RASCAL TRAINING

Unit 3 – Evolving Scenario

RASCAL TRAINERS

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Unit 3 Outline

- We'll provide an evolving scenario and use that to guide several RASCAL runs, each including:
  - Scenario introduction
  - Model discussion
  - Run RASCAL on your computer
  - Results discussion
- Each section is a continuation of the changing scenario to show how RASCAL can be used throughout the course of a real-world event
- *Break in the middle of the session*

SCENARIO

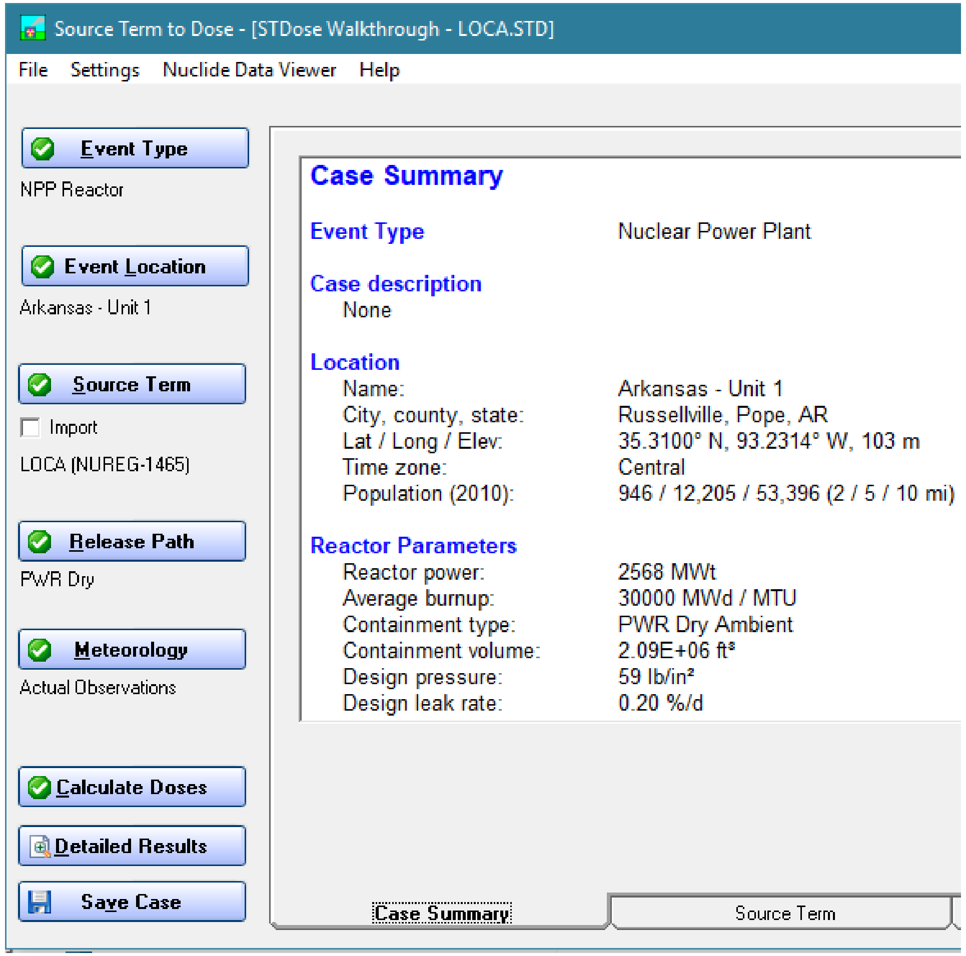
For today, the overall scenario will include:

- **Plant has Small Break LOCA**
  - **MODEL: Containment Radiation Monitor**
- **Small Leak into Aux Building**
  - **MODEL: Coolant Release**
- **Conditions Worsen**
  - **MODEL: Containment Radiation Monitor**
  - **MODEL: LOCA**
- **Field measurement Comparison**

RASCAL SLIDE

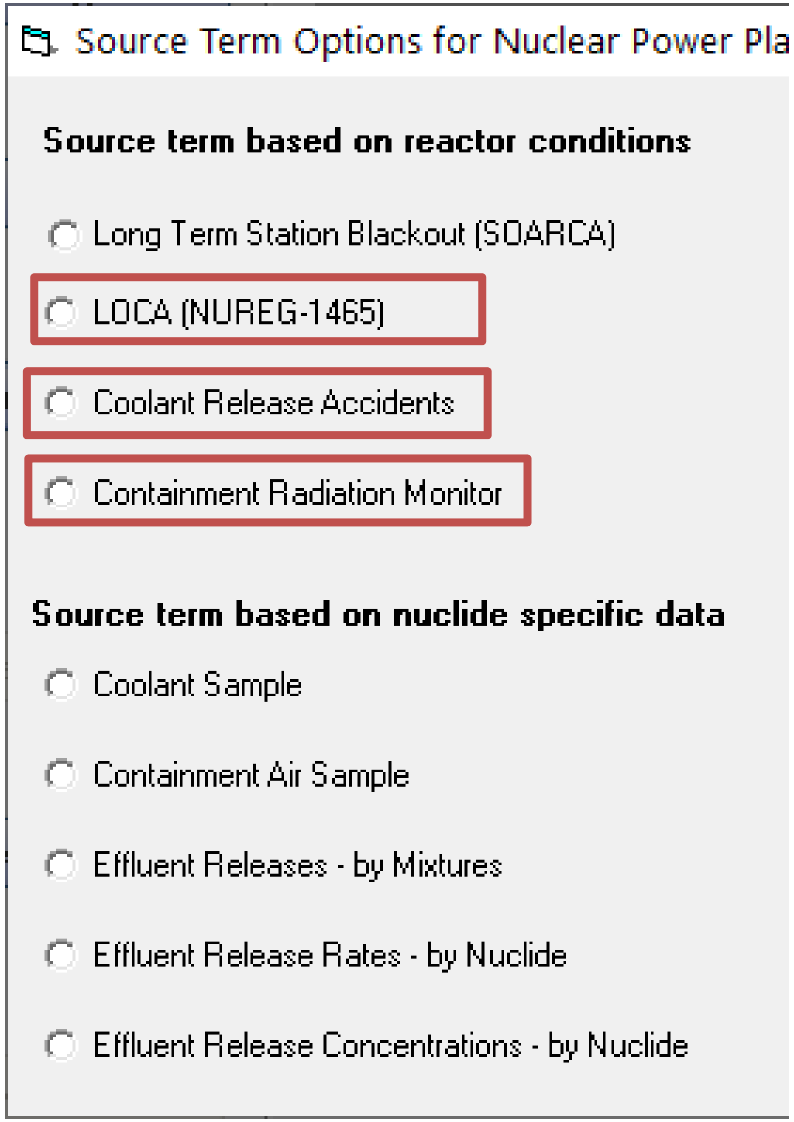
- Every time we ask you to use RASCAL, you'll see one of these blue slides.
- It will include information needed to complete the steps.
- If you have multiple screens, put the presentation in one screen and use RASCAL in the other. Otherwise, you will have to switch back and forth.
- If you don't have RASCAL installed, you can just watch us use it.
- We will do a short step-by-step after each slide, followed by some questions.

Source Term Reminder



- Source Terms available depend on Event Type/Location
- Source Term & Release Pathway combine to generate atmospheric source term
- One of the hardest parts of using RASCAL outside training is obtaining information and knowing what models can be used, sometimes even multiple per scenario

Source Terms for Today



- When Nuclear Power Plant is selected as the Event Type, you will see this screen for Source Term options (models)
- Today, we will be using the highlighted 3 models

SCENARIO

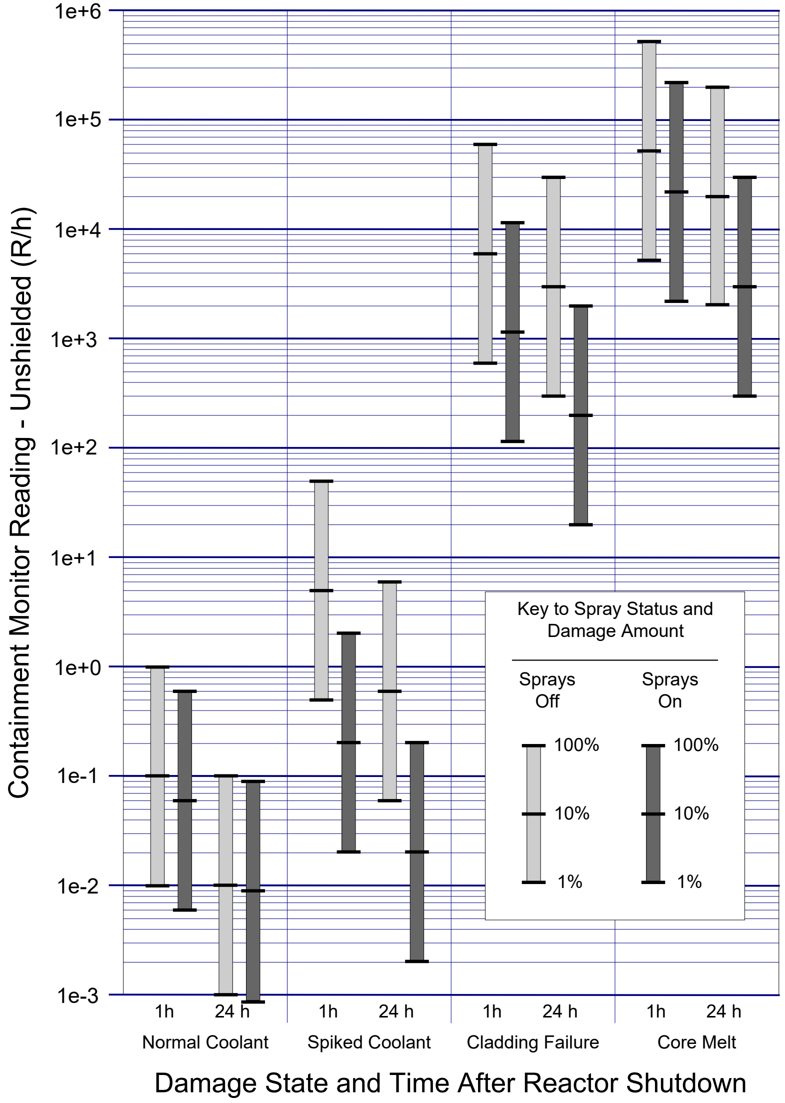
- Palo Verde Unit 1 trips automatically at 08:35
  - Operators suggest that a LOCA may be in progress, but the size is unknown
  - Very little information is available; but operators do have containment radiation monitor readings

- Strategy
  - Too early to have any useful details for a dose assessment
    - We don't know if LOCA model would apply (assumes core damage)
    - No release path to environment
  - We can use the Containment Radiation Monitor model to estimate core conditions

Containment Rad Monitor - Background

- One or more instruments inside containment used to continuously survey the containment volume for radiation.
- Generally reads out in units of R/h.
- Readings will be shown in the control room and will likely be available from plant data systems.

Containment Rad Monitor - How This Works in RASCAL

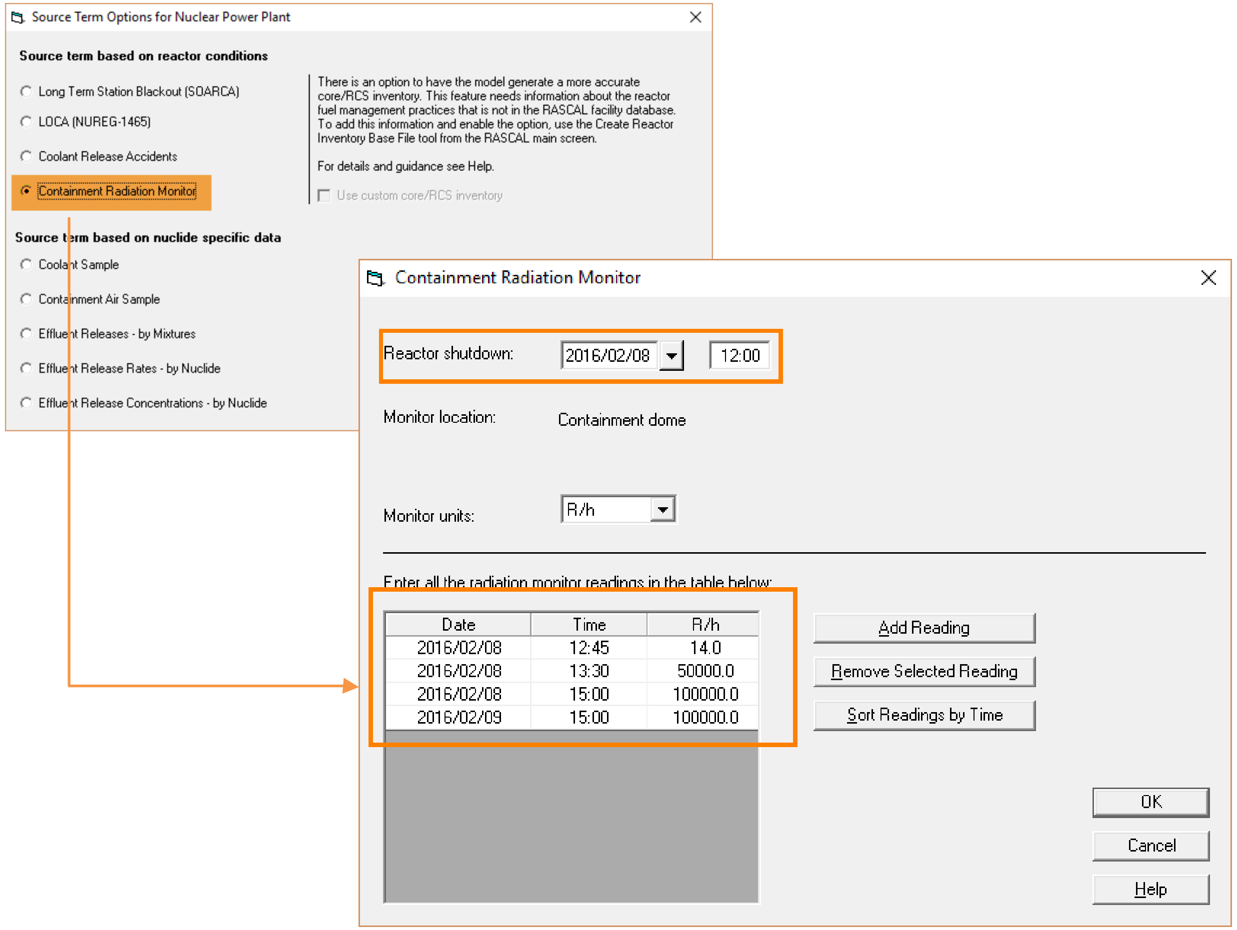


The model uses tables such as this one to convert the reading into a damage amount.

Two factors in addition to the R/h reading are considered:

Time since reactor shutdown, and whether sprays are on or off.

Containment Rad Monitor - How This Works in RASCAL



The only entries required are the shutdown time and the actual rad monitor readings.

This model is not predictive and persists damage amounts until it reaches a new entry.

Your Turn to Use RASCAL

Given the scenario excerpt below, run the entire case in RASCAL.

Palo Verde Unit 1. Shutdown at 08:35.
Sprays are off and readings are shown below:

Time	Containment Radiation Monitor Reading (R/h)
08:40	2.4
08:55	5.1

Since we are running this model only to determine core damage state and not doses downwind, the release pathway and weather details are not important at this time. Use default (design) containment leakage, predefined standard meteorology and default calc distance/duration.

Let's walk through the problem together

Knowledge Check

The 5.1 R/h reading translates into how much core damage?

- 8.47E-03% cladding failure
- 1.09E-02% cladding failure
- 1.72E-02% cladding failure
- None of the above values

CONCLUSION

From the case summary, we can see the calculated core damage:

Source Term

Type:	Containment Radiation Monitor	
Monitor location:	Containment dome	
Shutdown:	2020/10/18 08:35	
Inventory:	Default	
Monitor readings	R/h	Calculated damage
2020/10/18 08:40	2.4	3.96E-03% cladding failure
2020/10/18 08:55	5.1	8.47E-03% cladding failure

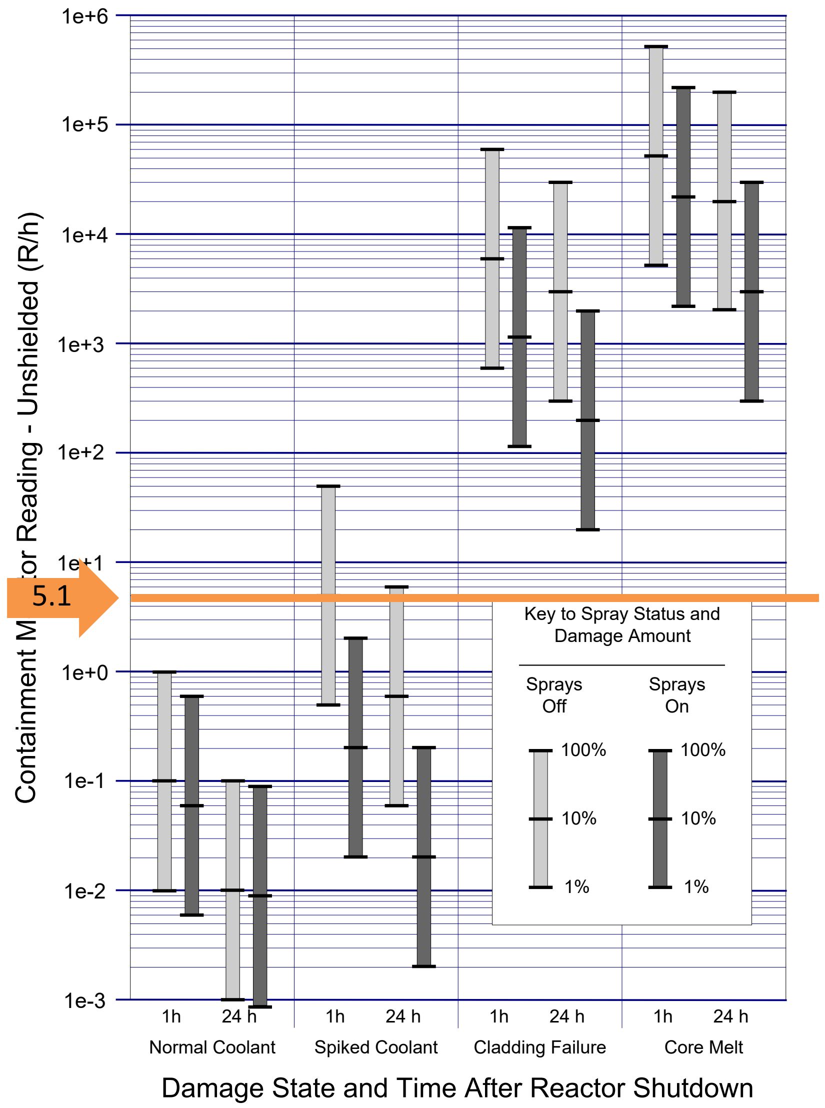
Release Pathway

Type:	PWR - Dry Containment Leakage or Failure
Release height:	10. m

Time	Containment Radiation Monitor Reading (R/h)	RASCAL Calculated Core Damage
08:40	2.4	3.96E-03% cladding failure
08:55	5.1	8.47E-03% cladding failure

After completion, **save your case!**

IS THE CORE REALLY DAMAGED?



Our RASCAL results show small amounts of clad failure. The table shows spiked coolant. Since RASCAL only calculates clad failure and core melt states with this model, our results show as extrapolated clad failure.

We can translate this as no clad failure.

SCENARIO

- **At 09:30, there are indications that a valve in the ECCS (Emergency Core Cooling System), which is providing make-up water, has failed resulting in some reactor coolant flowing into the auxiliary building.**

- **Strategy**
  - **Previously**
    - **Containment radiation run suggested no core damage**
    - **Had no release path, but now have a pathway to environment through aux building**
  - **We can use the Coolant Release model to estimate RCS inventory leaking to environment**

Coolant Release - How This Works in RASCAL

- All reactor system pipe breaks can be modeled 2 ways depending on volume of coolant leak:
  - LOCA (large or unrecoverable break, core melt)
  - Coolant Release (smaller break, no core melt)
- For coolant release models (simple SGTRs or small bypass LOCAs with no degrading conditions):
  - Database has information about nuclides that would be in normal coolant
  - Coolant spiking

Your Turn to Use RASCAL

Given the scenario excerpt below, run the entire case in RASCAL

Palo Verde Unit 1. Shutdown (same as before) at 08:35. Containment rad monitor run suggested spiked coolant (leave at default 30). Coolant release starts when ECCS valve failed at 09:30.

Release is through aux building (bypass) and operators estimate backflow rate at 100 gal/min. Filters remain on.

Weather data is as follows:

Type	Date	Time	Wind Dir (deg)	Wind spd (mph)	Stability	Precip	Air Temp (F)
Obs	Today	08:00	20	7	C	None	75
Fcst	Today	10:00	30	6	Unknown	None	80

Since we expect this to be a small release and are estimating approximate dose values early on, we will start with an 8-hour calculation duration.

Let's walk through the problem together

KNOWLEDGE CHECK

What is the TEDE at 0.1 miles?

- *** *(less than 1 mrem)*
- 0.0E+00 rem
- 2.0E-03 rem
- None of the above values

Would this source term (coolant release) be usable later if the fuel became damaged?

- No
- Yes

QUESTIONS

- Our Answers

	Dose at 0.1 miles from the site
TEDE (rem)	***
Adult Thyroid CDE (rem)	***

- Additional Thoughts
  - Doses are low – coolant release; no core damage
  - Improved fuel quality reduces spiking factor

Scenario

- **An additional containment radiation monitor reading of 105,000 R/h now becomes available**

- **Strategy**
  - **This reading seems high enough to warrant a second containment radiation monitor run to find core damage state**
  - **Although we have a release path to environment, we still only want to use this run as core damage confirmation, not as a dose projection**

Your Turn to Use RASCAL

Given the scenario excerpt below, run the entire case in RASCAL.

Load previous Containment Rad Monitor case and add new reading.

Palo Verde Unit 1. Shutdown at 08:35. Sprays are off and readings are shown below:

Time	Containment Radiation Monitor Reading (R/h)
08:40	2.4
08:55	5.1
09:45	**105,000**

Since we are running this model only to determine core damage state and not doses downwind, the release pathway and weather details are not important at this time. Use default (design) containment leakage, predefined standard meteorology and default calc distance/duration.

LET'S WALK THROUGH THE PROBLEM TOGETHER

Knowledge Check

The 105,000 R/h reading translates into how much core damage?

- 1.9% core melt
- 18.9% core melt
- 27.7% core melt
- None of the above values

Are the offsite doses shown in the Maximum Dose Values table useable?

- No. The release pathway and weather data were not matched to real conditions.
- Yes, but there are uncertainties in the values.

CONCLUSION

From the case summary, we can see the calculated core damage:

Source Term

Type:	Containment Radiation Monitor	
Monitor location:	Containment dome	
Shutdown:	2020/10/18 08:35	
Inventory:	Default	
Monitor readings	R/h	Calculated damage
2020/10/18 08:40	2.4	3.96E-03% cladding failure
2020/10/18 08:55	5.1	8.47E-03% cladding failure
2020/10/18 09:45	105000.0	18.9% core melt

Time	Containment Radiation Monitor Reading (R/h)	RASCAL Calculated Core Damage
08:40	2.4	3.96E-03% cladding failure
08:55	5.1	8.47E-03% cladding failure
09:45	**105,000**	**18.9% core melt**

Conclusion

- Reminder, this is not an ideal model to be your first choice for modeling a severe accident; however, it can be a good secondary, confirmatory calculation

- Model assumptions:
  - Readings represent the full amount of damage; may lag significantly or the release may bypass the containment
  - Uniform mixing of fission products in the containment atmosphere
  - Monitors are unshielded and see a large fraction of the containment volume

SCENARIO

- **The licensee confirms the leak to the auxiliary building is larger than their attempts to make up level to the core. They estimate the core will become uncovered shortly.**
- **Strategy**
  - **Now we have enough information to run a complete dose assessment with a significant release and a release pathway.**
  - **The information we have (suggesting core uncovery) aligns with the RASCAL LOCA model.**

LOCA - How This Works in RASCAL

The source term model for Loss-of-Coolant Accidents (LOCA) in RASCAL is based on NUREG-1465.

It assumes that a core not covered by water is unable to remove enough heat and starts to heat to the point of fuel melt. After the reactor is uncovered, the model will release fractions of the core inventory based on these phases:

- 30 minutes of cladding failure/gap release
- 80-90 minutes of core melt
- 2-3 hours of vessel melt-through

The shutdown time in the model is used to decay correct all the isotopes in the core. The reactor recovery time is used to stop additional nuclides from contributing to the source term. The core damage processes after heat-up are very similar to the LTSBO timeline.

Your Turn to Use RASCAL

Given the scenario excerpt below, run the entire case in RASCAL.

Run a LOCA model case using the following information.

Palo Verde Unit 1. Shutdown at 08:35. The licensee estimates the core will become uncovered at 09:45. There is currently no estimated time of recovery. The licensee estimates that given their makeup attempts and sump fill rates, the leak into the aux building is approximately 100 gal/min. They believe their aux building filters are intact and operating. Use the previously entered observation/forecast for weather.

Additionally, protective actions are being considered for 12 hours from now. Run your assessment using 12-hour calculation duration to estimate potential doses until that time.

LET'S WALK THROUGH THE PROBLEM TOGETHER

Knowledge Check

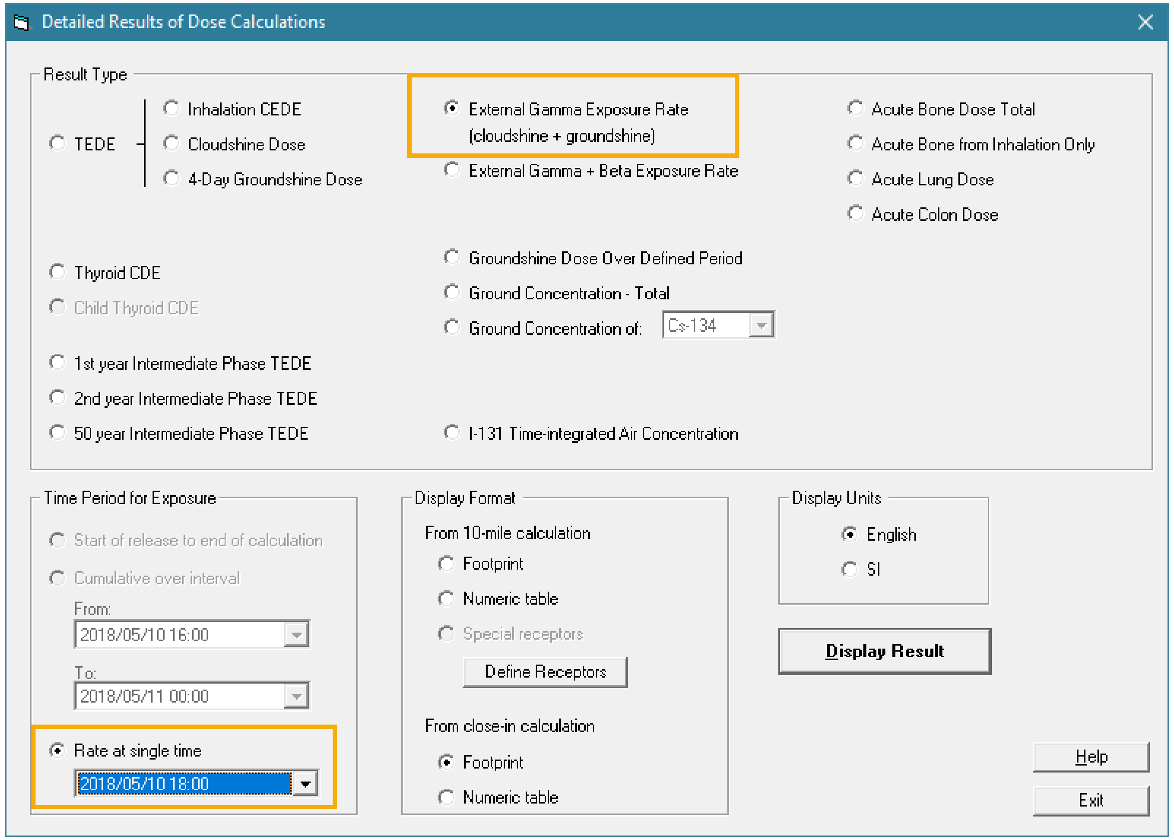
What is the projected TEDE (rem) at 5.0 miles?

- 6.9E-01
- 1.5E+00
- 3.3E+01
- None of the above values

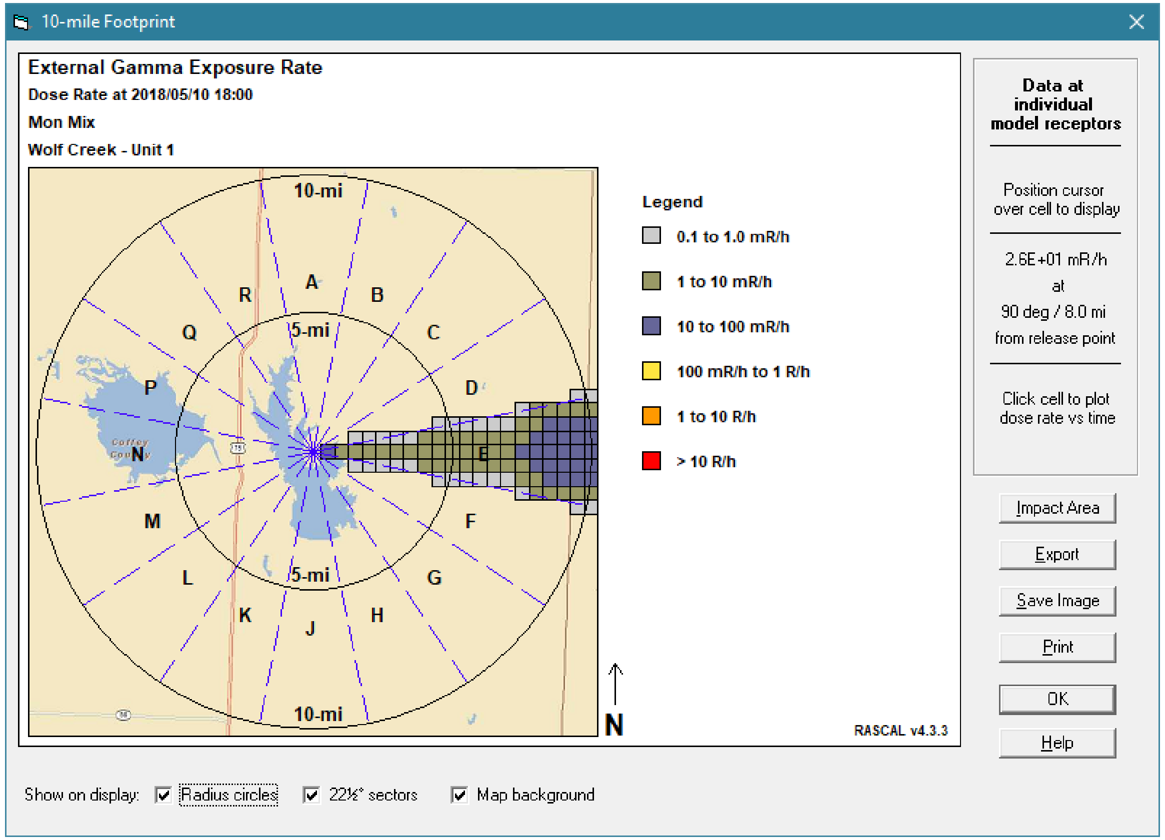
SCENARIO

- Field teams have been dispatched to several locations.
- Strategy
  - Field measurements will always provide better data than RASCAL projections; however, it may be useful to align projections to field team data before lots of field data is available.
  - This alignment can help inform future field team operations or interpolate field team data points.

FIELD TEAM COMPARISON - HOW THIS WORKS IN RASCAL



One of the detailed results options is to view the gamma dose rate.
Set the time to the time of the field measurement



Mouse over the cells to see the data values. More information can be seen if you click on the cell.

Your Turn to Use RASCAL

Use the previous RASCAL run and compare the results to below

Field teams have been dispatched and reported measurements at 14:00 local time. Do these readings confirm that your dose projections are representative of the actual release?

Field Team & Location	Gamma Reading	RASCAL Projected Value
Team 1 202° - 2.7 miles	162 mR/h	?
Team 2 193° - 9.2 miles	4.9 mR/h	?
Team 3 90° (east) – 2 miles	0.06 mR/h	?

Let’s walk through the problem together

***We can also show you useful result types like direct reading dosimeter conversions and at preset locations.**

Knowledge Check

For Field Team 1 (202 deg at 2.7 miles), what is the projected gamma reading (mR/h) at 14:00?

- 7.8E+01 mR/h
- 1.4E+02 mR/h
- 2.1E+02 mR/h
- None of the above values

Field team 3 reports a gamma value of 0.06 mR/h at a point 2 miles east of the plant. Does your RASCAL projection align with that?

- No, the field team must be measuring wrong
- No, my RASCAL results are probably wrong
- Yes, my RASCAL run reported 0.06 at that location
- Yes, my run projected 0.0 but field team numbers reflect background and noise

Field Team Comparison - Conclusion

- **Our Answers**

Field Team & Location	Gamma Reading	RASCAL Projection
Team 1 202° - 2.7 miles	162 mR/h	140 mR/h
Team 2 193° - 9.2 miles	4.9 mR/h	5.4 mR/h
Team 3 90° (east) – 2 miles	0.06 mR/h	0

Review

- **Today, we covered a more realistic scenario that used multiple RASCAL runs and models**
- **It is likely that during a real event, more than 1 run will be needed**
- **Sometimes information changes and becomes more available throughout the event**

This concludes our Evolving Scenario unit

Remember that resources & training can be found at:

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