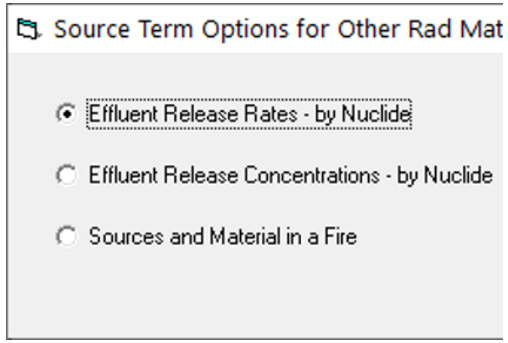


Spent Fuel

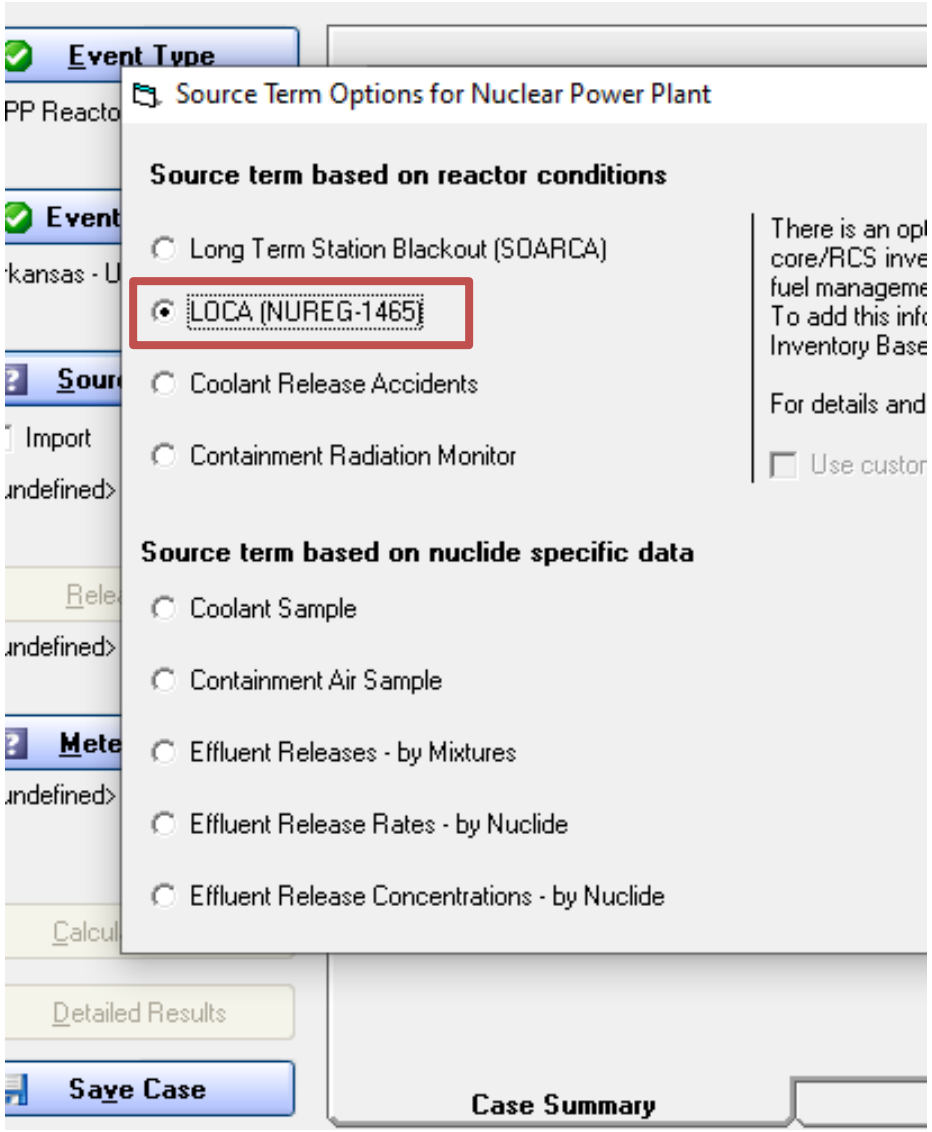


Fuel Cycle

Other Materials

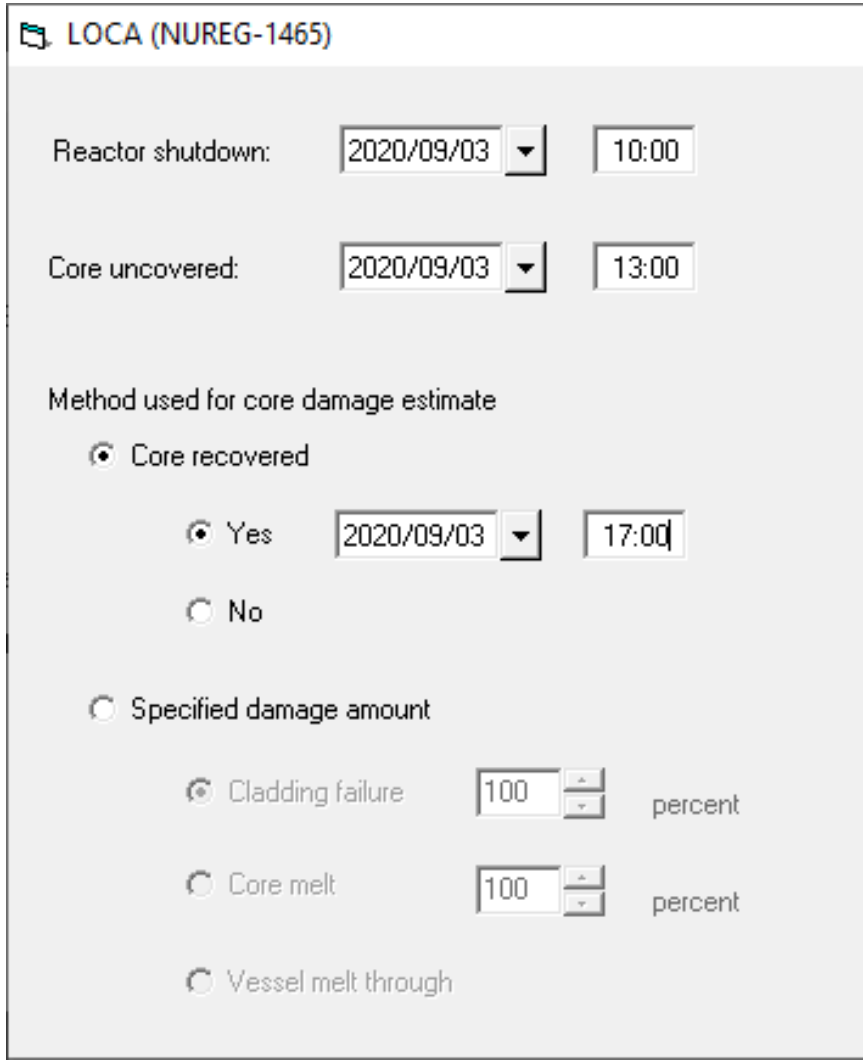


Pick a Source Term



For this scenario, the most appropriate model would be the LOCA model

Enter Source Term Details



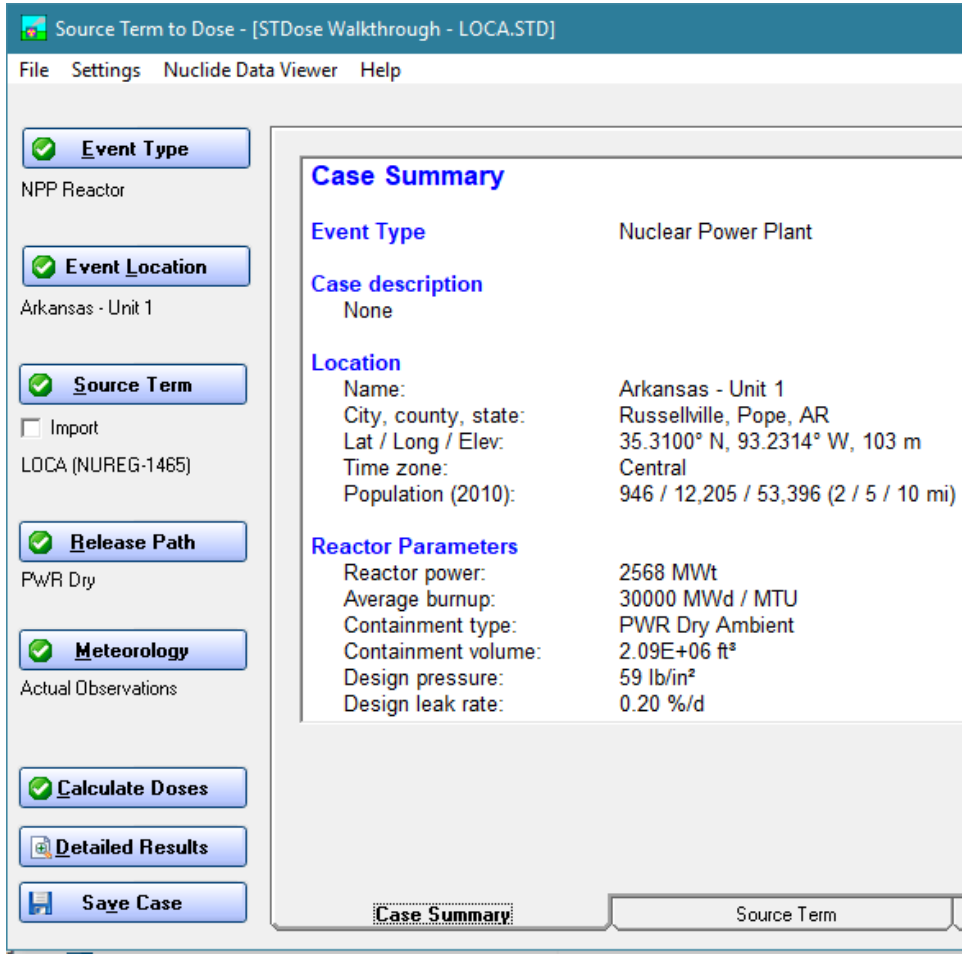
- Each model requires additional details like timing or measurements
- For the LOCA model:
  - Time of reactor shutdown
    - Starts the decay of all nuclides in the core (they're in equilibrium before)
  - Time core was uncovered
    - When NUREG-1465 models start, starting with 30 min of gap activity, then fuel melt
  - Is the core recovered?
    - Additional material stops being generated after the core becomes recovered
- All times entered with 24-hour clock

Your Turn to Use RASCAL

- Click Source Term
- Select Loss of Coolant Accident (LOCA)
  - Click OK
- Input timing sequence numbers
  - Shutdown Time - 0800
  - Time of Core Uncovery – 1030
  - Select Yes for Core Recovered, Time – 1800
  - Click OK

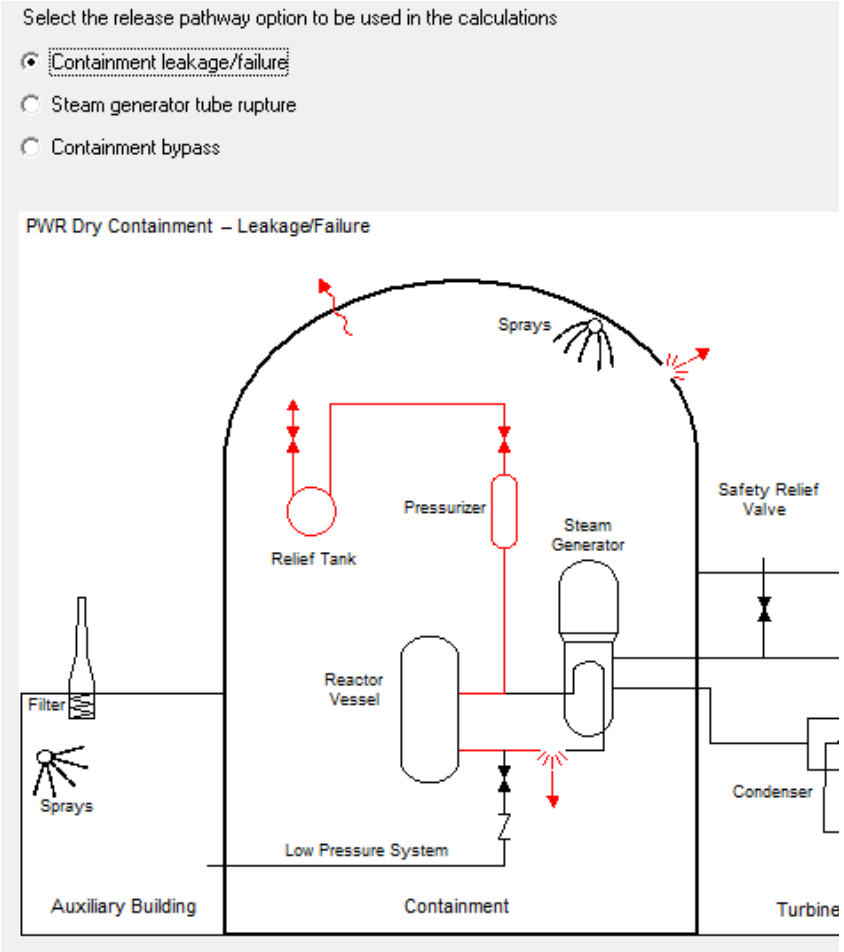
- Answer the Zoom Poll that pops up shortly

As you can see, the Case Summary tab updates as information is added



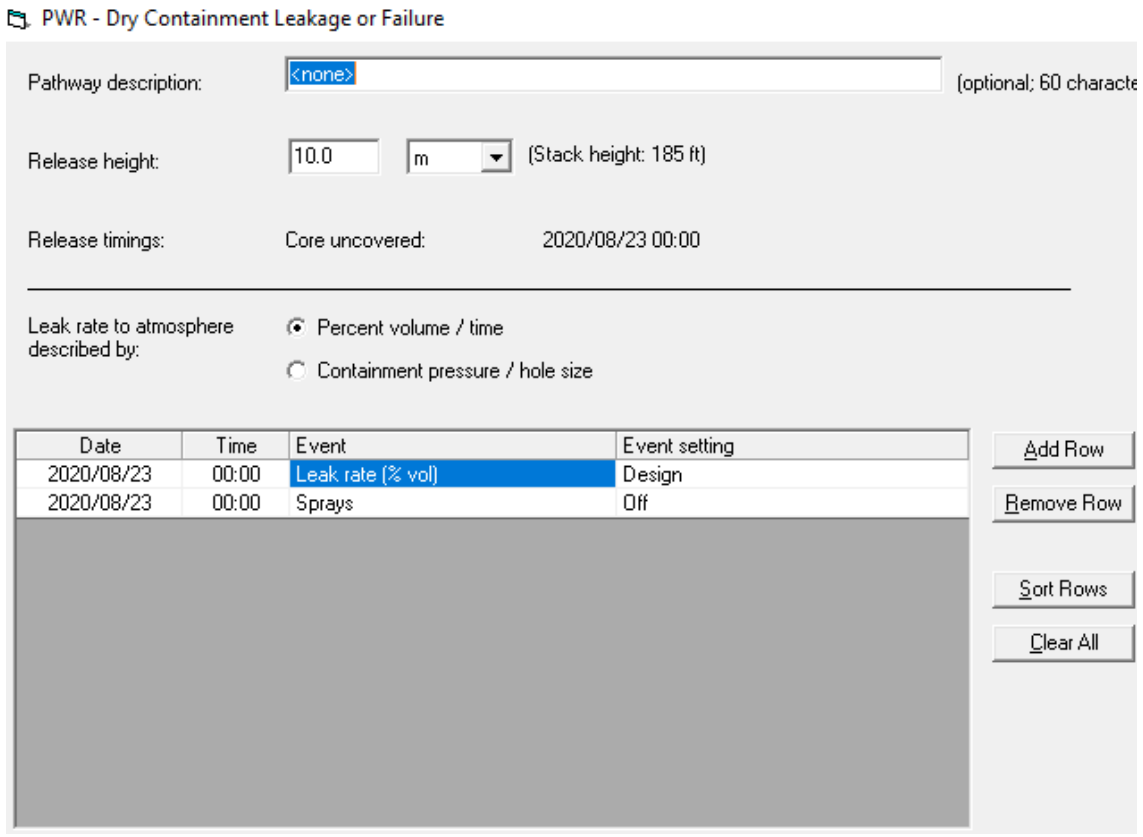
As each step is completed, the input information is added to the case summary displayed.

Now We'll look at Release Pathway



- RASCAL needs information on how generated material is released to the atmosphere
  - Pathway
  - Height
    - Wind speeds change with height
  - Reduction
    - Amount of material reduced by decay, holdup, filter, sprays
  - Timing
    - Release rates, start and stop
- We'll start by selecting the Pathway

For this Release Pathway option, We'll need to input:



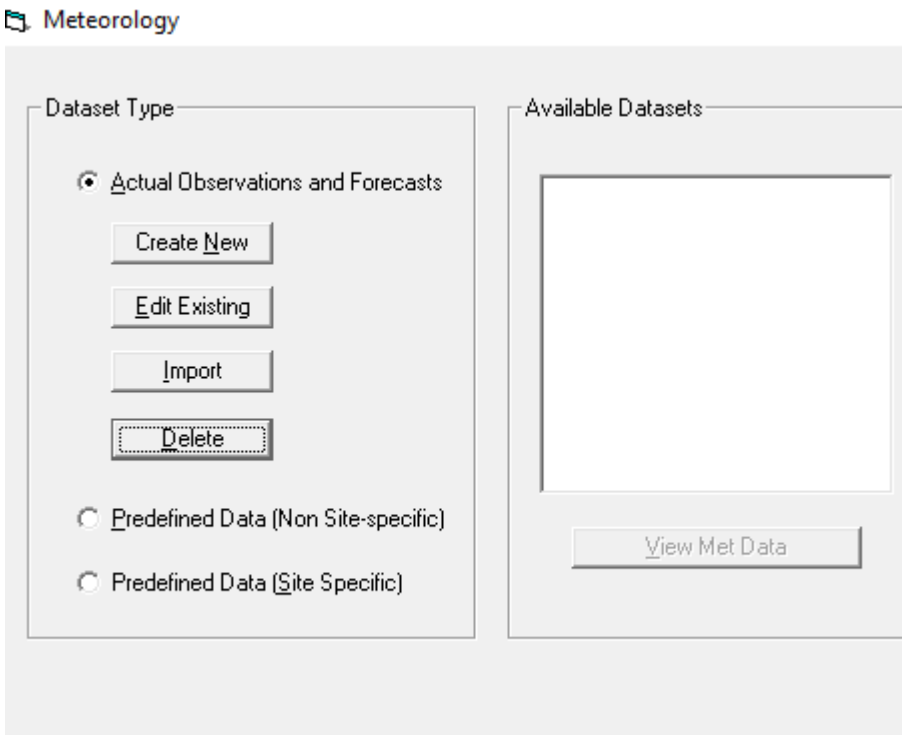
- Release Height
  - 10m is minimum height allowed (ground release)
- Select leak rate type
  - Percent Volume / Time (e.g., 3%/hour)
  - Containment pressure / Hole Size (e.g., 30 psi/2 cm^2)
- Define release timeline
  - Used for leak rate and additional conditions
  - Need to review/set initial conditions, then can add rows as needed

Your Turn to Use RASCAL

- Click Release Path
- Select Containment leakage/failure, Click OK
- Ensure release height is set to 10m
- Change the initial leak rate (at 10:30) to 5% / day
- Keep sprays off
- Add row and enter
  - Time: 18:00 Event Type = Leak rate Setting = 0.0 %/d
- Click OK

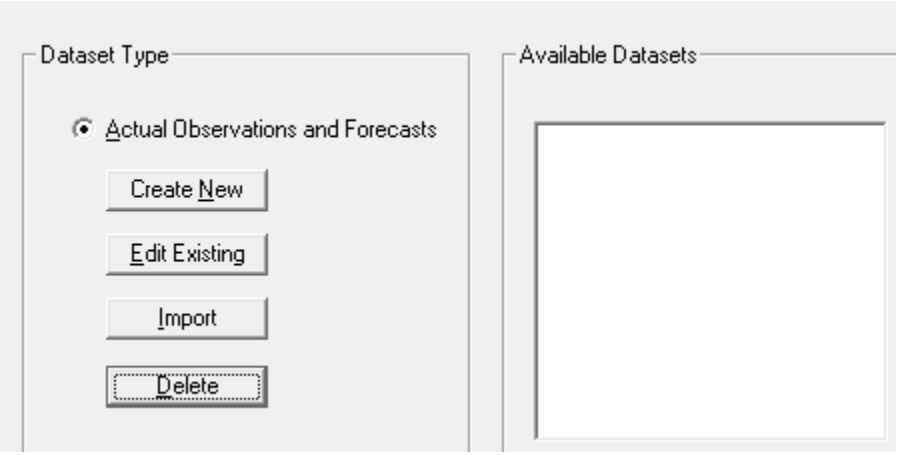
- Answer the Zoom Poll that pops up shortly

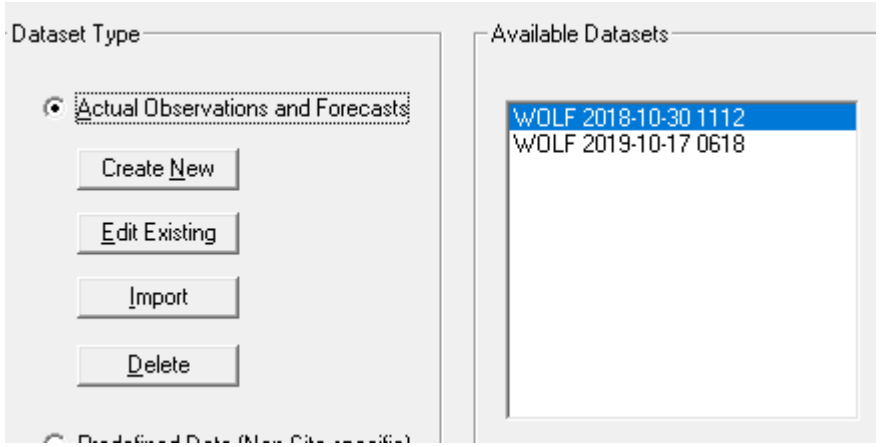
Moving onto Meteorology



- Actual
  - Enter station observations/forecasts
  - Manual entry or internet download
- Pre-defined (non site-specific)
  - Simple static weather conditions
  - Easy/fast if no meteorological data known, but doesn't include topo/roughness
- Predefined (site-specific)
  - Allows custom creation of likely conditions

We'll Mostly Use Actual for Exercises/Events



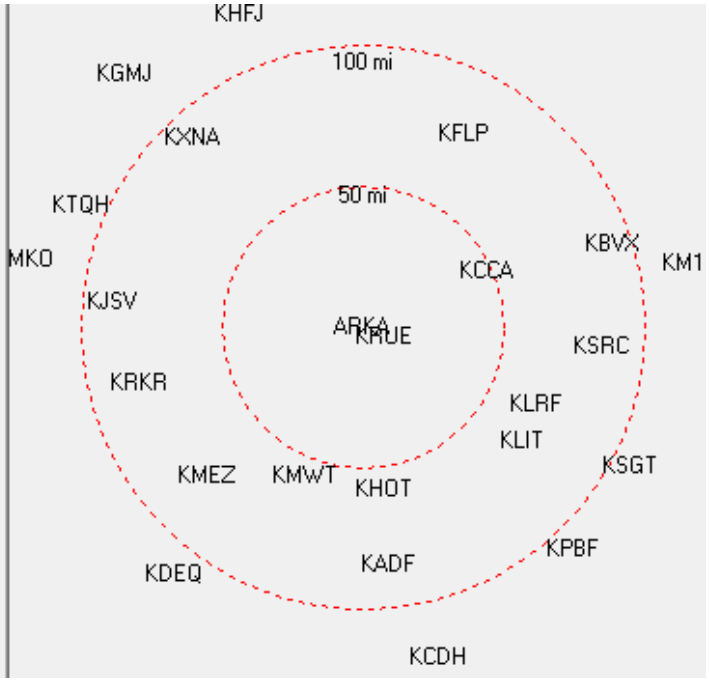


- We won't use pre-defined except in training
- For actual conditions, weather data is managed as site-dependent files
  - Create New / Edit
  - View any previously saved weather files
  - Usable as long as times support scenario

EACH SITE CONTAINS PREDEFINED WEATHER STATIONS

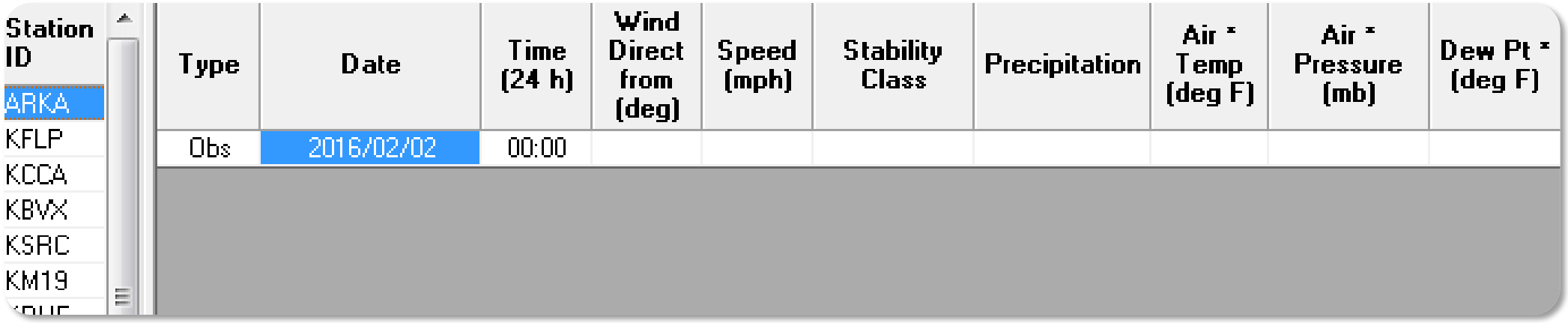
Available meteorological stations

Station ID	Distance (miles)	Bearing (deg)
ARKA	0.0	0.
KFLP	77.3	27.8
KCCA	48.1	65.6
KBVX	93.4	71.7
KSRC	84.6	94.6
KM19	117.6	78.9
KRUE	8.6	114.4
KLRF	67.0	113.9
KSGT	106.6	117.4
KLIT	69.4	125.5
KPBF	107.9	136.6
KCDH	120.0	167.1
KHOT	58.0	172.4



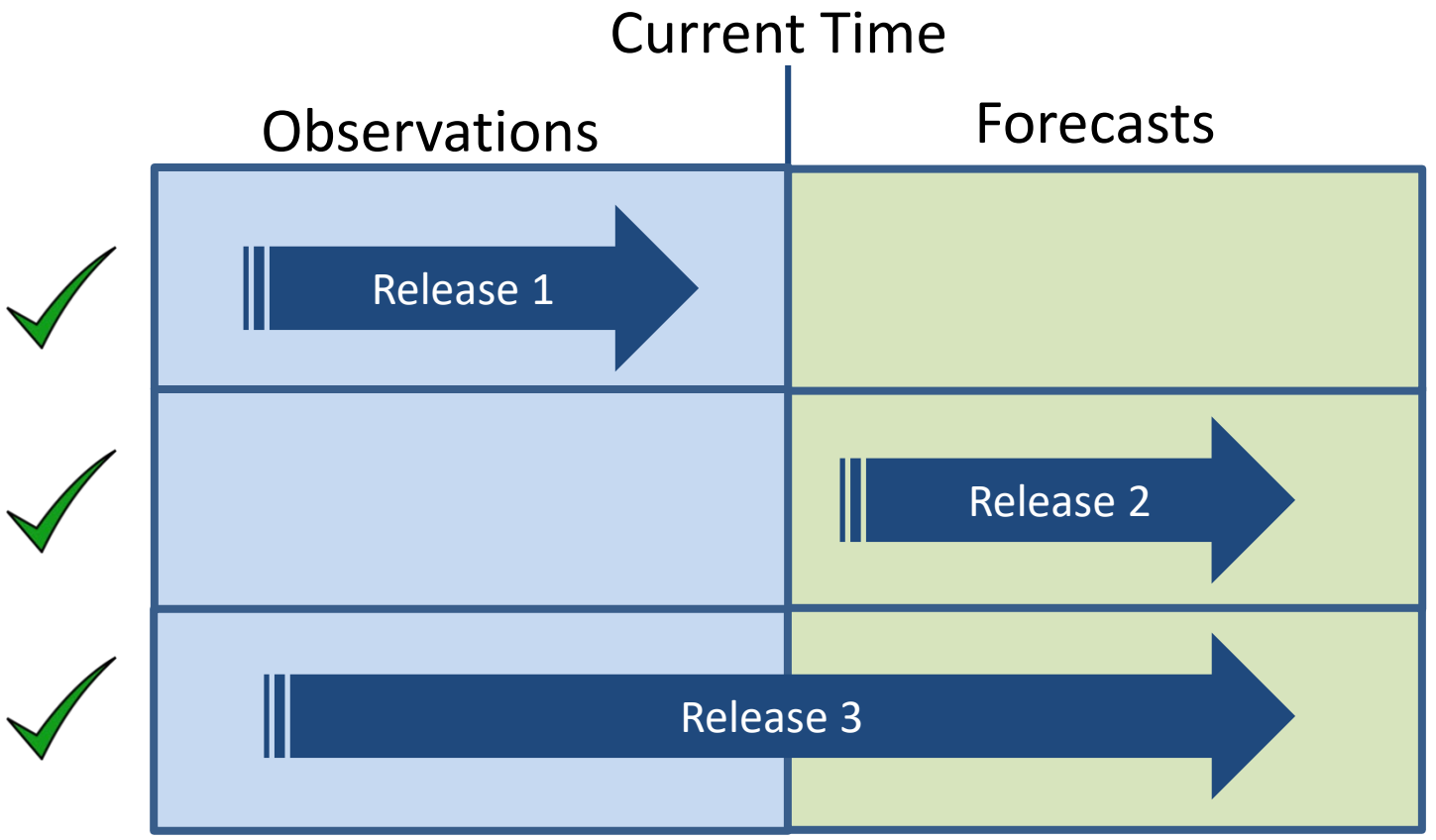
- Table and map show site and surrounding weather stations
- Select stations with plume direction in mind

Inputting Weather Data



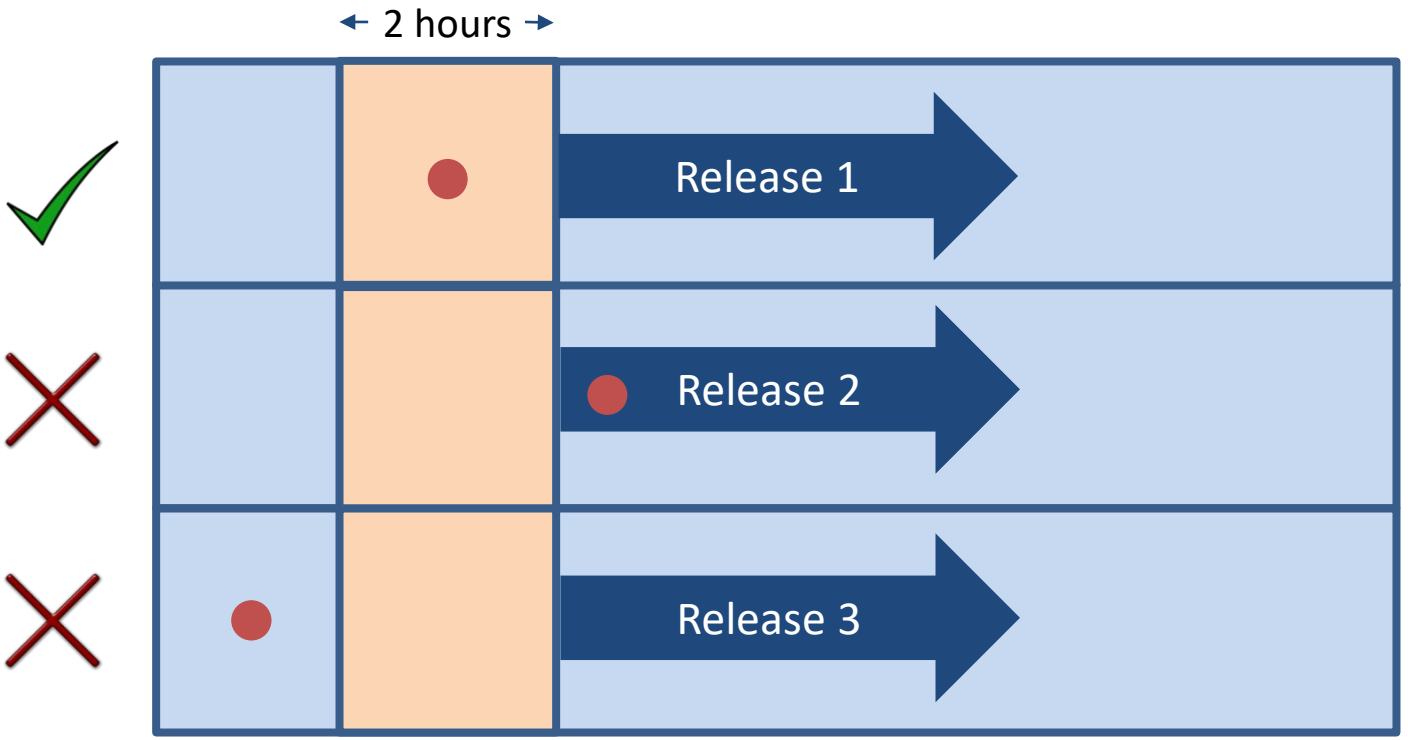
- Select weather station on the left to input its data on the right:
  - Type
  - Date/Time
  - Wind Direction/Speed
  - Stability
  - Precipitation

RASCAL USES OBSERVED AND/OR FORECAST WEATHER DATA



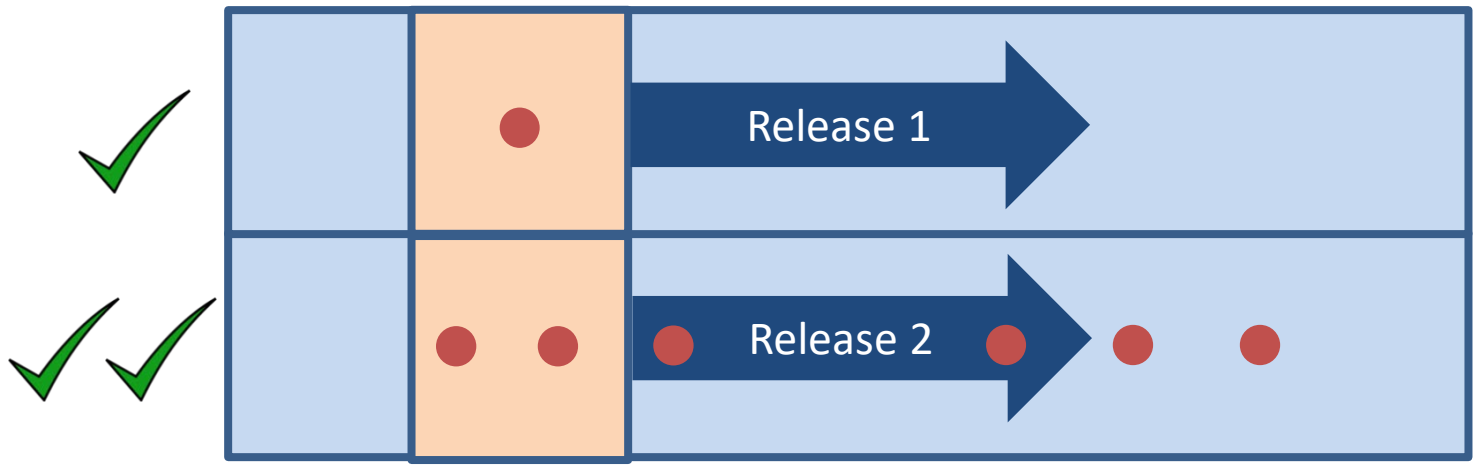
RASCAL can model releases in the past (all observations), in the future (all forecasts), or that span both.

RASCAL Can Run with a Single Weather Datapoint



However, the initial meteorological data must fall within 2 hours before the start of the release to the atmosphere. (Release starts at 10:30; must have some meteorology defined within the 8:30 to 10:30 window)

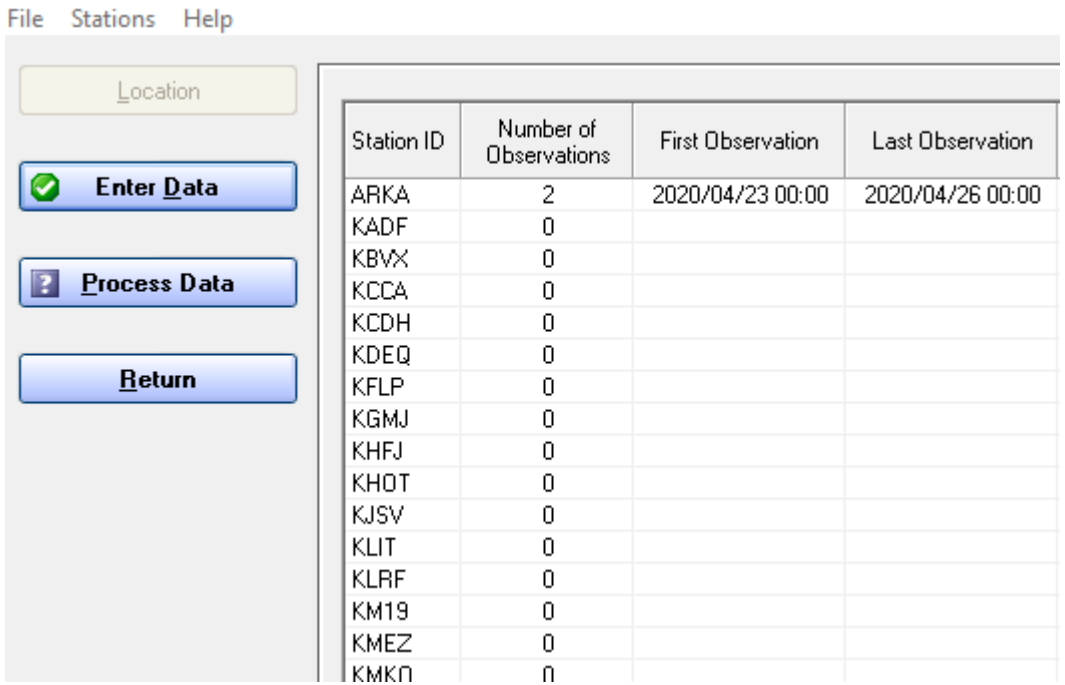
Although Single Datapoint Weather is possible, More Data is Preferred



Important when the release may start in the future or may continue for some period of time. You will likely need both observed and forecast data.

However, our scenario doesn't have additional info like forecasts yet.

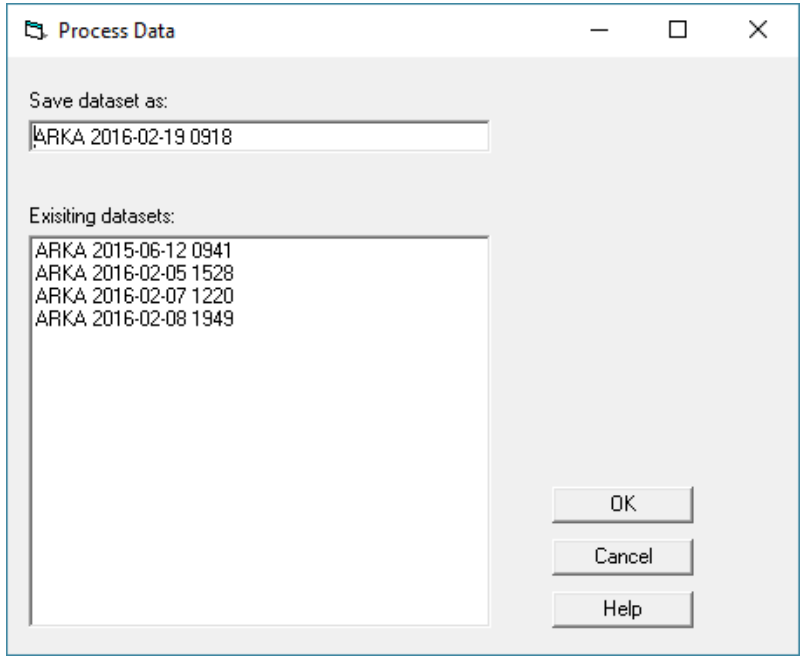
PROCESS DATA



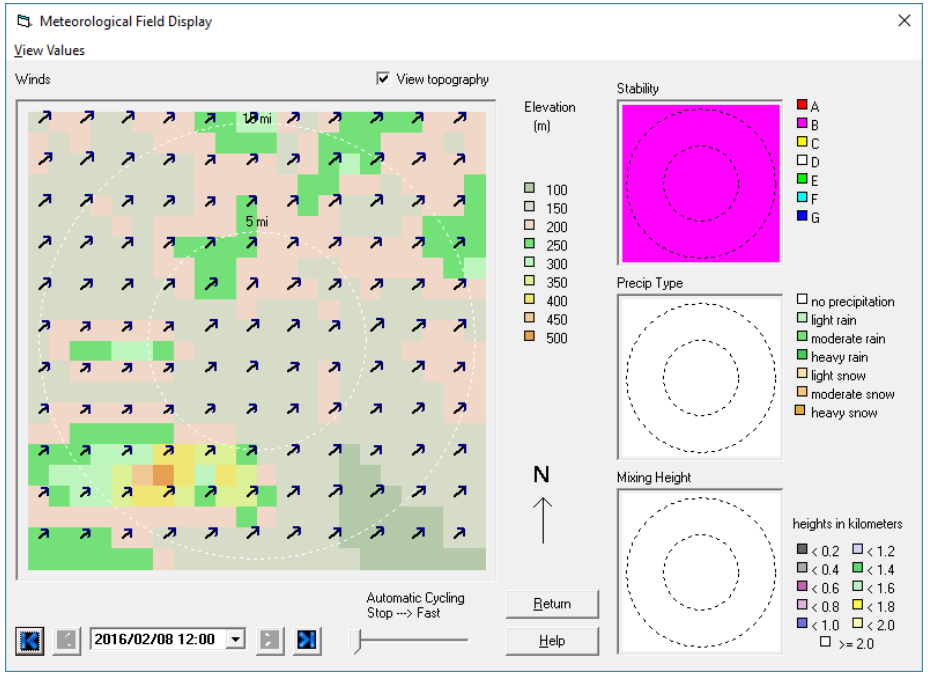
Click Process Data to compile all the weather data into a form that the models can use.

RASCAL PROCESSES ALL ENTERED DATA INTO A MERGED GRIDDED FIELD THAT CHANGES OVER TIME

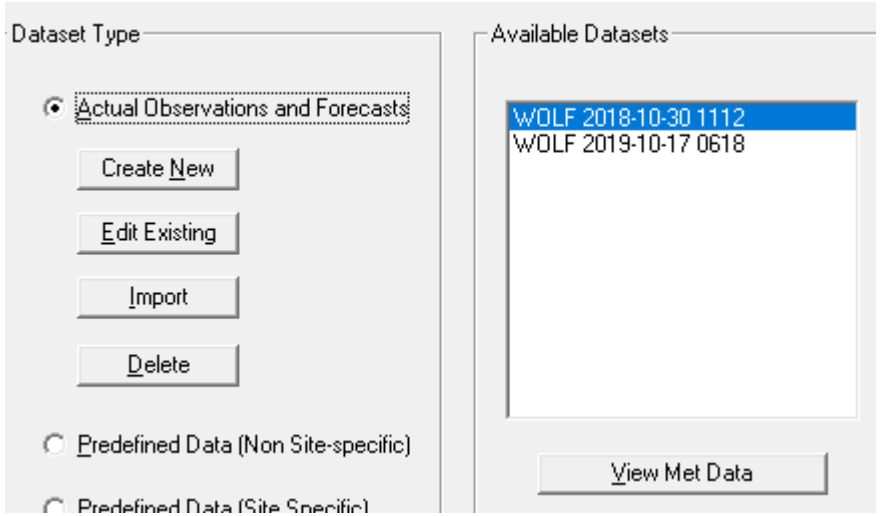
- This named file will show on the main met screen



- Weather details can be viewed if needed (View dataset)



Finally, Select Which Weather File You Want RASCAL to Use

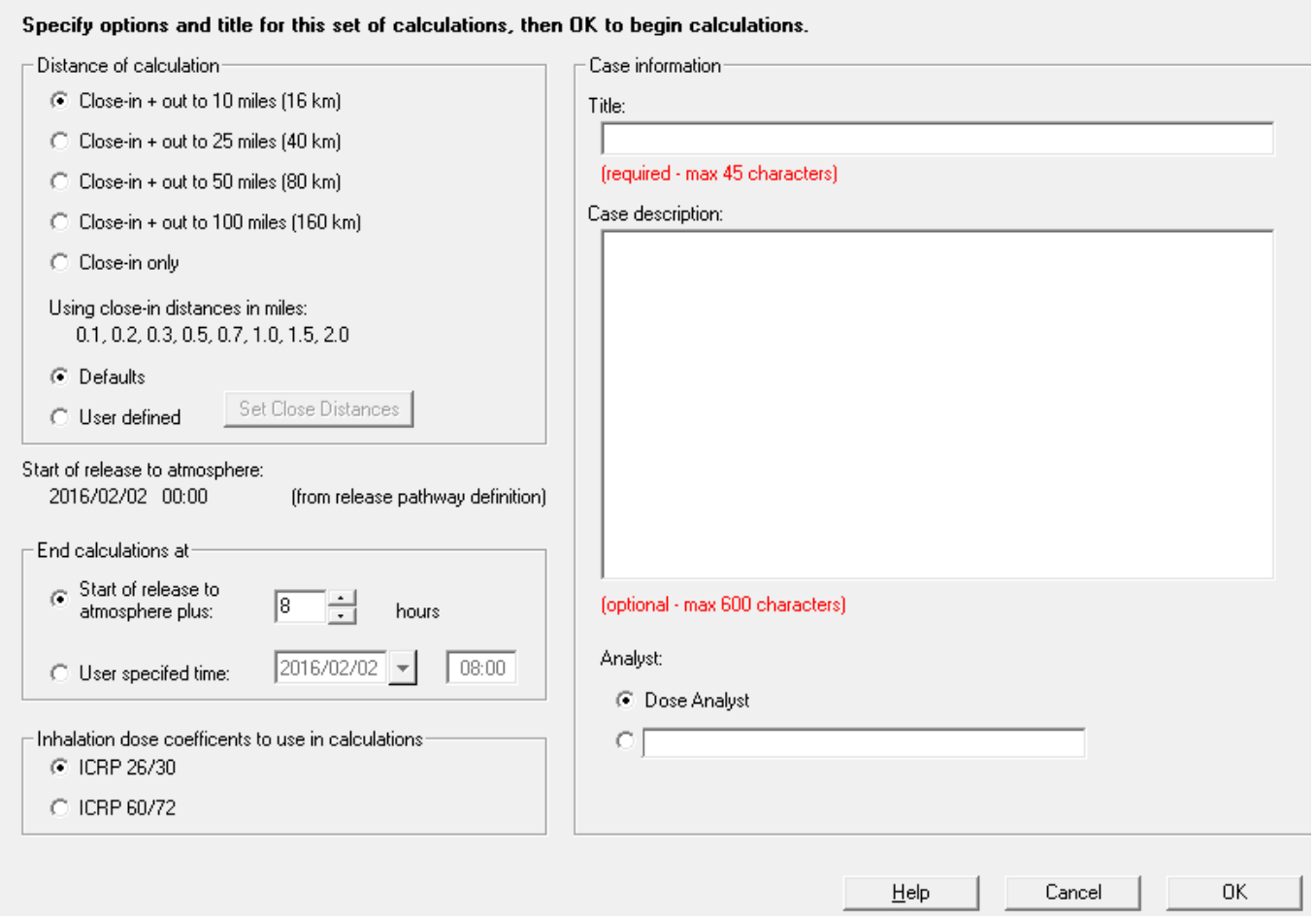


- RASCAL will return to the main Meteorology screen
- Highlight the desired weather data
  - Likely the one at the top

Your Turn to Use RASCAL

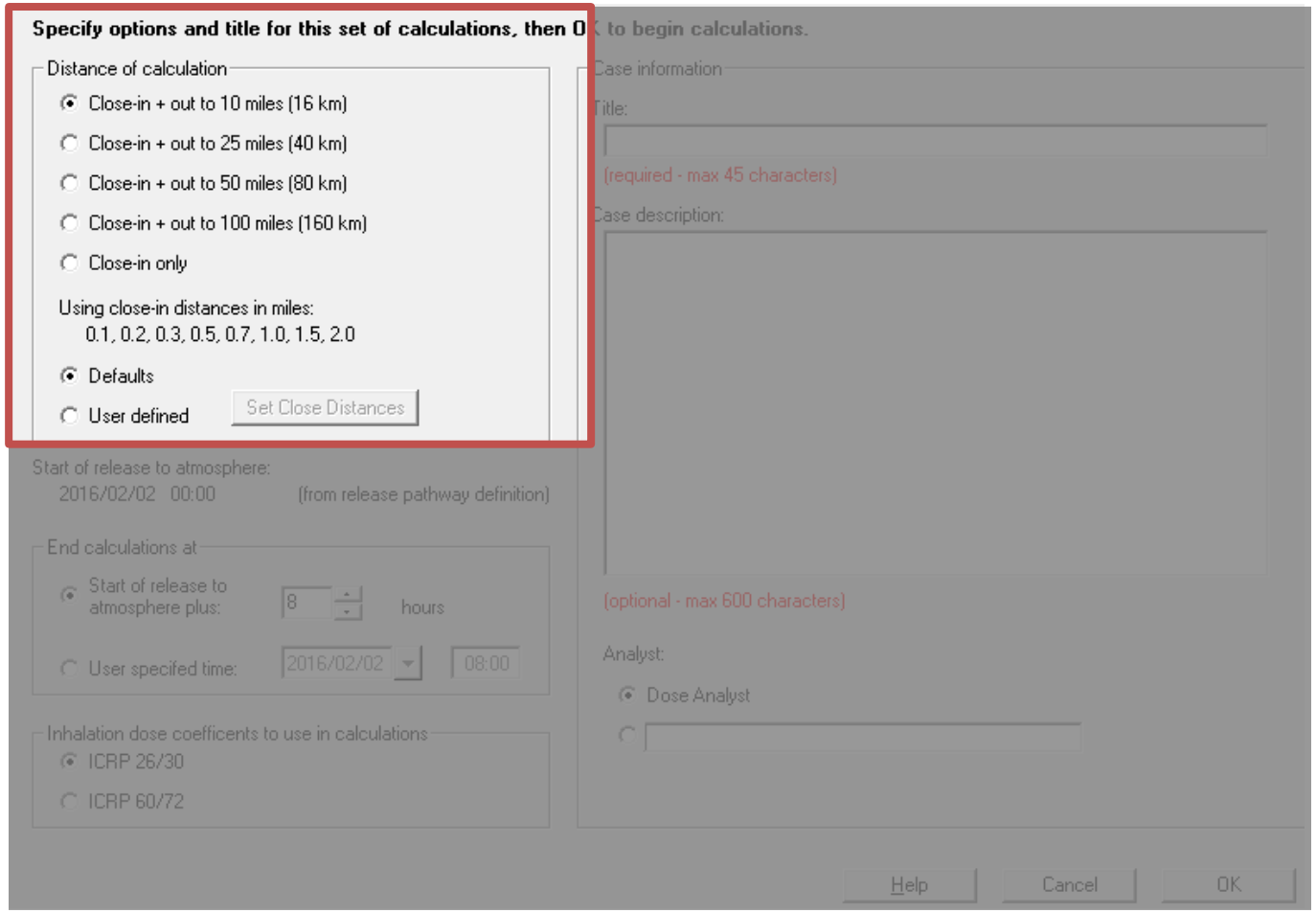
- Click Meteorology
- Select option for Actual Observations and Forecasts
  - Click Create New button
- Click Enter Data button
- For the BEAV station enter the following:
  - Time = 10:00
  - Winds = from 45 deg at 2 mph
  - Stability class = B
  - Precipitation = None
  - Click OK
- Click Process Data button then click OK
- Click the Return button
- Make sure your newly created file is selected in blue in the list of available datasets. Click OK
- Answer the Zoom Poll that pops up shortly

CALCULATE DOSES



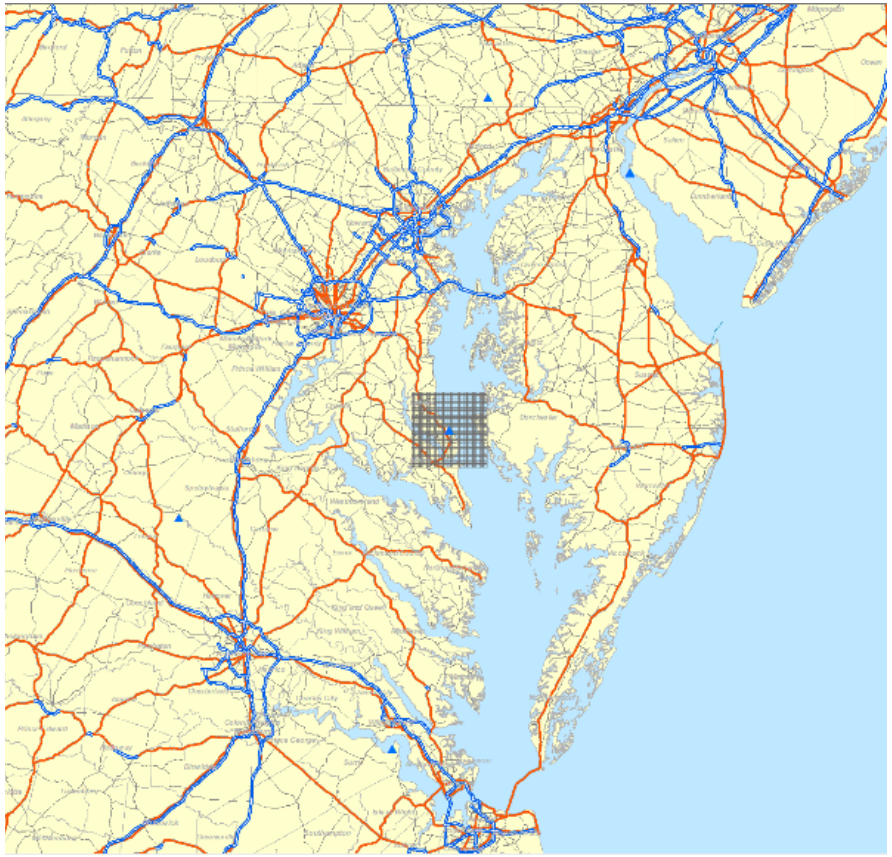
- Nothing has been calculated at this point
- With a few additional parameters, RASCAL will perform all its calculations

PICK A DISTANCE TO SET THE CALCULATION AREA

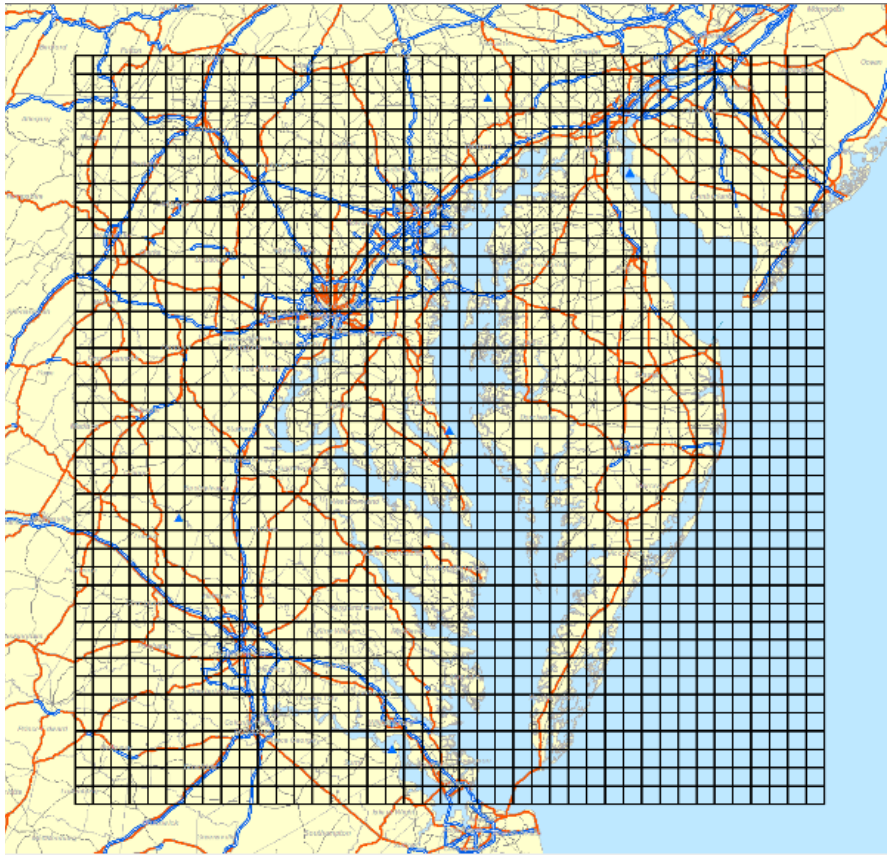


- Shorter distances provide higher resolution
- Rule of Thumb – start on the 10 mile distance. If doses are high at the 10 mile edge, go to 25 miles

CLOSER CALC DISTANCES PROVIDE BETTER RESOLUTION IF YOU DON'T NEED TO SEE FURTHER OUT

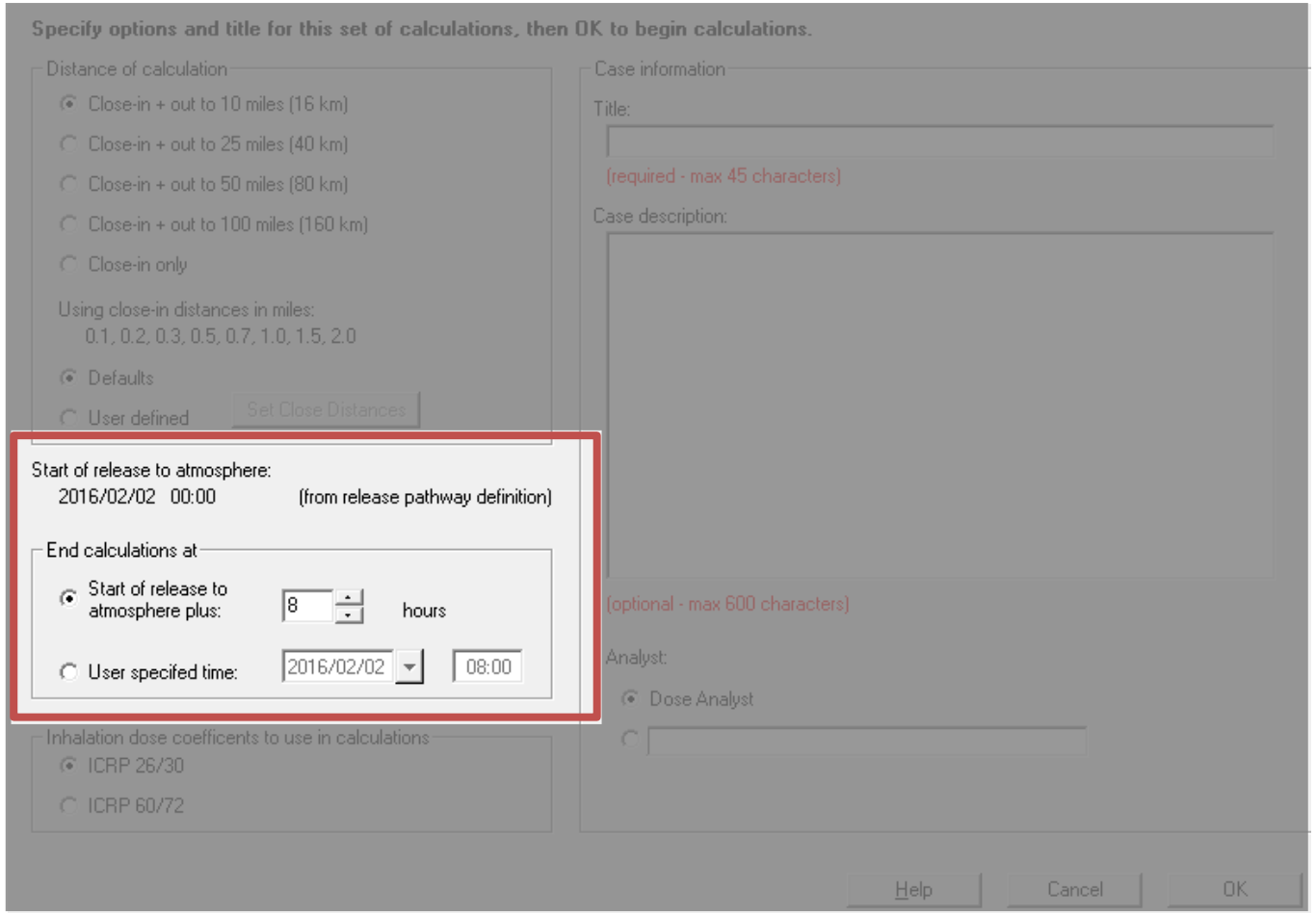


10 mile grid – cells are .5 mile wide



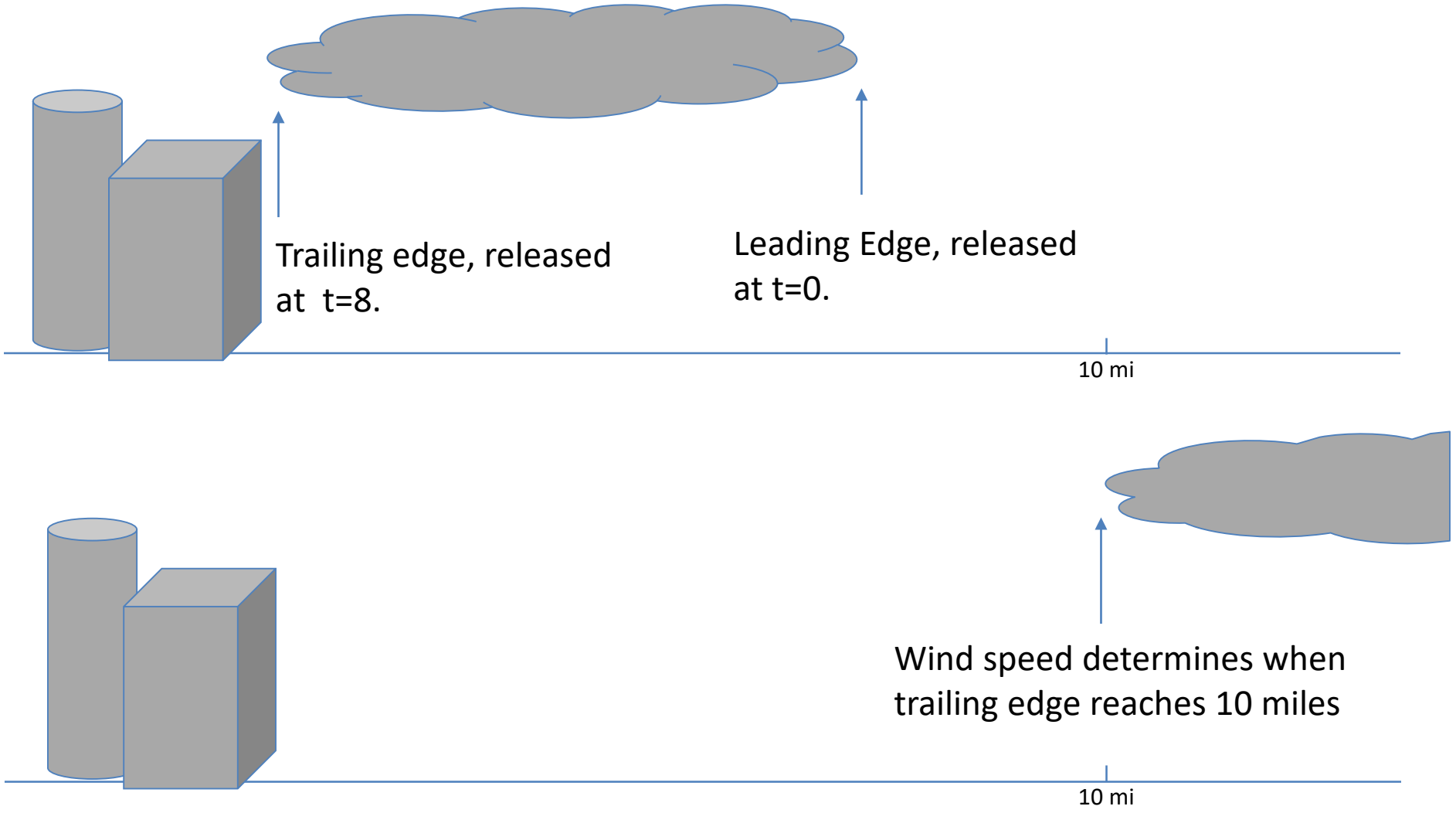
100 mile grid – cells are 5 miles wide

Define a Calculation Time



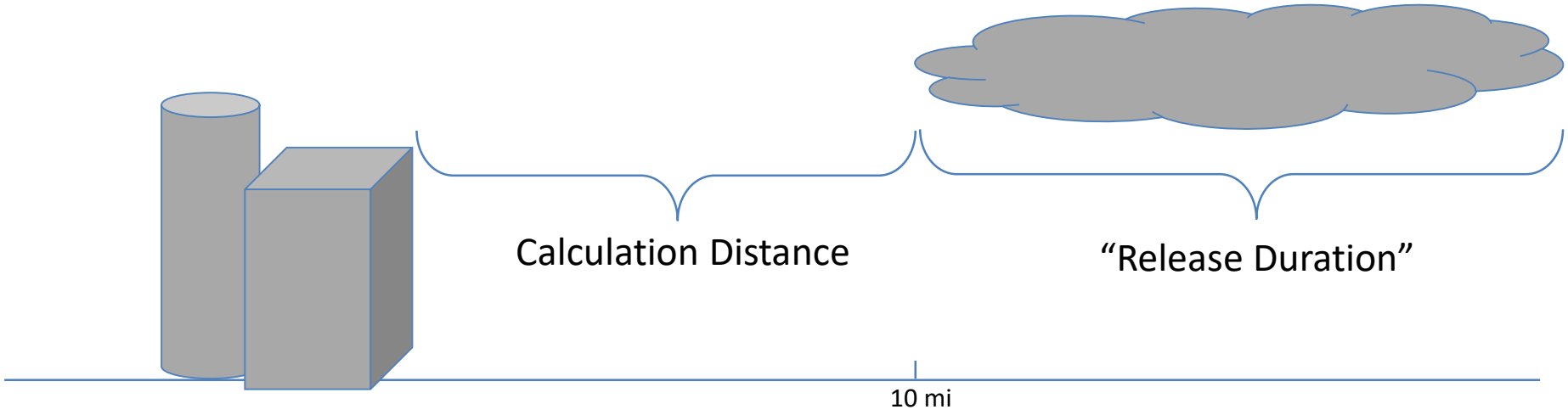
- Duration after the first release to atmosphere that RASCAL terminates the release, plume movement and dose calculations
- If time is set too short, dose may be missed; no disadvantage to going long (except runtime)

SET CALCULATION DURATION TO ALLOW FOR TRAILING PLUME EDGE TO REACH SET DISTANCE



THERE IS A RULE-OF-THUMB FOR ESTIMATING THE CALCULATION DURATION

$$Calculation\ Duration \geq \left(Release\ Duration + \frac{Calculation\ Distance}{Wind\ Speed}\right) \times 1.1$$

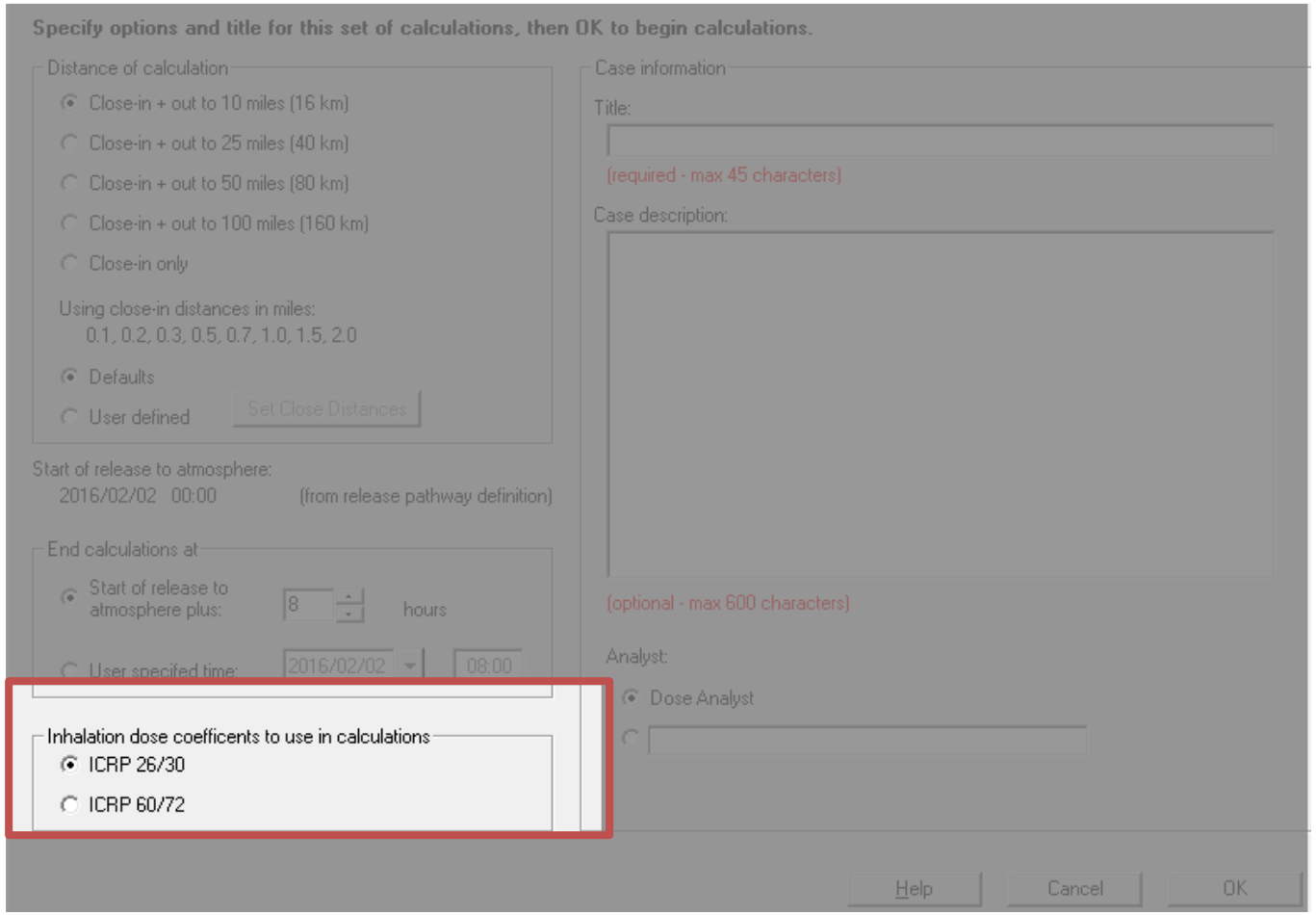


For a 7.5 hour release with 2 mph winds, calculate a duration for a 10 mile grid.

7.5 hours + (10 miles / 2 mph) = 12.5 hours

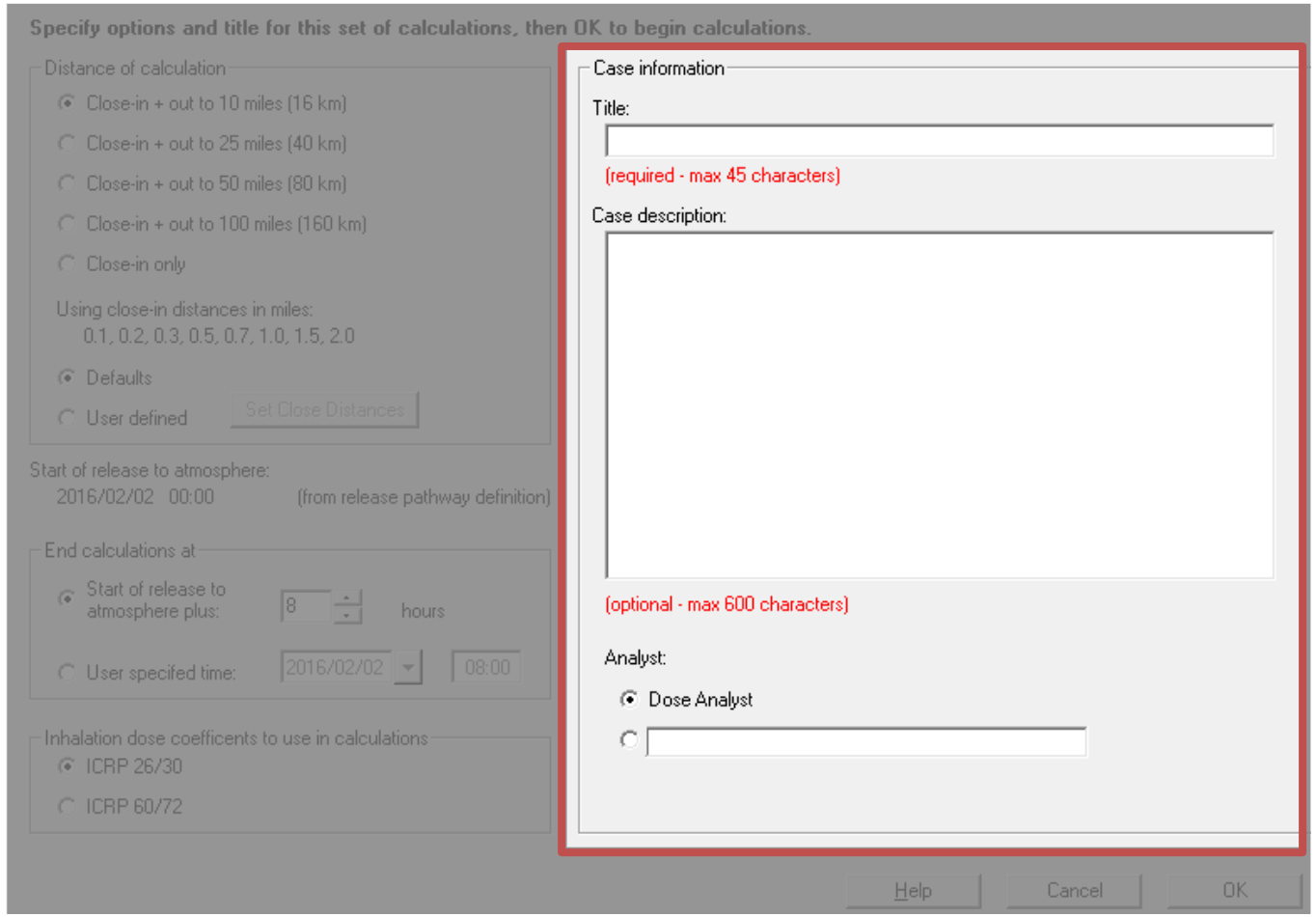
Add 10% to get 13.75, then round up to the nearest hour (14)

SELECT THE INHALATION DOSE COEFFICIENTS TO BE USED



- ICRP 26/30 vs 60/72
- Currently, NRC and most States use 26/30
- New EPA PAG Manual uses 60/72
- Differences are inclusion of child thyroid CEDE and some minor dose values changes

ENTER THE CASE INFORMATION



- RASCAL requires a case title
- Description used for justification or special notes; don’t need to repeat case info
- Select and/or define an analyst name

What happens when the OK button is clicked?

- RASCAL calculates the atmospheric source term and runs the ATD models with the given weather
  - You cannot interrupt the calculations
- Once complete, view results tabs at the bottom
  - Case Summary
  - Source Term
  - Maximum Dose Values

Your Turn to Use RASCAL

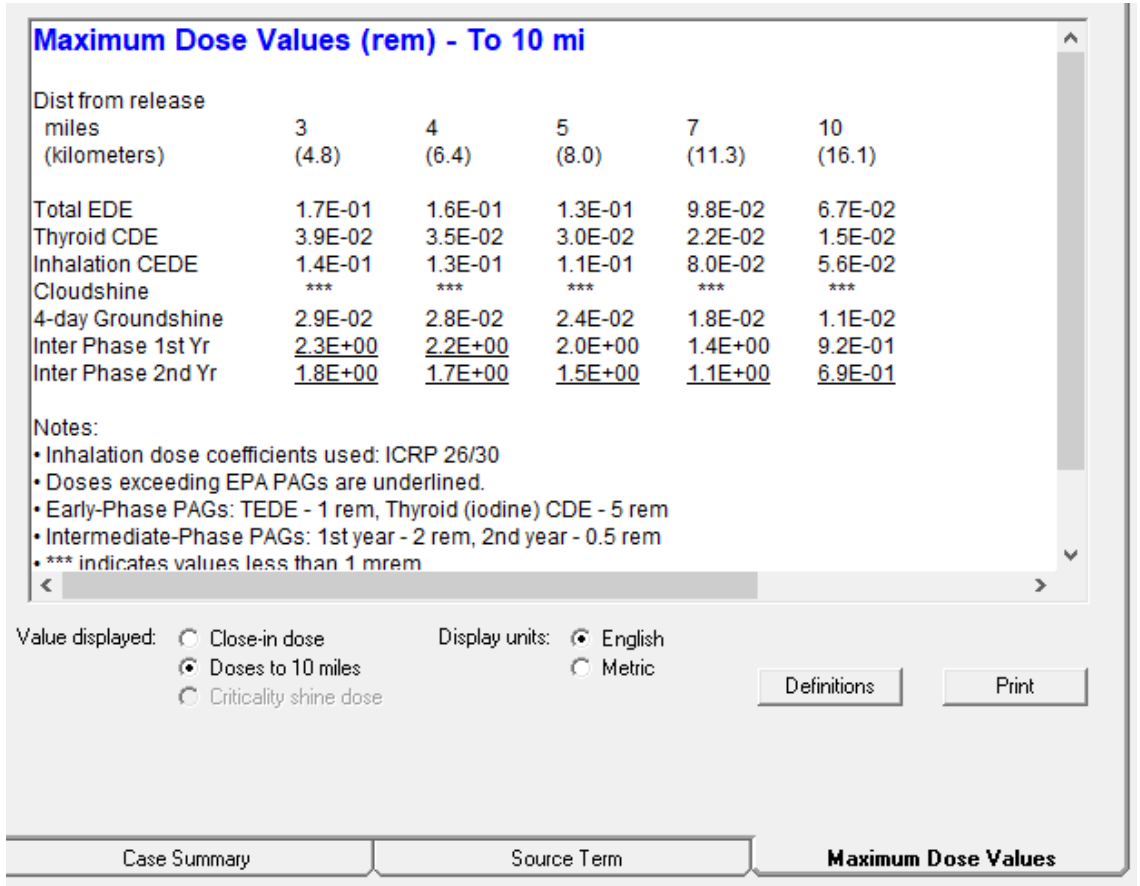
- Click Calculate Doses

- Leave Distance of Calculation at 10 miles
- Set End Calculations at:
  - Start of release to atmosphere plus: 14h

$$Calculation\ Duration \geq \left(Release\ Duration + \frac{Calculation\ Distance}{Wind\ Speed}\right) \times 1.1$$

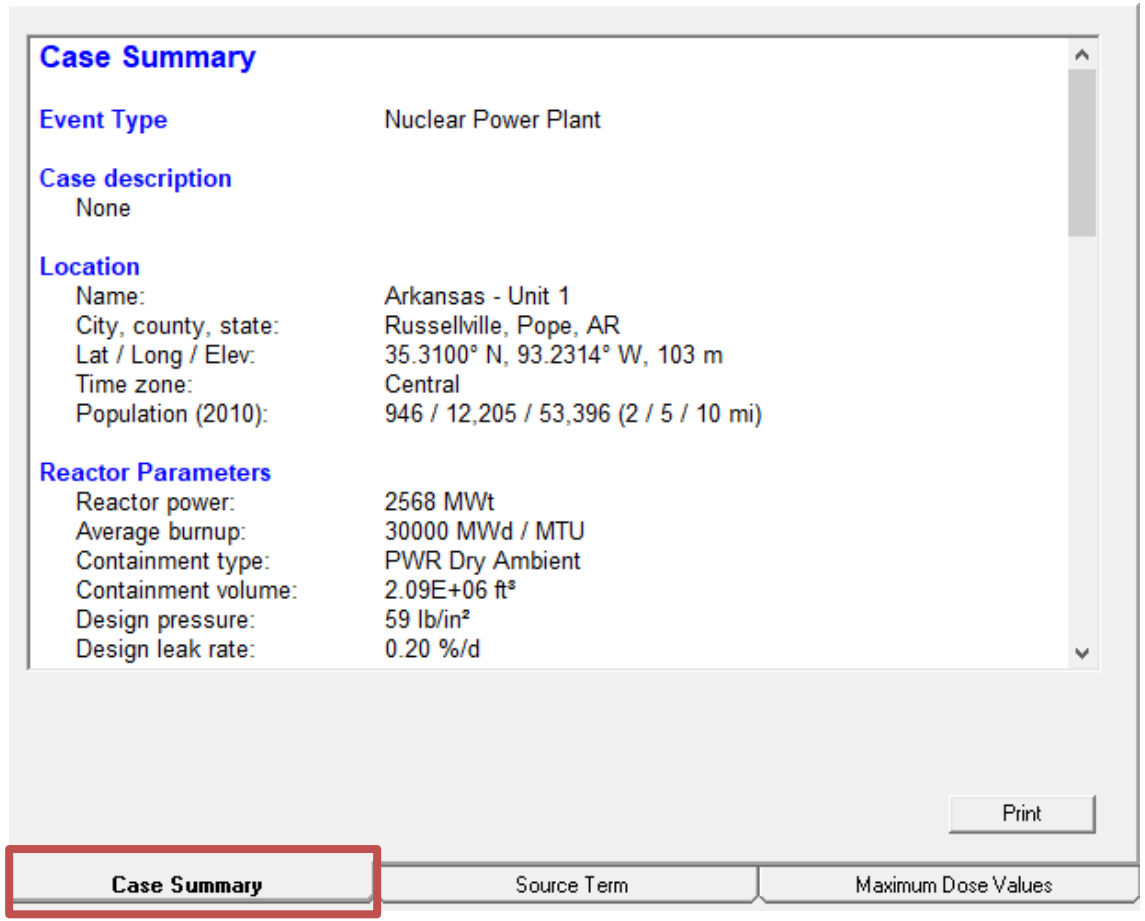
- Click OK to start the calculations
- Answer the Zoom Poll that pops up shortly

RASCAL Results



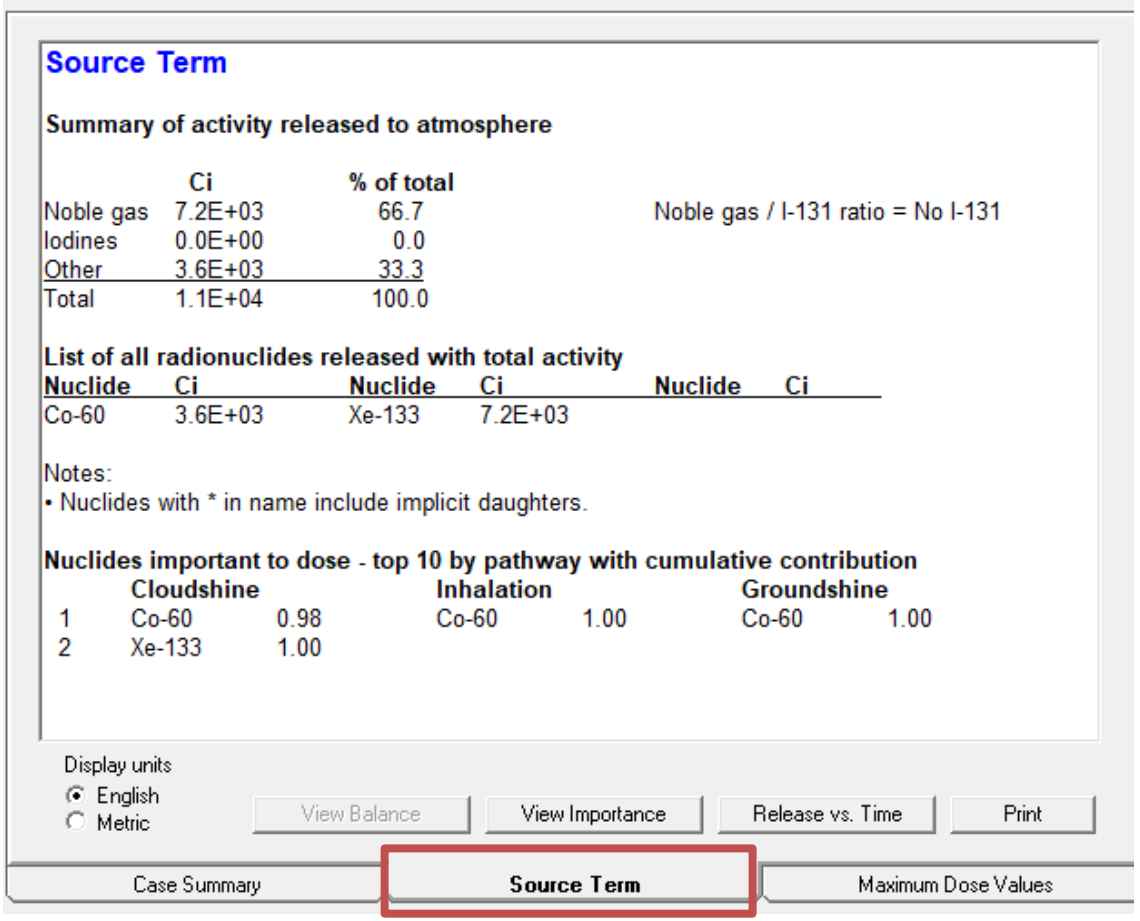
- When RASCAL is finished calculating, it shows this screen, which is just 1 of 3 tabs at the bottom
- They each contain different information and have a different purpose, let's go through them

Case Summary Tab Shows Inputs



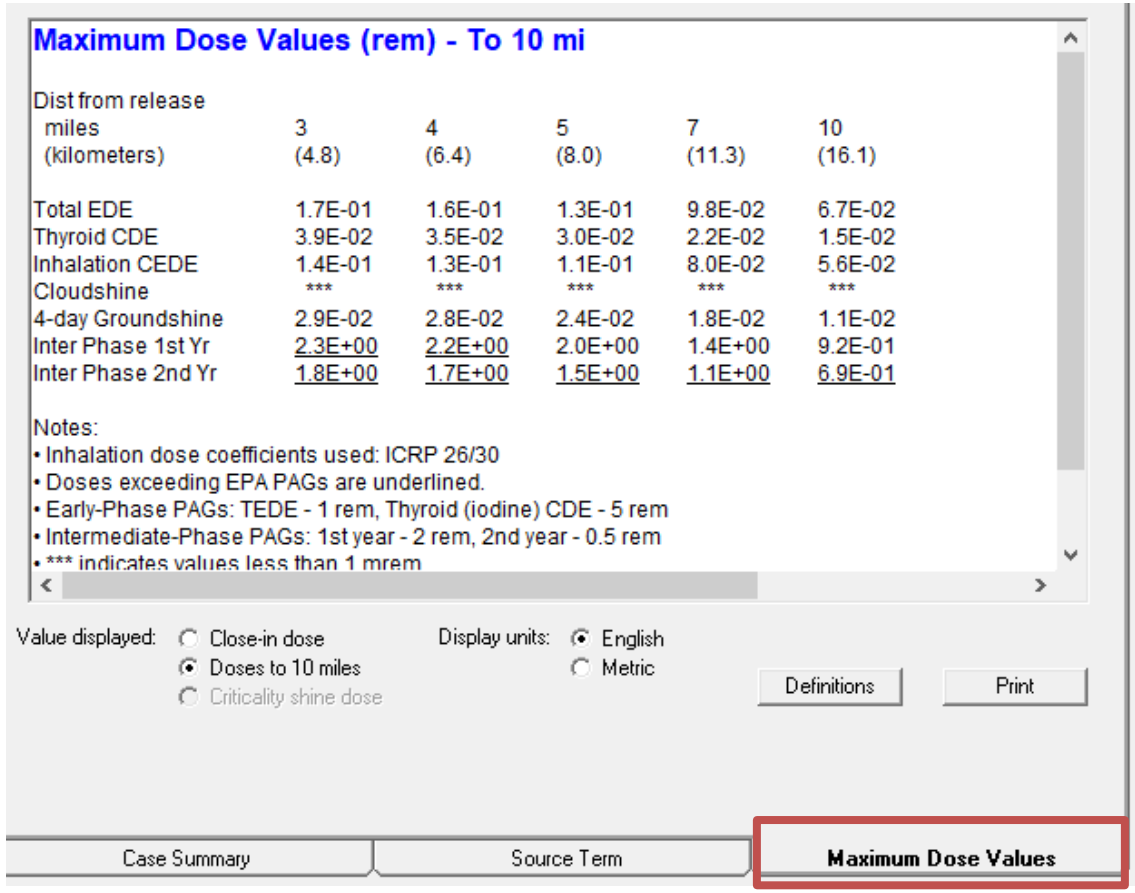
- The Case Summary tab has been populating as we added info
- You can use it as a great way to check your inputs all at once or compare inputs against other dose assessors

Source Term Tab Shows Details for Release to Atmosphere



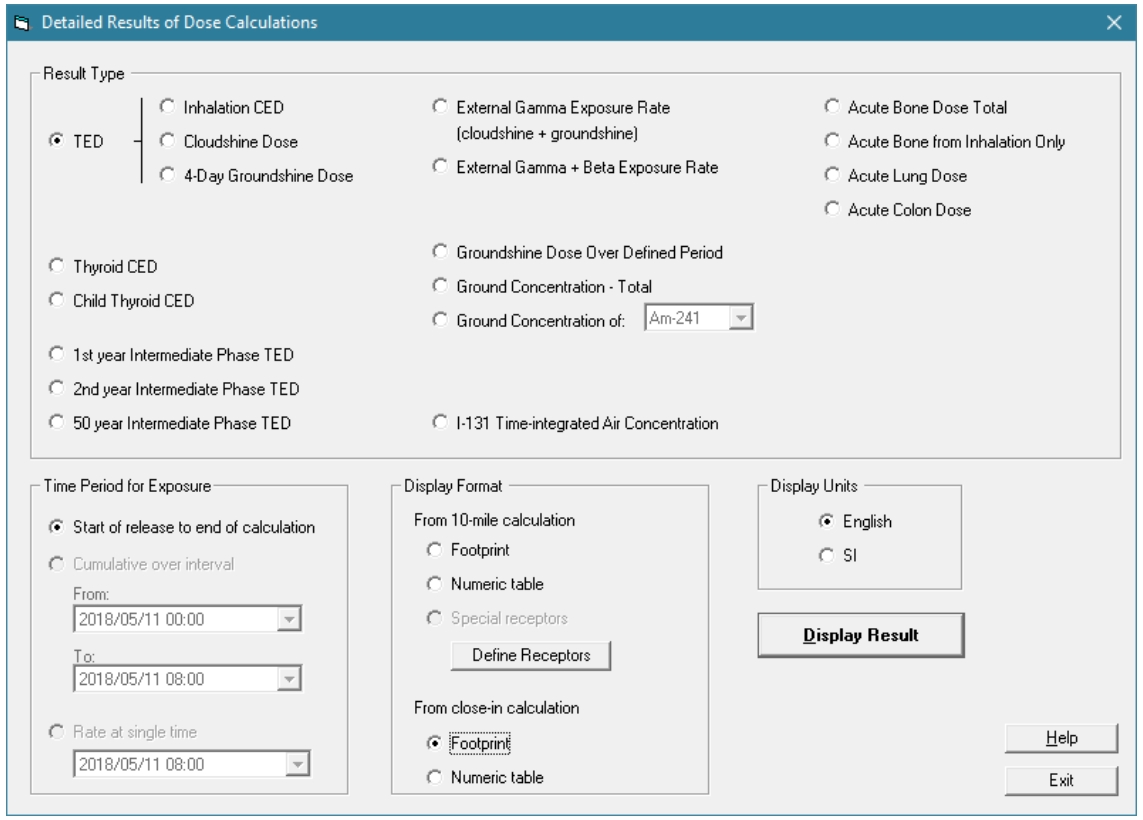
- Summary window
- View Balance
  - Where nuclides are at the end of the simulation
- View Importance
  - What nuclides are contributing the most to dose
- Release vs. Time
  - Displays amount of each nuclide released each 15 minute time step
  - Can be exported

MAX VALUES TABLE SHOWS DOSE SNAPSHOT



- Summary window
  - Doses important for protective actions (TEDE, Thyroid)
  - Underlines doses exceeding PAGs
- Select distance
  - Close in vs selected “far out” model distance
- Does not show direction

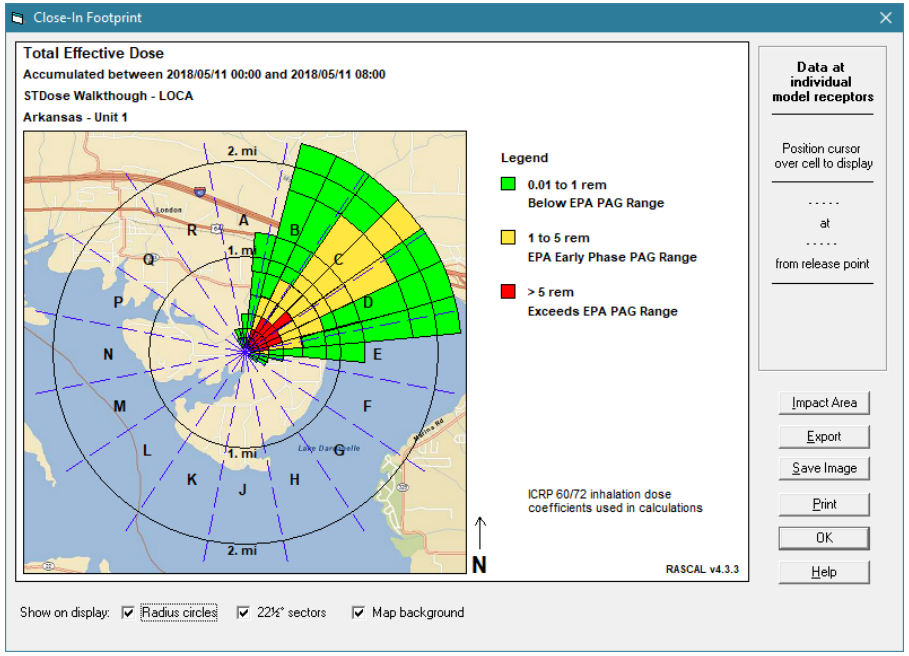
For Additional Result Information, Click Detailed Results



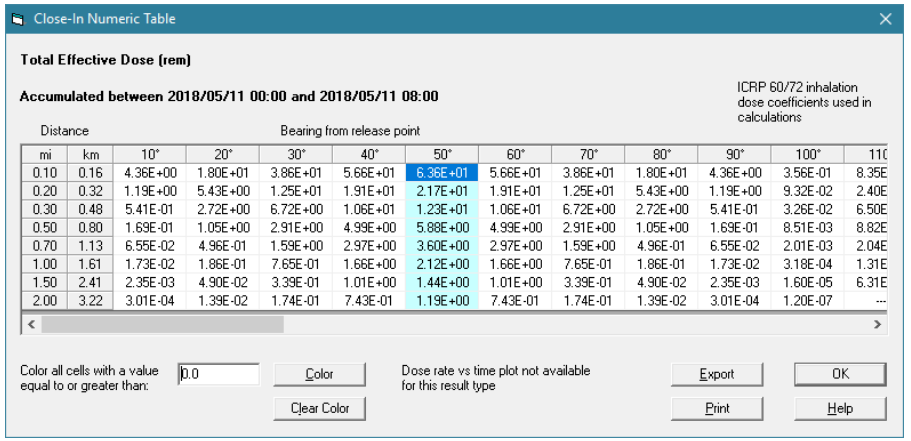
- Provides additional graphical and tabular outputs
- Result types at top
  - Dose-related
  - Deposition/Measurements
  - Acute doses
- Settings on the bottom
  - Time - cumulative or rate
  - Map/Table; Close-in or Further Out
  - Units

Difference between Footprint and Table check chat

- Footprint provides celled results on map
- Table provides numeric values
- Both can be exported, map can be queried, table can be filtered



Footprint

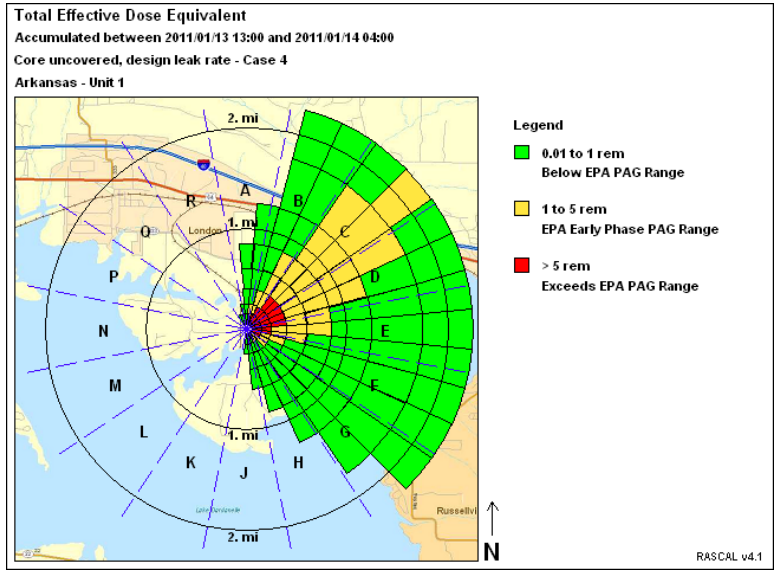


Table

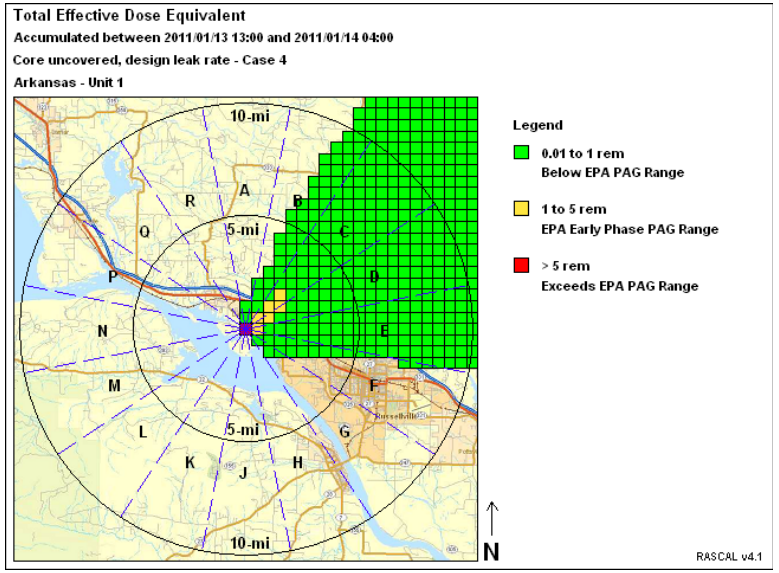
Difference between "close in" and "Far Out"

Two ATD models are used in the calculations

- Resolution advantages
- Overlap may not line up exactly



Plume Model



Puff Model

Your Turn to Use RASCAL

- Examine the results
  - Maximum Dose Values tab shows some doses at selected distances
  - Source Term tab show details about the atmospheric release
  - Click Details Results to see options for looking at dose on a map

- Answer the Zoom Poll that pops up shortly

THIS CONCLUDES OUR INTRO WALKTHROUGH

You should now be able to click through RASCAL start to finish.

Remember that resources & training can be found at:

https://ramp.nrc-gateway.gov/

Questions?

Unmute yourself or chat us a question

No Questions?

You're free to leave the meeting