



RASCAL 4.0

Radiological Assessment System for Consequence Analysis

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RASCAL v4 – The New RASCAL

- What is new?
- Why is it changed?
- What are the implications of the changes?
- Are the changes reasonable?

The Changes

- Radioactive decay scheme
- Monitored mix release type
- Atmospheric dispersion and deposition

Radioactive Decay

- What are the Implications of the Change?
 - The changes in decay schemes should not result in any significant changes in dose estimates; however, they significantly alter DRL estimates.
 - Truncation errors have been evaluated and are generally $\ll 1\%$
 - Addition of implicit daughters and simplification of chains that include branching increases doses slightly at short times

Monitored Release

- Assumptions
 - Monitored pathway
 - Monitor capable of distinguishing between particle and noble gas activity
 - Reactor is shutdown with core damage
 - Particles are CsI

Monitored Release

Monitored Release Particle Activity Fraction

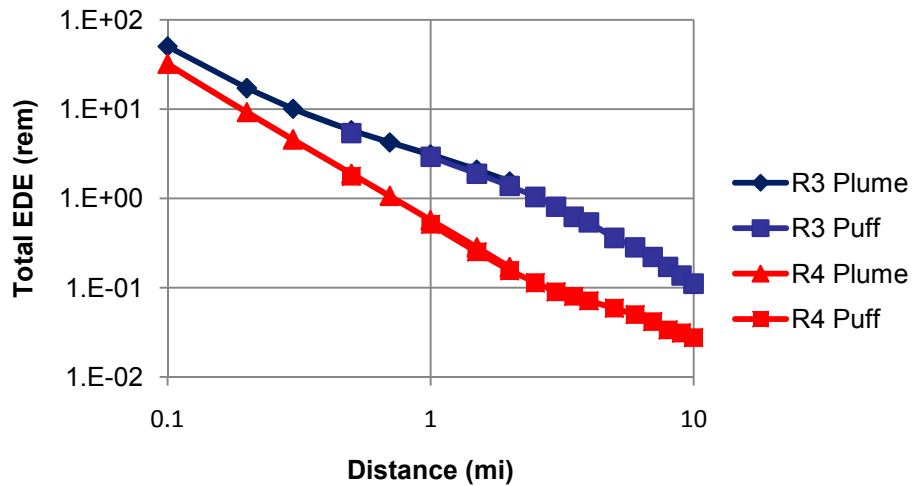
Isotope	RASCAL v3.0.5	RASCAL v4
I-131	0.500	0.115
I-132		0.167
I-133		0.233
I-134		0.258
I-135		0.223
Cs-134		0.00193
Cs-136		0.000613
Cs-137	0.500	0.00134

Atmospheric Dispersion

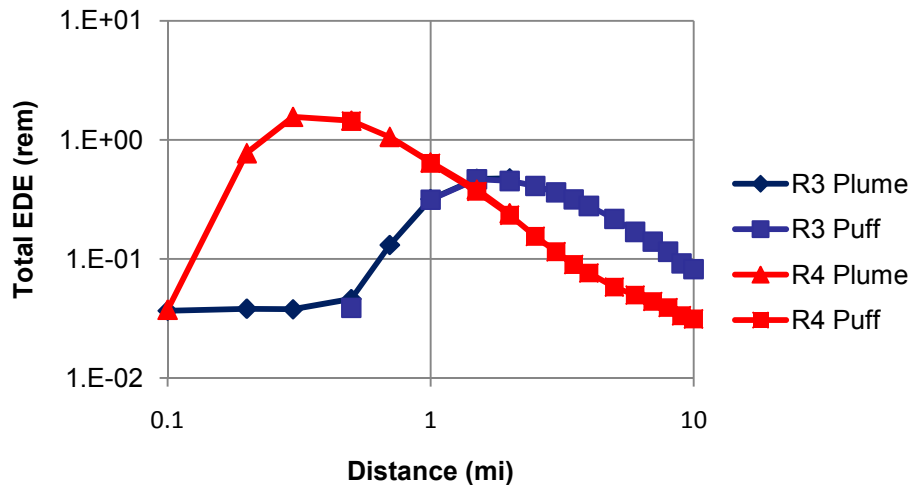
- Why the Change?
 - The Pasquill-Gifford dispersion parameters were based on dispersion experiments in the 1950s.
 - Atmospheric experiments on dispersion and boundary layer processes in the 1960s, 1970s, and 1980s provide better methods of estimating atmospheric dispersion.

Atmospheric Dispersion

Ground Level,
D Stability, 3 m/s



Elevated,
D Stability, 3 m/s



Atmospheric Dispersion and Deposition

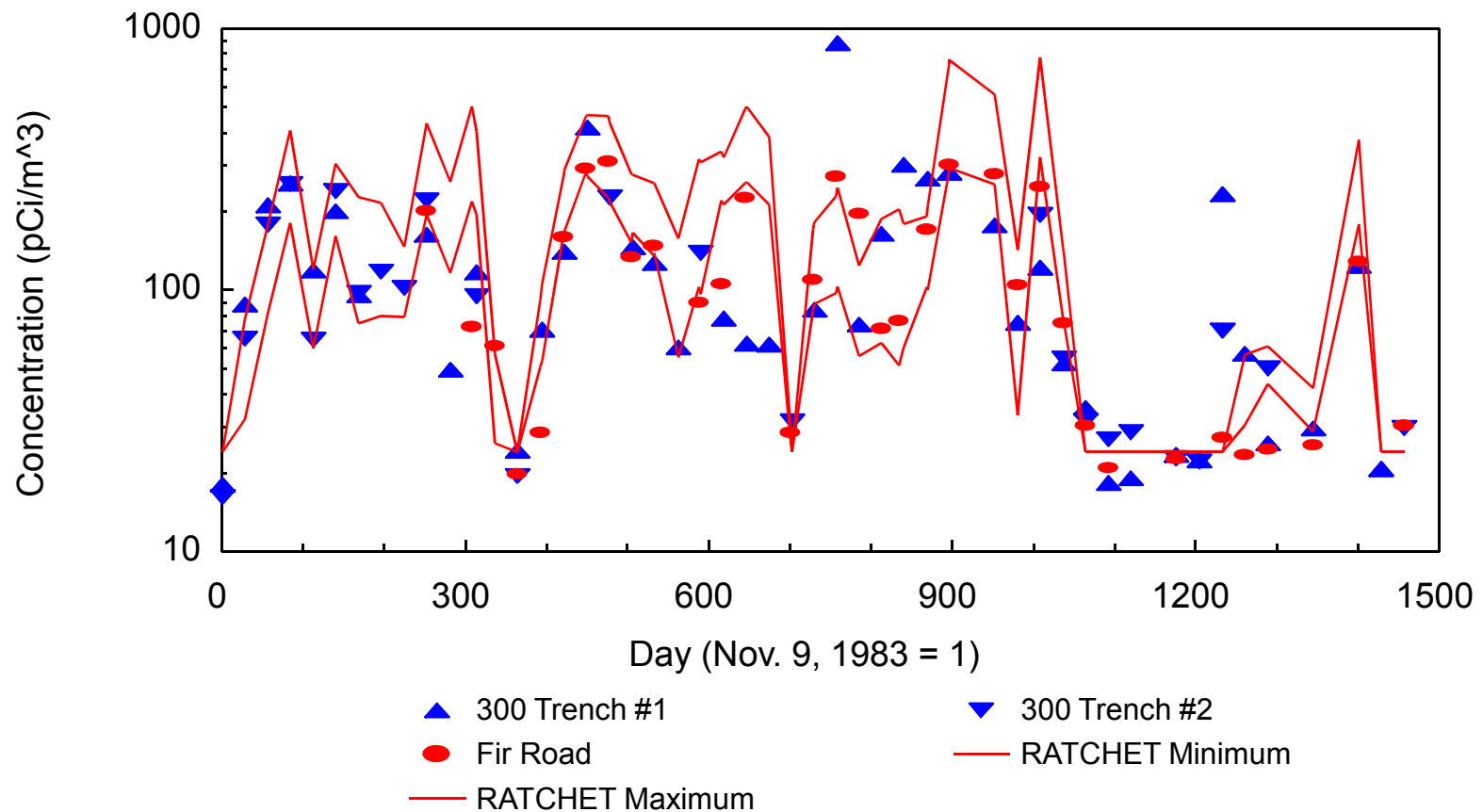
- Are the Dispersion and Deposition Changes Reasonable?
 - The new dispersion and deposition algorithms were developed for environmental dose reconstruction at Hanford in the 1990s
 - The development and application of the new algorithms were extensively reviewed by leading experts including F. Gifford and scientific organizations including the National Academy of Sciences.

Atmospheric Dispersion and Deposition

- Are the Dispersion and Deposition Changes Reasonable?
 - The Hanford Environmental Dose Reconstruction Project included an extensive validation effort
 - The dispersion and deposition algorithms have been used in subsequent dose reconstruction projects (ORNL, INEL, Rocky Flats, and Mayak, USSR)

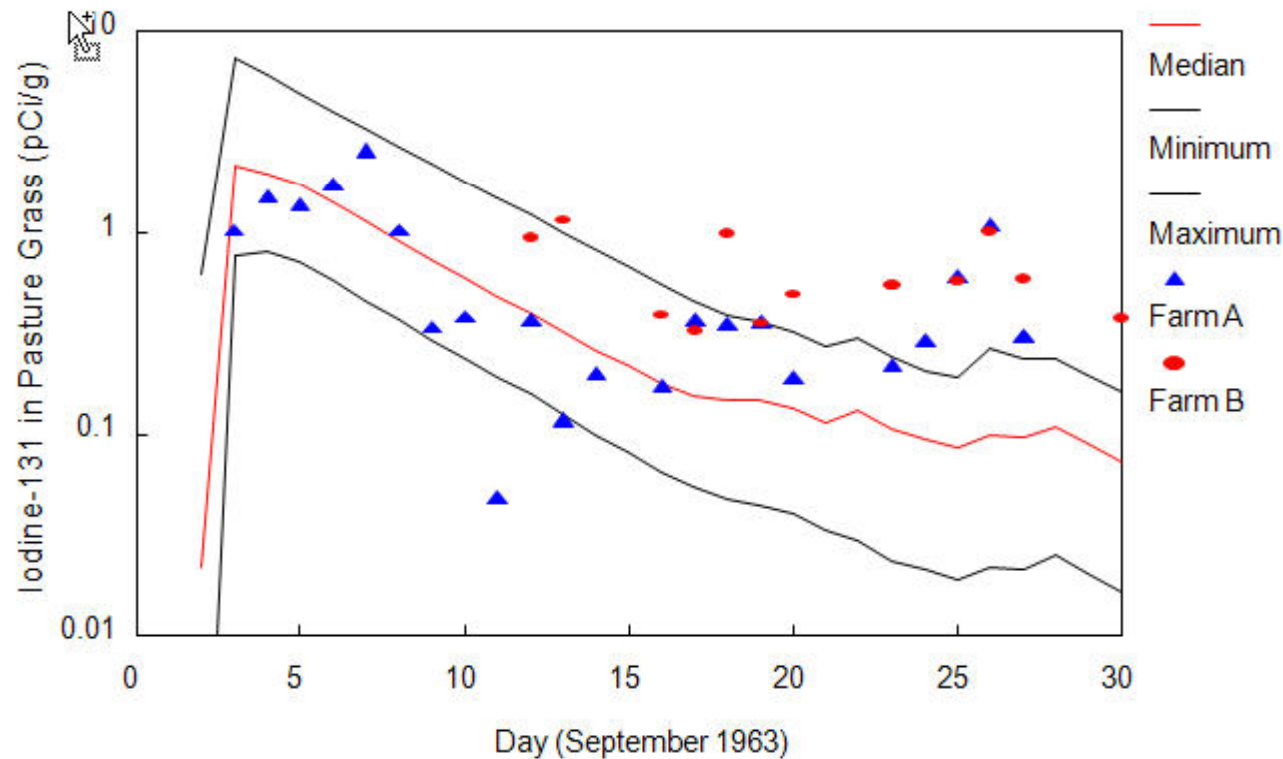
Atmospheric Dispersion

Kr-85 Predictions for Routine Releases at Hanford



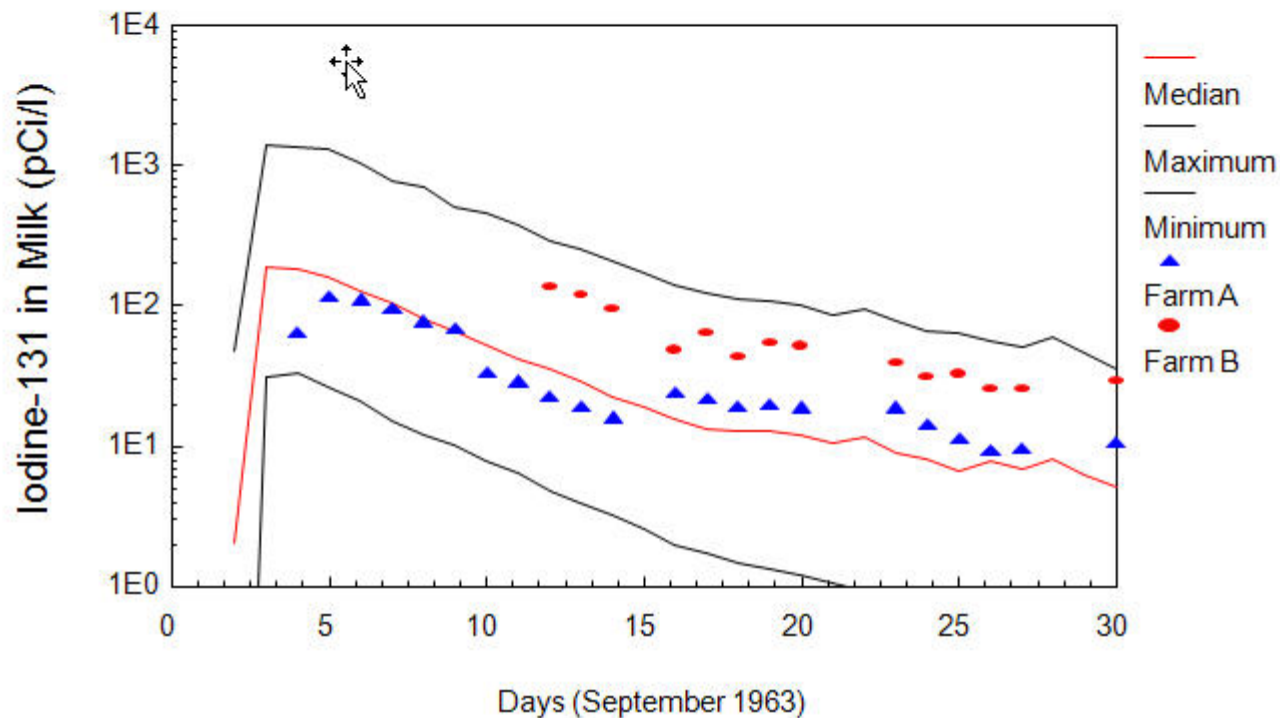
Atmospheric Dispersion and Deposition

Iodine in Grass Following Unintended Release at Hanford (Sept. 1963)



Atmospheric Dispersion and Deposition

Iodine in Milk Following Unintended Release at Hanford (Sept. 1963)



Atmospheric Dispersion and Deposition

The Bottom Line For an Unintended Release at Hanford
(Sept 1963)

	HEDR Median Thyroid Dose Estimate (mrad)	Contemporary Thyroid Burden Estimates (mrad)
Boy	45.3	35
Girl	11.3	9

Contrast w/RASCAL 3.0.5

- Highlight new features – new ATD model
- Case Study - Fixed Parameters

Byron NPP, Core uncovered 1 hr

2% release per day, no spray, no filters

activity released – 9.5 E5 Curies 3.0.5

-- 8.9 E5 Curies 4.0

- Case Study – Varying Parameters
Stability Classes B and E
2 & 8 mph wind speeds, no precip

Byron Unit 2: Source Term

The screenshot displays the 'Source Term to Dose - [New Case.STD]' application window. The main interface has a menu bar (File, Options, Nuclide Data Viewer, Site / Facility Data Viewer, Help) and a sidebar with buttons for 'Event Type' (NPP Reactor), 'Event Location' (Byron - Unit 2), 'Source Term' (highlighted with an orange box), 'Meteorology', 'Release Path', 'Calculate Doses', 'Detailed Results', and 'Save Case'. The main area shows a 'Case Summary' with fields for 'Event Type' (Nuclear Power Plant), 'Location' (Byron - Unit 2, Byron, Ogle, IL), and 'Reactor Parameters' (Reactor power: 358, Average fuel burn-up: 300, Containment type: PW, Containment volume: 2.90, Design pressure: 61, Design leak rate: 0.10, Coolant mass: 2.51, Assemblies in core: 193, Steam generator type: U-Tube).

Two sub-dialogs are open. The 'Source Term Options for Nuclear Power Plant' dialog shows 'Source term based on reactor conditions' with 'Time Core Is Uncovered' selected (highlighted with an orange box). The 'Time Core Is Uncovered' dialog shows 'Reactor shutdown' (2010/02/20 00:00), 'Core uncovered?' (Yes, 2010/02/20 01:00, highlighted with an orange box), and 'Core recovered?' (Yes, 2010/02/20 02:00, highlighted with an orange box). The 'Time Core Is Uncovered' dialog also includes 'OK', 'Cancel', and 'Help' buttons.

Release Pathway

Source Term to Dose - [New Case]

File Options Nuclide Data View

Follow the steps below to define and run a problem

☒ **Event Type**
NPP Reactor

☒ **Event Location**
Byron - Unit 2

☒ **Source Term**
Time Core Is Uncovered

☒ **Release Path**
<undefined>

☐ **Meteorology**
<undefined>

Calculate Doses

Detailed Results

Save Case

Available release pathways

Select the release pathway option to be used in the calculations

☒ Containment leakage/failure

☐ Steam generator tube rupture

☐ Containment bypass

PWR Dry Containment – Leakage/Failure

OK

Cancel

Help

Print

Release Pathway Options

PWR - Dry Containment Leakage or Failure

Pathway description: (optional; 60 character max)

Release height:

Release timings: Core uncovered: 2010/02/20 01:00

Leak rate to atmosphere described by: ☒ Percent volume / time
☐ Containment pressure / hole size

Date	Time	Event	Event setting
2010/02/20	01:00	Leak rate (% vol)	2.000 %/d
2010/02/20	01:00	Sprays	Off

Leak Rate as Percent of Volume

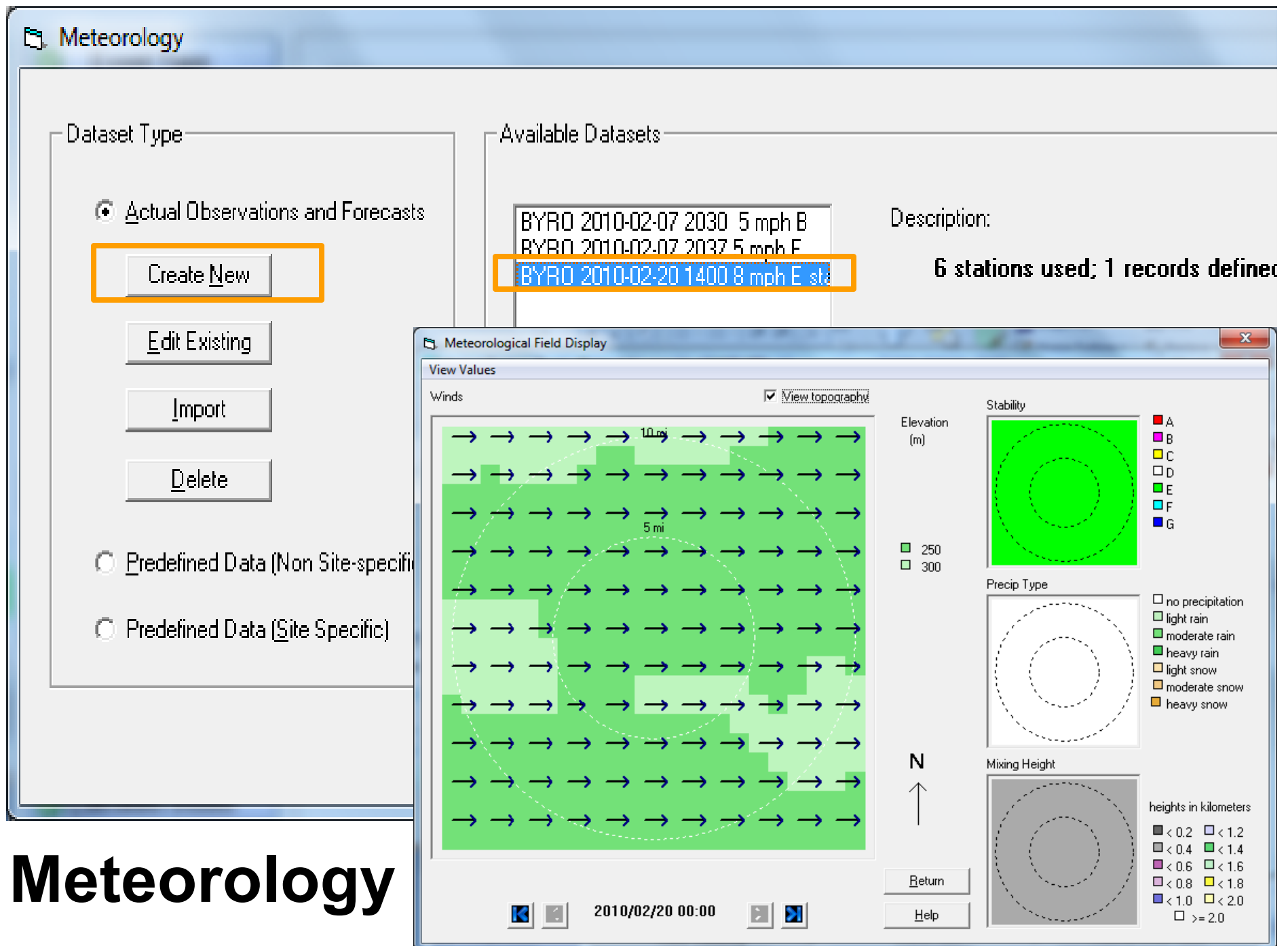
☐ Total Failure (100 %/h)

☒ Percent Volume: % per

☐ Design (0.10 %/d)

Buttons: Add Row, Remove Row, Sort Rows, Clear All, OK, Cancel, Help

Minimum 10 m release height
is optimum model default



Meteorology

Calculate

Source Term to Dose - [Byron 1 hr uncovered N]

File Options Nuclide Data Viewer Site / Facility

Follow the steps below to define and run a problem

- ☒ **Event Type**
NPP Reactor
- ☒ **Event Location**
Byron - Unit 2
- ☒ **Source Term**
Time Core Is Uncovered
- ☒ **Release Path**
PWR Dry
- ☒ **Meteorology**
Actual Observations
- ☒ **Calculate Doses**
- Detailed Results
- ☐ **Save Case**

Case Summary

Event Type

Location
Name:
City, county:
Lat / Long / E:
Time zone:
Population (2

Reactor Param
Reactor power:
Average fuel:
Containment:
Containment:
Design press:
Design leak r:
Coolant mass:
Assemblies i:
Steam gener

Start the Calculations

Specify options and description for this set of calculations, then OK to begin calculations.

Distance of calculation:

- ☒ Close-in + out to 10 miles (16 km)
- ☐ Close-in + out to 25 miles (40 km)
- ☐ Close-in + out to 50 miles (80 km)
- ☐ Close-in only

Using close-in distances in miles:
0.1, 0.2, 0.3, 0.5, 0.7, 1.0, 1.5, 2.0

☒ Defaults ☐ User defined

Start of release to atmosphere: 2010/02/20 01:00 (from release pathway definition)

End calculations at:

- ☒ Start of release to atmosphere plus: 8 hours
- ☐ User specified time: 2010/02/20 07:00

Case description: Byron 1 hr uncovered (required)

OK Cancel Help

Case Summary Source Term Maximum Dose Values

Default 8
hour dose
calculation

Source Term to Dose - [Byron 1 hr uncovered NREP.STD]

File Options Nuclide Data Viewer Site / Facility Data Viewer Help

Follow the steps below to define and run a problem

Use the Tabs below to review information.

Results

☒ **Event Type**
NPP Reactor

☒ **Event Location**
Byron - Unit 2

☒ **Source Term**
Time Core Is Uncovered

☒ **Release Path**
PWR Dry

☒ **Meteorology**
Actual Observations

☒ **Calculate Doses**

☐ **Detailed Results**

☐ **Save Case**

Maximum Dose Values (rem) - To 10 mi

Dist from release miles (kilometers)	3 (4.8)	4 (6.4)	5 (8.0)	7 (11.3)	10 (16.1)
Total EDE	6.9E-01	4.8E-01	3.8E-01	2.5E-01	1.6E-01
Thyroid CDE	<u>1.0E+01</u>	<u>7.1E+00</u>	<u>5.7E+00</u>	3.8E+00	2.4E+00
Inhalation CEDE	4.4E-01	3.1E-01	2.5E-01	1.6E-01	1.0E-01
Cloudshine	4.1E-02	3.0E-02	2.5E-02	1.7E-02	1.1E-02
1 day Groundshine	2.0E-01	1.4E-01	1.1E-01	7.1E-02	4.3E-02
Inter Phase 1st Yr	<u>3.0E+00</u>	<u>2.0E+00</u>	1.6E+00	1.0E+00	6.3E-01
Inter Phase 2nd Yr	<u>1.9E+00</u>	<u>1.3E+00</u>	1.0E+00	6.6E-01	4.1E-01

Notes:

- Doses exceeding PAGs are underlined.
- Early-Phase PAGs: TEDE - 1 rem, Thyroid (iodine) CDE - 5 rem
- Intermediate-Phase PAGs: 1st year - 2 rem, 2nd year - 0.5 rem
- *** indicates values less than 0.1 mrem
- To view all values - use Detailed Results | Numeric Table

Value displayed: ☐ Close-in dose ☒ Doses to 10 miles ☐ Criticality shine dose

Display units: ☒ English ☐ Metric

Definitions Print

Case Summary **Source Term** Maximum Dose Values

New

Check this

m to Dose Model

Viewer Site / Facility Data Viewer Help

Use the Tabs below to review information.

RASCAL 3.0.5

Source Term

Total activity released to atmosphere: 9.5E+05 Ci

Activity Released 6% lower

Nuclide	Ci	Nuclide
Ba-137m	1.1E+03	La-140
Ba-140	1.5E+03	Mo-99
Ce-144	2.0E+01	Np-239
Cs-134	2.2E+03	Pr-144
Cs-135	9.2E-06	Pr-144m
Cs-136	5.1E+02	Pu-239
Cs-137	1.4E+03	Rb-87
Cs-138	1.3E+03	Rb-88
I-129	3.1E-08	Rh-103m
I-131	1.8E+04	Rh-106
I-132	1.8E+04	Ru-103
I-133	3.3E+04	Ru-106
I-134	5.6E+03	Sb-127
I-135	2.3E+04	Sb-129

Notice Cs-137*

Source Term to Dose - [Byron 1 hr uncovered NREP.STD]

File Options Nuclide Data Viewer Site / Facility Data Viewer Help

Follow the steps below to define and run a problem

RASCAL 4.0

Use the Tabs below to review information.

☒ **Event Type**
 NPP Reactor

☒ **Event Location**
 Byron - Unit 2

☒ **Source Term**
 Time Core Is Uncovered

☒ **Release Path**
 PWR Dry

☒ **Meteorology**
 Actual Observations

Source Term

Total amount released to atmosphere: 8.9E+05 Ci

Nuclide	Ci	Nuclide	Ci	Nuclide
Ba-139	2.8E+02	La-142	3.0E+00	Sr-92
Ba-140	1.3E+03	Mo-99	1.7E+02	Tc-99m
Ce-141	3.1E+01	Nb-95	1.3E+01	Te-127
Ce-143	2.6E+01	Nb-97	4.6E-01	Te-127m
Ce-144*	2.5E+01	Nd-147	4.9E+00	Te-129
Cm-242	3.2E-01	Np-239	3.9E+02	Te-129m
Cs-134	1.9E+03	Pm-147	5.7E-04	Te-131
Cs-136	7.5E+02	Pr-143	1.1E+01	Te-131m
Cs-137*	1.3E+03	Pr-144	2.1E+01	Te-132
Cs-138	9.1E+02	Pu-241	2.4E+00	Xe-131m
I-131	1.7E+04	Rb-86	2.7E+01	Xe-133
I-132	1.7E+04	Rb-88	4.0E+04	Xe-133m
I-133	3.1E+04	Rh-103m	1.3E+02	Xe-135

the Tabs below to review information.

RASCAL 3.0.5

s (rem) - Close-In

TEDE (top) & CDE

0.2 (0.32)	0.3 (0.48)	0.5 (0.8)	0.7 (1.13)	1. (1.61)	1.5 (2.41)	2. (3.22)
<u>3.5E+01</u>	<u>2.1E+01</u>	<u>1.2E+01</u>	<u>9.2E+00</u>	<u>7.0E+00</u>	<u>5.0E+00</u>	<u>3.9E+00</u>
<u>6.6E+02</u>	<u>3.8E+02</u>	<u>2.2E+02</u>	<u>1.7E+02</u>	<u>1.3E+02</u>	<u>9.1E+01</u>	<u>7.1E+01</u>
<u>2.2E+01</u>	<u>1.3E+01</u>	<u>7.4E+00</u>	<u>5.5E+00</u>	<u>4.2E+00</u>	<u>3.0E+00</u>	<u>2.3E+00</u>
<u>2.9E+00</u>	<u>1.8E+00</u>	<u>1.1E+00</u>	<u>8.8E-01</u>	<u>7.0E-01</u>	<u>5.1E-01</u>	<u>4.0E-01</u>
<u>2.8E+01</u>	<u>1.6E+01</u>	<u>9.5E+00</u>	<u>7.1E+00</u>	<u>5.4E+00</u>	<u>3.9E+00</u>	<u>3.0E+00</u>
<u>8.7E-01</u>	<u>6.3E-01</u>	<u>4.5E-01</u>	<u>3.6E-01</u>	<u>3.1E-01</u>	<u>2.4E-01</u>	<u>1.9E-01</u>
<u>1.4E+00</u>	<u>8.0E-01</u>	<u>4.7E-01</u>	<u>3.5E-01</u>	<u>2.6E-01</u>	<u>1.8E-01</u>	<u>1.4E-01</u>
<u>6.6E+00</u>	<u>3.9E+00</u>	<u>2.2E+00</u>	<u>1.7E+00</u>	<u>1.3E+00</u>	<u>9.1E-01</u>	<u>7.0E-01</u>

underlined.

rem Thyroid (iodine) CDE - 5 rem

Display units: ☒ English
☐ Metric

Definitions

Print

Source Term Summary

Maximum Dose Values

the Tabs below to review information.

4.0

n) - Close-In

0.3 (0.48)	0.5 (0.8)	0.7 (1.13)	1. (1.61)	1.5 (2.41)
<u>0.1</u>	<u>1.4E+01</u>	<u>6.3E+00</u>	<u>4.1E+00</u>	<u>2.6E+00</u>
<u>0.2</u>	<u>2.0E+02</u>	<u>9.1E+01</u>	<u>5.9E+01</u>	<u>3.7E+01</u>
<u>0.1</u>	<u>8.6E+00</u>	<u>3.9E+00</u>	<u>2.6E+00</u>	<u>1.6E+00</u>
<u>0.1</u>	<u>4.0E-01</u>	<u>2.5E-01</u>	<u>1.8E-01</u>	<u>1.2E-01</u>
<u>0.0</u>	<u>4.6E+00</u>	<u>2.1E+00</u>	<u>1.3E+00</u>	<u>8.5E-01</u>
<u>0.2</u>	<u>6.3E+01</u>	<u>2.9E+01</u>	<u>1.9E+01</u>	<u>1.2E+01</u>
<u>0.1</u>	<u>4.0E+01</u>	<u>1.8E+01</u>	<u>1.2E+01</u>	<u>7.6E+00</u>

Values about 1/3 lower

ed.

Thyroid (iodine) CDE - 5 rem

Year - 2 rem, 2nd year - 0.5 rem

n

Results | Numeric Table

Display units: ☒ English
☐ Metric

Definitions

Source Term

23 Maxim

Detailed Results of Dose Calculations

Result Type

- ☒ **TEDE**
 - ☐ Inhalation CEDE
 - ☐ Cloudshine Dose
 - ☐ 4-Day Groundshine Dose
- ☐ External Gamma Dose Rate (cloudshine + groundshine)
- ☐ Acute Bone Dose Total
- ☐ Acute Bone from Inhalation Only
- ☐ Acute Lung Dose
- ☐ Acute Colon Dose
- ☐ Groundshine Dose Over Defined Time Period
- ☐ Ground Concentration - Total
- ☐ Ground Concentration of: Am-241
- ☐ I-131 Air Concentration
- ☐ Thyroid CDE
- ☐ 1st year Intermediate Phase TEDE
- ☐ 2nd year Intermediate Phase TEDE
- ☐ 50 year Intermediate Phase TEDE

Time Period for Exposure

- ☒ Start of release to end of calculation
- ☐ Cumulative over interval

From: 2010/02/20 01:00

To: 2010/02/20 09:00
- ☐ Rate at single time

2010/02/20 09:00

Display Format

From 10-mile calculation

- ☐ Footprint
- ☐ Numeric table
- ☐ Special receptors

Define Receptors

From close-in calculation

- ☒ Footprint
- ☐ Numeric table

Display Units

- ☒ English
- ☐ SI

Display Result

Help

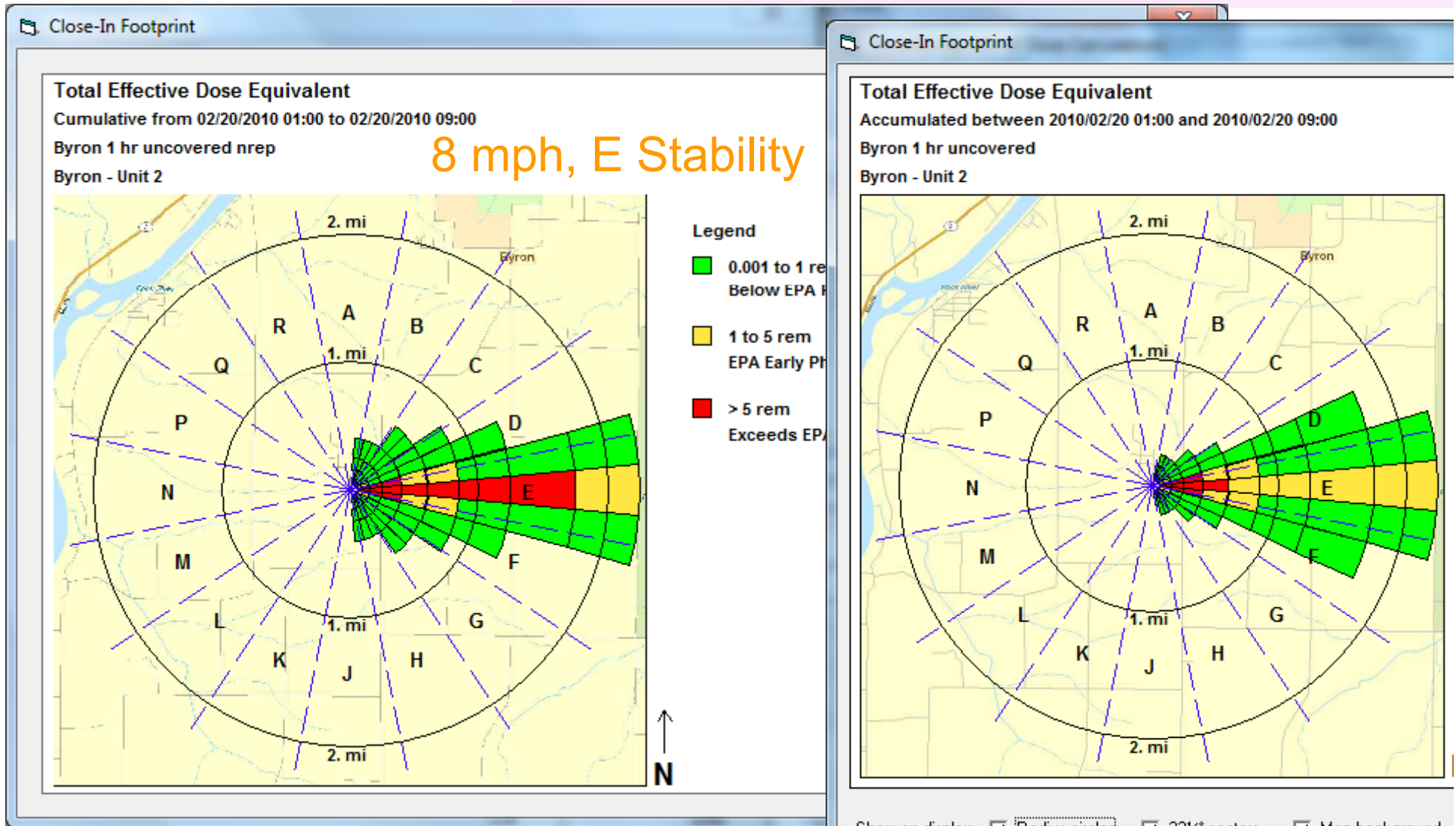
Exit

New
options

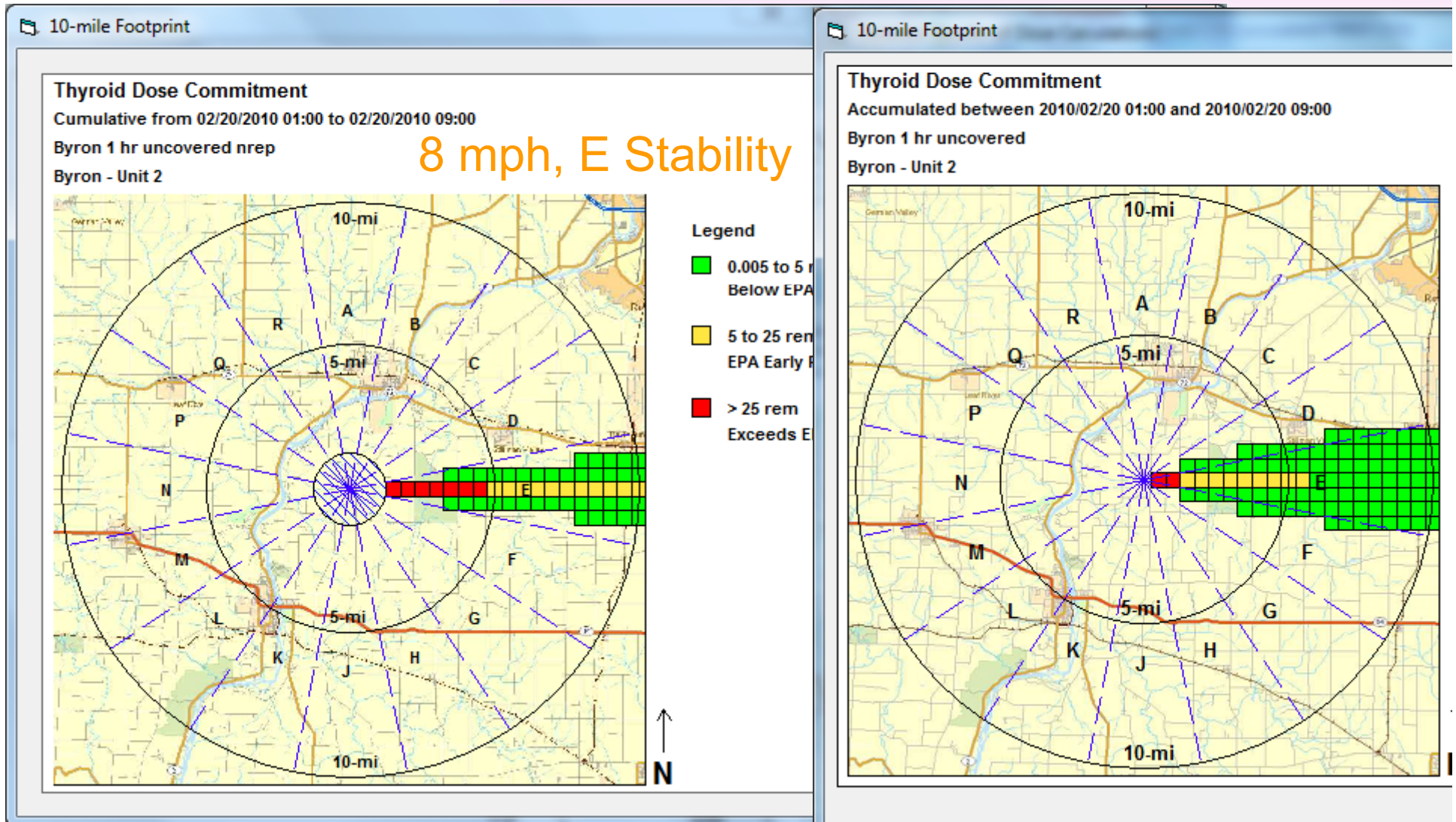
Check TEDE

3.0.5 (left) vs 4.0 TEDE

3.9 rem vs 1.2 rem at 2 mi
1.3 rem vs 0.38 at 5 mi



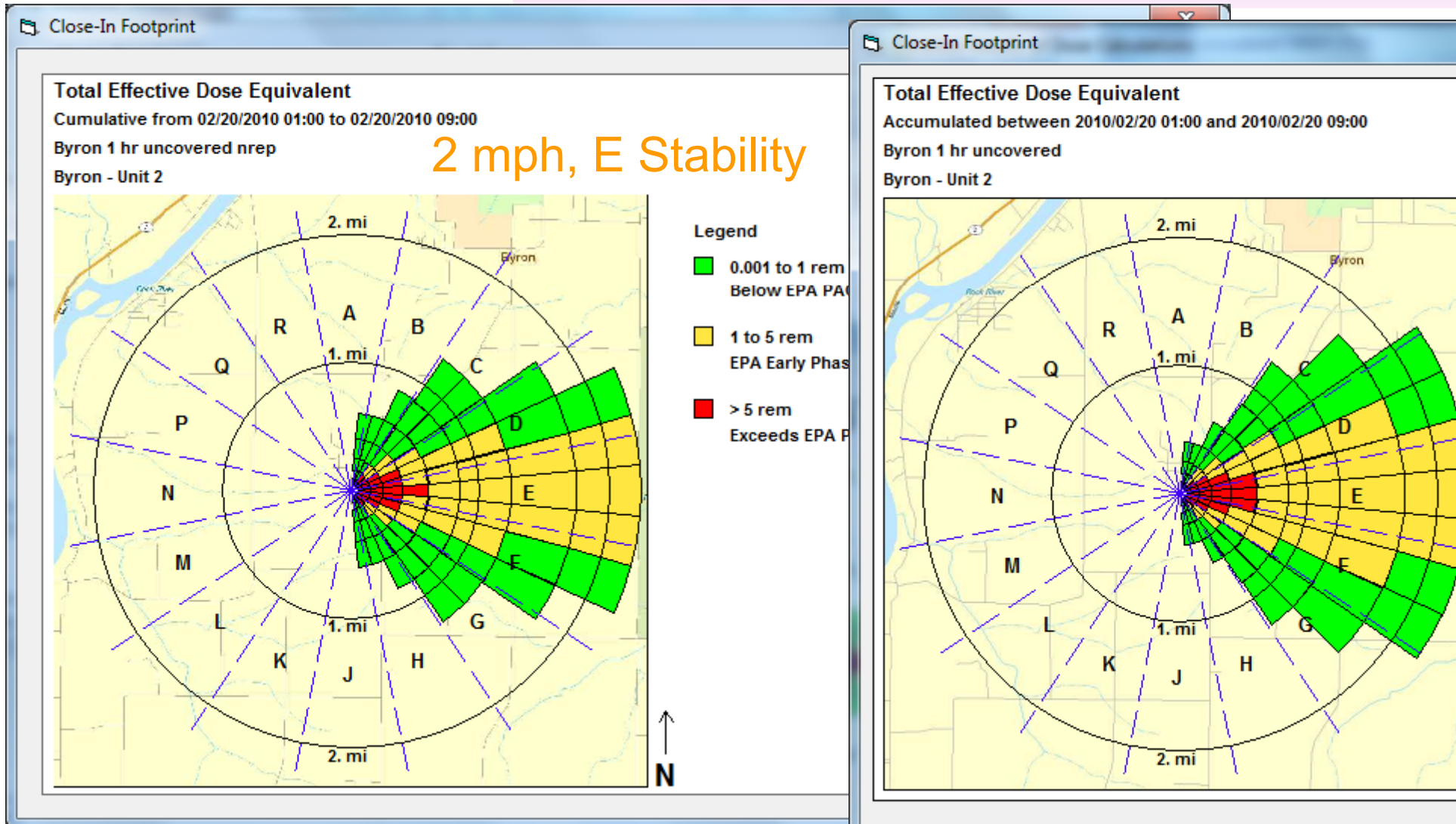
3.0.5 (left) vs 4.0 **Thyroid** 23 rem vs 5.7 rem at 5 mi 8.9 rem vs 2.4 rem at 10 mi



3.0.5 (left) vs 4.0 TEDE

3.3 rem vs 2.3 rem at 2 mi

1.9 rem vs 0.65 at 5 mi



3.0.5 (left) vs 4.0 Thyroid
36 rem vs 13 at 5 mi
15 rem vs 3.2 at 10 mi

10-mile Footprint

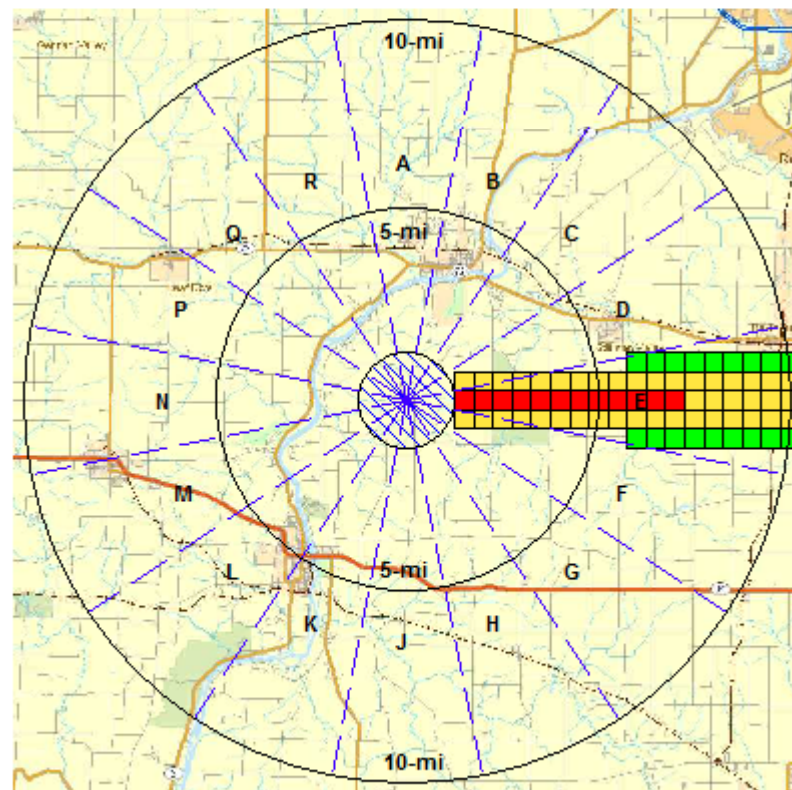
Thyroid Dose Commitment

Cumulative from 02/20/2010 01:00 to 02/20/2010 09:00

Byron 1 hr uncovered nrep

Byron - Unit 2

2 mph, E Stability



Legend

- 0.005 to Below EPA Ear
- 5 to 25 rem
- > 25 rem Exceed

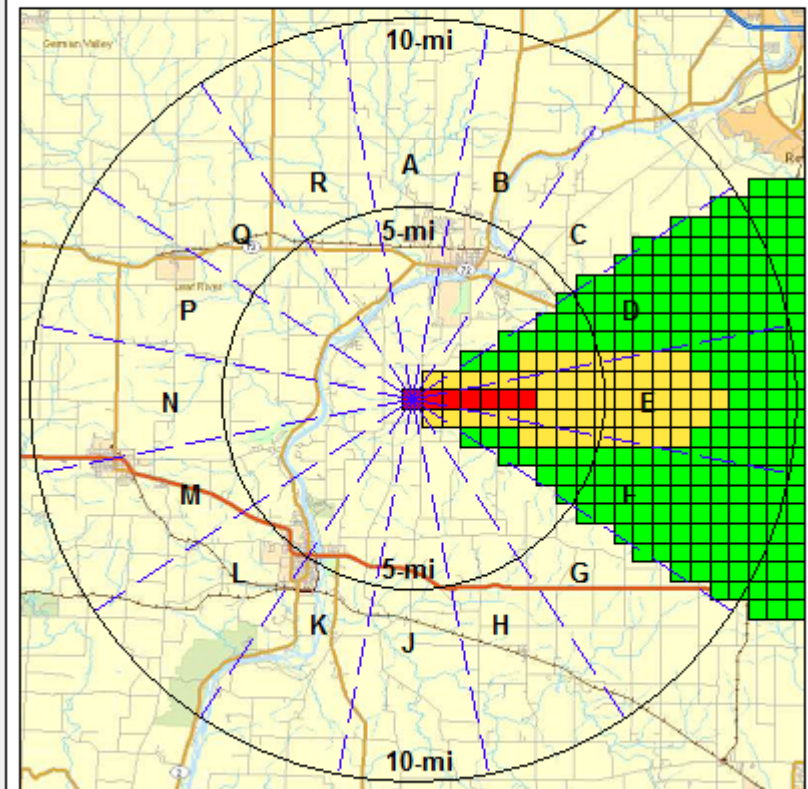
10-mile Footprint

Thyroid Dose Commitment

Accumulated between 2010/02/20 01:00 and 2010/02/20 09:00

Byron 1 hr uncovered

Byron - Unit 2

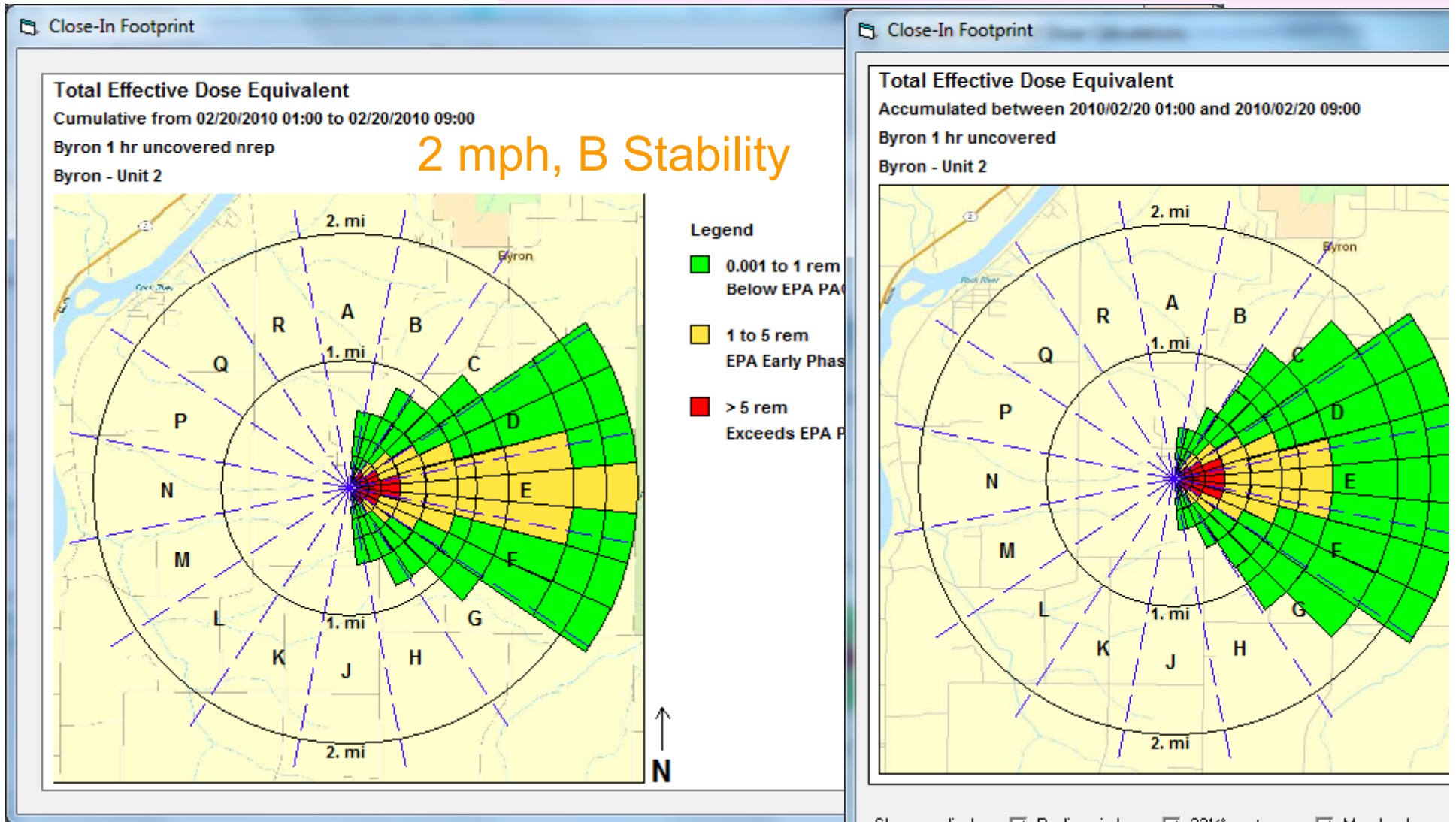


Legend

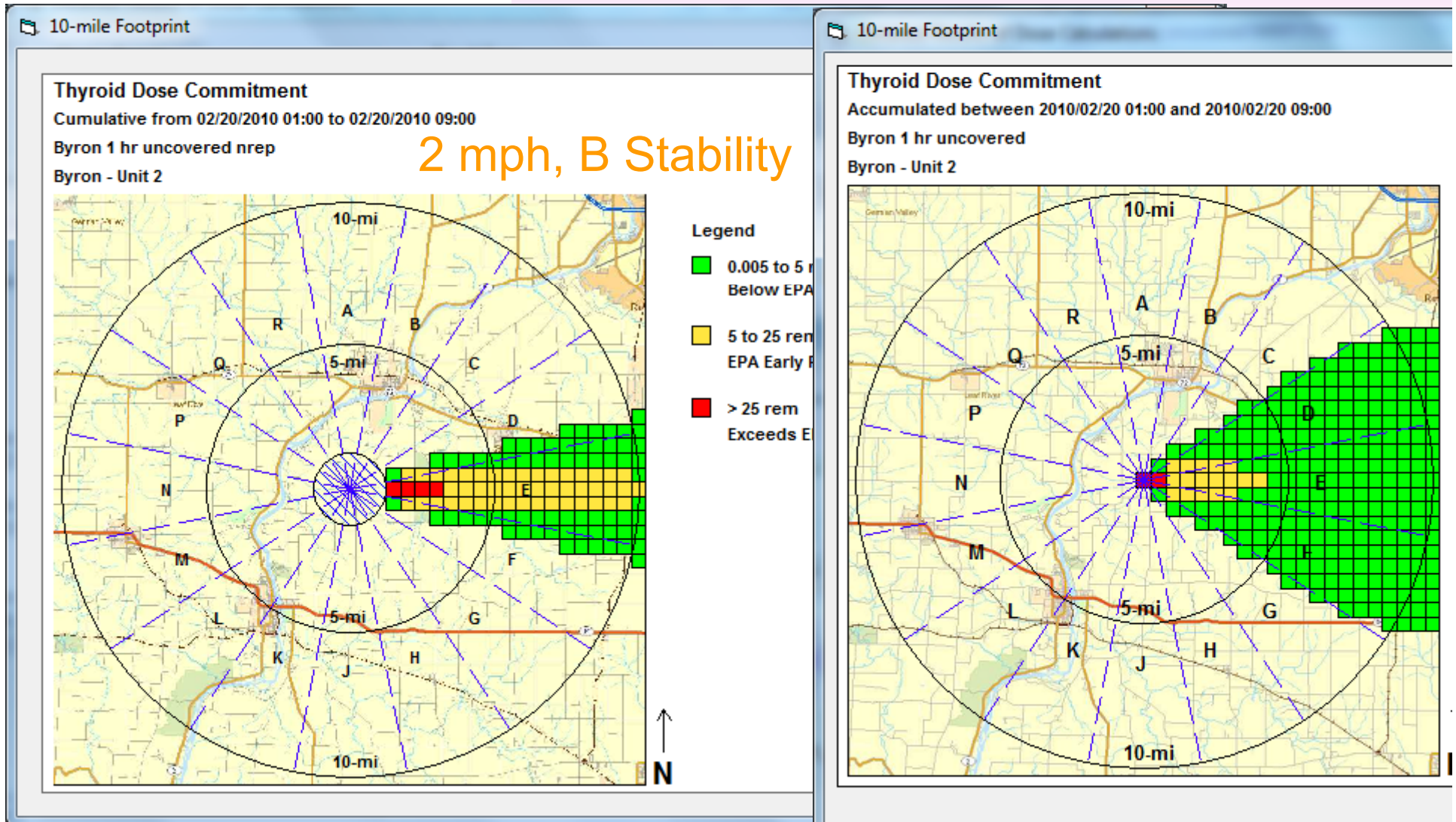
-
-
-

3.0.5 (left) vs 4.0 TEDE

2.1 rem vs **0.44** rem at 2 mi
0.88 rem vs **0.23** at 5 mi

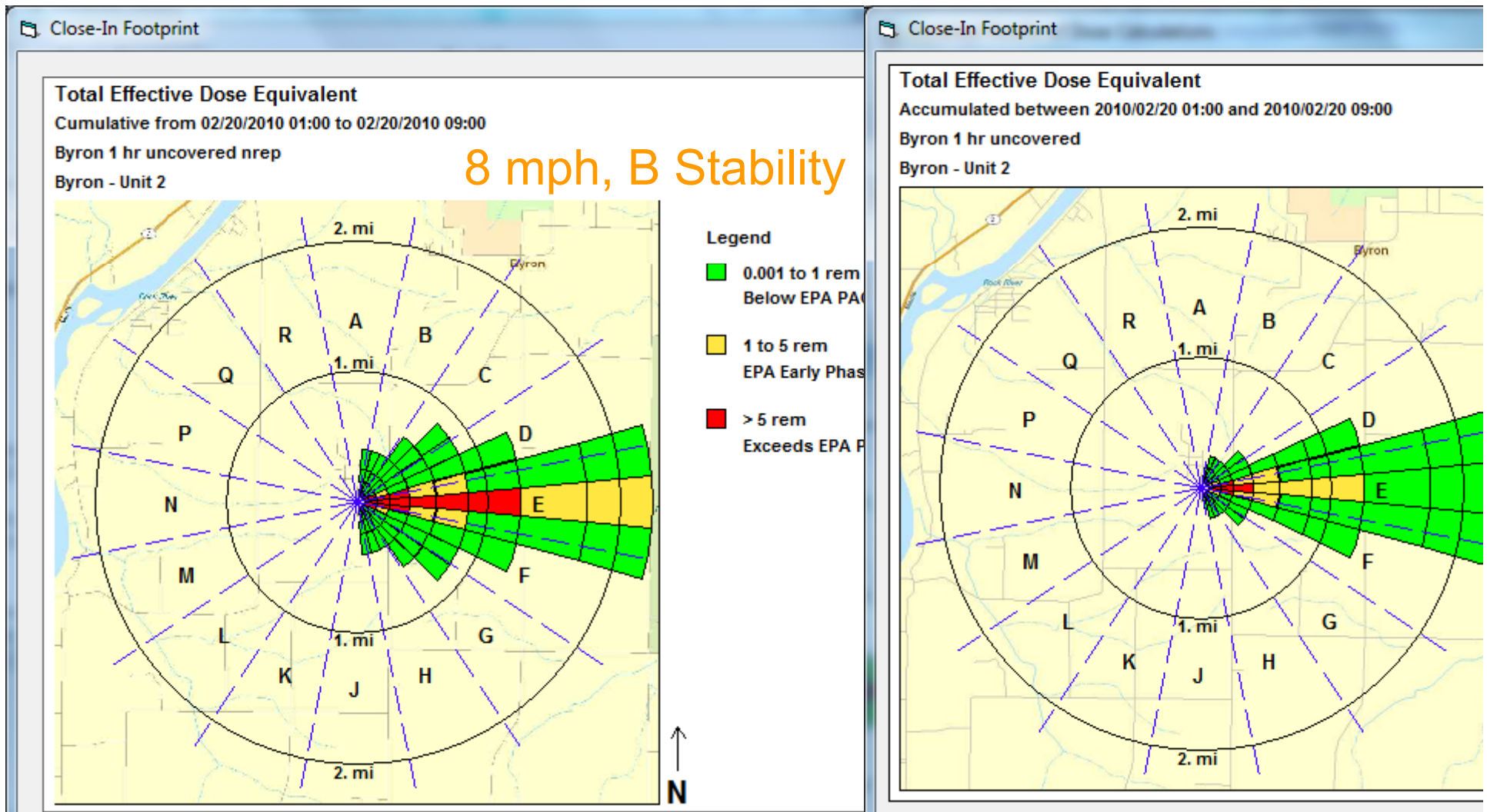


3.0.5 (left) vs 4.0 Thyroid
16 rem vs 3.9 at 5 mi
5.9 rem vs 1.2 at 10 mi

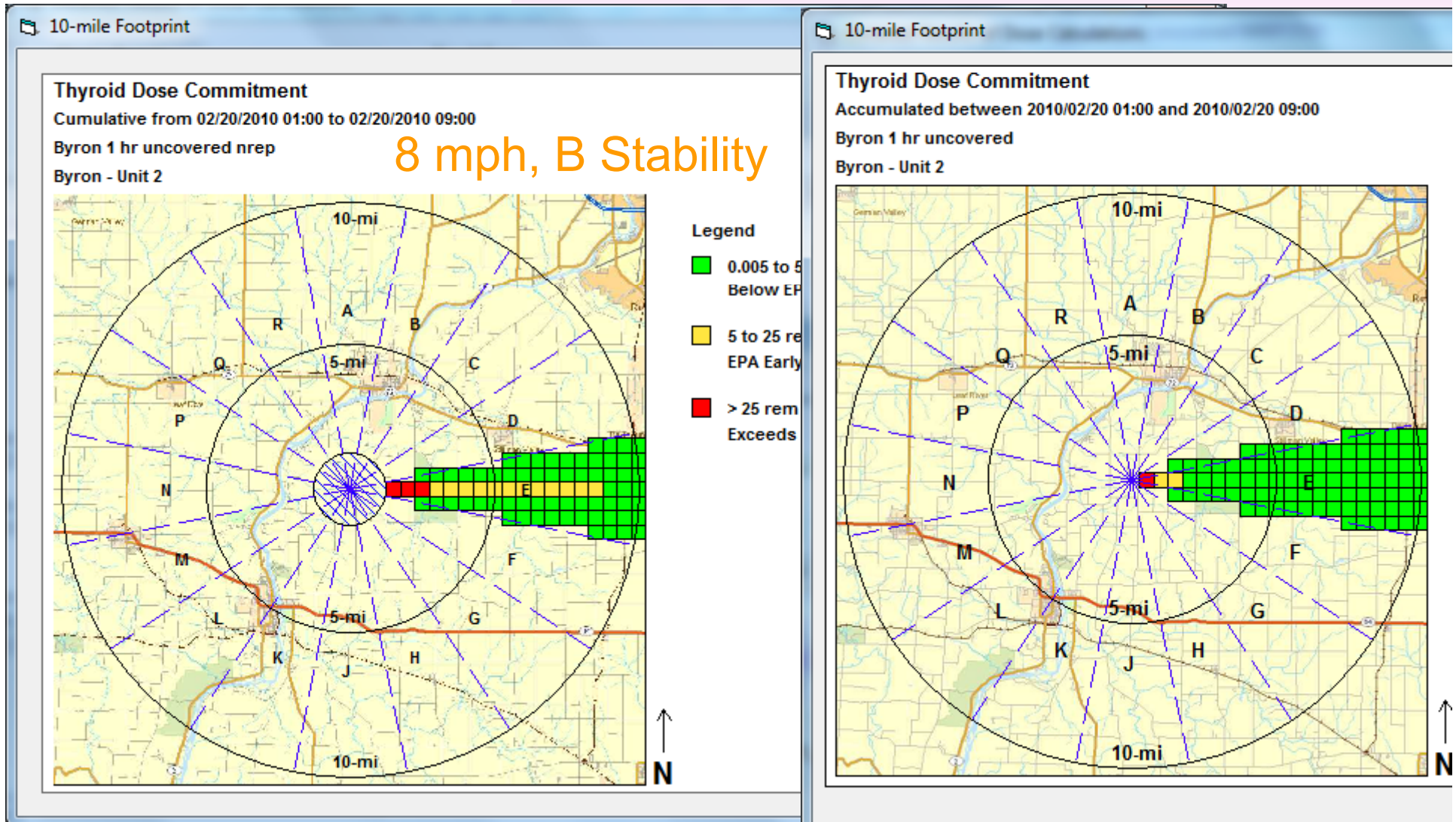


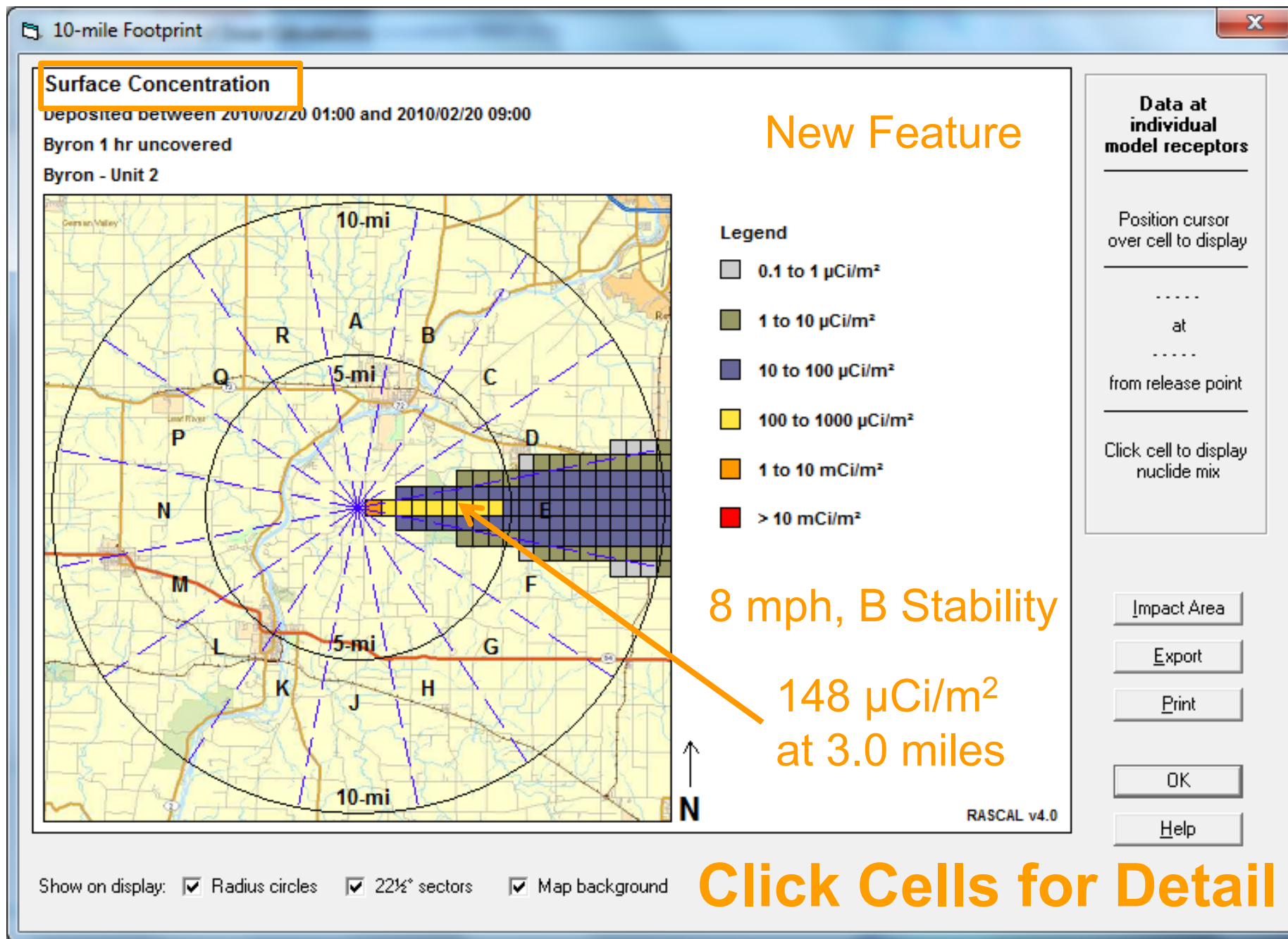
3.0.5 (left) vs 4.0 TEDE

2.4 rem vs 0.33 rem at 2 mi
0.64 rem vs 0.11 at 5 mi



3.0.5 (left) vs 4.0 Thyroid
11 rem vs 1.6 at 5 mi
4.0 rem vs 0.83 at 10 mi





Radionuclide Deposition

Surface Concentration - Radionuclide Mix

Nuclide	$\mu\text{Ci}/\text{m}^2$
I-133	4.67E+01
I-131	3.01E+01
I-135	2.36E+01
Te-132	4.64E+00
Cs-134	3.43E+00
Ba-140	2.46E+00
Cs-137*	2.37E+00
Sr-91	1.59E+00
Cs-136	1.37E+00
Sr-89	1.26E+00
Np-239	6.73E-01
Te-131m	5.81E-01

Deposited between 2010/02/20 01:00 and 2010/02/20 09:00

Bearing / Distance: 90 deg / 3.0 mi (from release point)

Latitude / Longitude: 42.076146° / -89.223617°

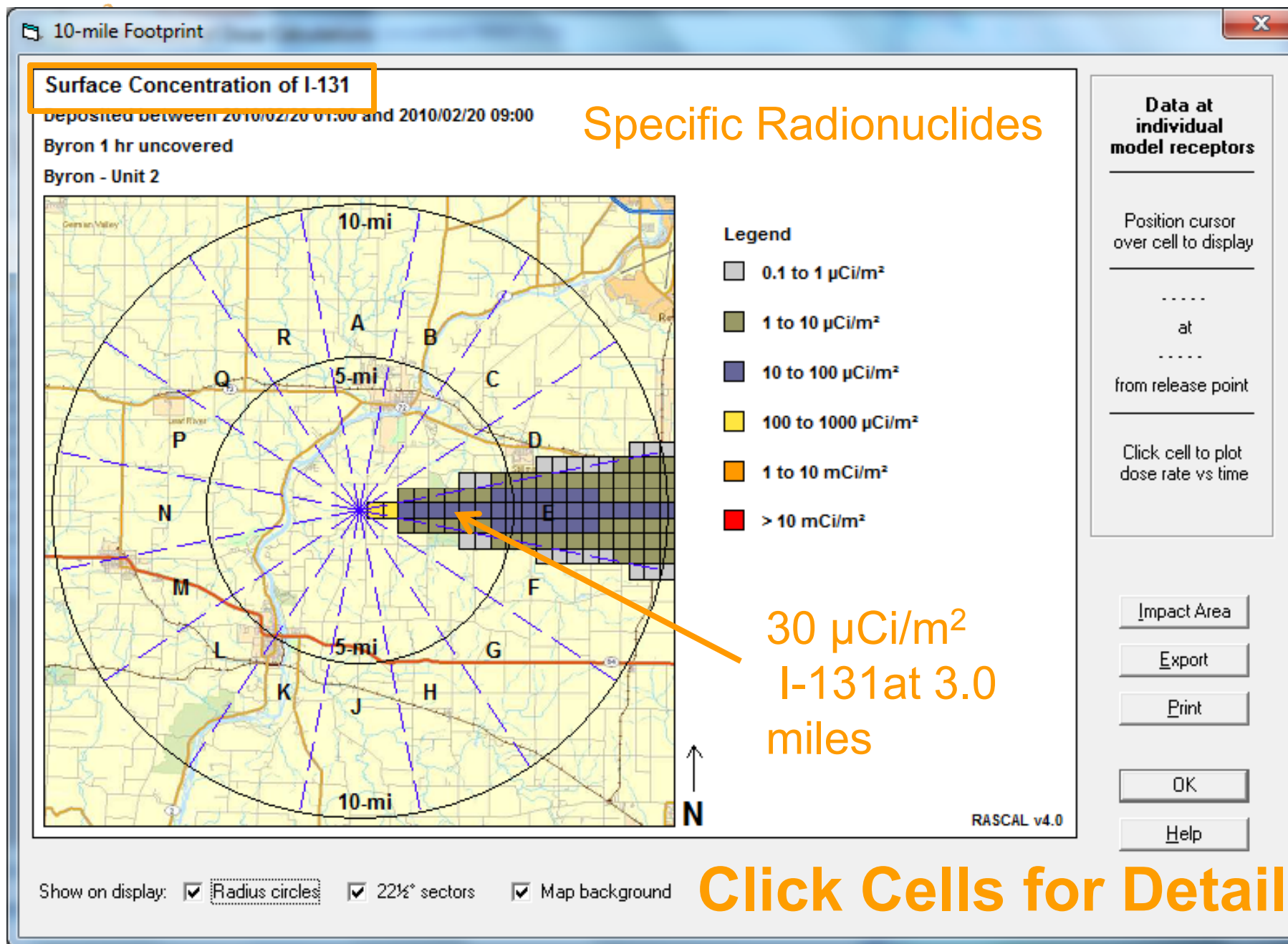
Notes on values displayed:
Activity on the ground is not decayed beyond the end of calculations
Values less than 1.0% of the largest concentration are not shown

Select option for display of nuclide list:

- ☒ All nuclides - sorted by activity
- ☐ Top 10 nuclides by activity
- ☐ Top 10 sorted by contribution to gamma dose rate
- ☐ Top 10 sorted by contribution to beta dose rate
- ☐ Nuclides important for ingestion of food

OK
Help
Print
Export

Sampling required before decision making



Dose vs Time Plot - 10 mile Calculations

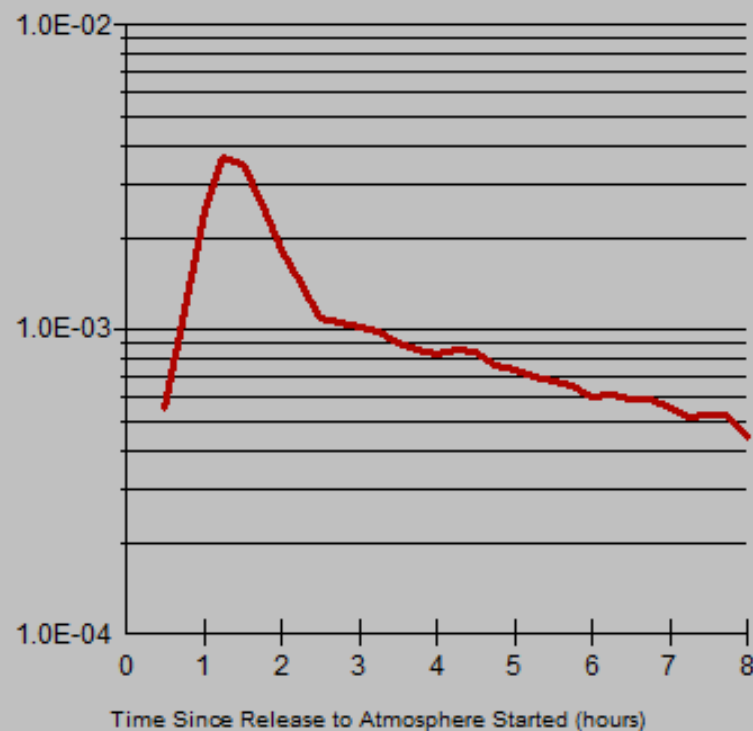
Case description: **Byron 1 hr uncovered**

Start of release: **2010/02/20 01:00**

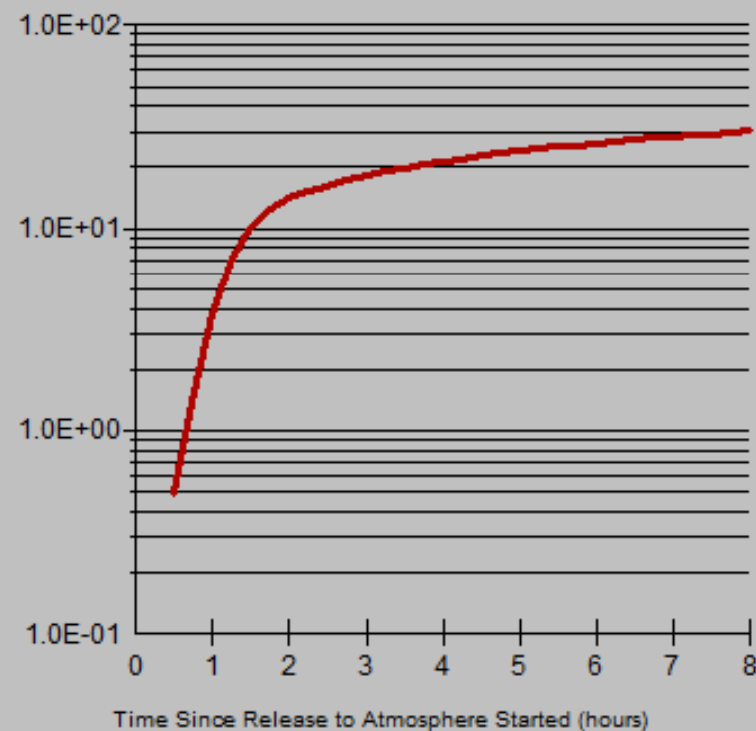
Receptor location: **90 deg, 3.0 mi (from release point)**

Release still in progress but
calculation stopped at 8 hr.

Deposition Rate ($\mu\text{Ci}/\text{m}^2/\text{s}$) of I-131



Surface Concentration ($\mu\text{Ci}/\text{m}^2$) of I-131



Print

OK

Help

Monitored Mixtures

Source Term to Dose - [Byron 1 hr uncovered NREP.S

File Options Nuclide Data Viewer Site / Facility Data

Follow the steps below to define and run a problem

☒ **Event Type**
NPP Reactor

☒ **Event Location**
Byron - Unit 2

☒ **Source Term**
Effluent Releases - by Mixtures

☐ **Release Path**
<undefined>

☒ **Meteorology**
Actual Observations

Calculate Doses

Detailed Results

Save Case

Case Summary Source Term Maximum Dose Values

Source Term Options

Source term base

☐ Time Core Is Unc

☐ Specified Core D

☐ Containment Rad

☐ Coolant Sample

☐ Air Sample

Source term base

☐ Effluent Release Rates - by Nuclide

☐ Effluent Release Concentrations - by Nuclide

☒ Effluent Releases - by Mixtures

Reactor shutdown: ☐ Yes 2010/02/20 00:00
☒ No

Sample taken: 2010/02/20 01:00

Release rate units: Ci/s

Release rates:

Noble gases 1.00E+03 (Ci/s)

Iodines
☐ Total
☒ I-131 equiv. 1.00E+00 (Ci/s)

Particulates 1.00E-01 (Ci/s)

Can now enter I-131 equivalent release rate

OK Cancel Help

Release Pathway – Monitored, Filtered

Direct to Atmosphere

Release height: 10.0 m

Release timings: Effluent mixture sample taken: 2010/02/20 01:00

Start of release to atmosphere: 2010/02/20 01:00

End of release to atmosphere: ☐ End time 2010/02/20 02:00

☒ Release duration: 0 days 04:00 hh:mm

OK Cancel

Release Path

<undefined>

Meteorology

Actual Observations

Calculate Doses

Detailed Results

Save Case

Reactor Parameters

Reactor power:	3586 MWt
Average fuel burn-up:	30000 MWD / MTU
Containment type:	PWR Dry Ambient
Containment volume:	2.90E+06 ft ³
Design pressure:	61 lb/in ²
Design leak rate:	0.10 %/d
Coolant mass:	2.51E+05 kg
Assemblies in core:	193
Steam generator type:	U-Tube

Print

Case Summary Source Term Maximum Dose Values

2 mph, E Stability, Results

Source Term to Dose - [Byron Mon Mix NREP R4.STD]

File Options Nuclide Data Viewer Site / Facility Data Viewer Help

Follow the steps below to define and run a problem. Use the Tabs below to review information.

Event Type
NPP Reactor

Event Location
Byron - Unit 2

Source Term
Effluent Releases - by Mixtures

Release Path
Direct to atmosphere

Meteorology
Actual Observations

Calculate Doses

Detailed Results

Save Case

Maximum Dose Values (rem) - To 10 mi

Dist from release miles (kilometers)	3 (4.8)	4 (6.4)	5 (8.0)	7 (11.3)	10 (16.1)
Total EDE	<u>1.7E+00</u>	<u>1.1E+00</u>	7.5E-01	<u>4.2E-01</u>	2.1E-01
Thyroid CDE	<u>1.8E+01</u>	<u>1.3E+01</u>	<u>9.3E+00</u>	<u>5.6E+00</u>	3.2E+00
Inhalation CEDE	6.5E-01	4.4E-01	3.1E-01	1.8E-01	1.0E-01
Cloudshine	9.8E-01	6.2E-01	4.2E-01	2.2E-01	1.0E-01
4-day Groundshine	7.0E-02	4.0E-02	2.5E-02	1.2E-02	5.8E-03
Inter Phase 1st Yr	1.1E-01	7.4E-02	5.3E-02	3.1E-02	1.7E-02
Inter Phase 2nd Yr	2.5E-03	1.6E-03	1.1E-03	***	***

Notes:

- Doses exceeding PAGs are underlined.
- Early-Phase PAGs: TEDE - 1 rem, Thyroid (iodine) CDE - 5 rem
- Intermediate-Phase PAGs: 1st year - 2 rem, 2nd year - 0.5 rem
- *** indicates values less than 0.1 mrem
- To view all values - use Detailed Results / Numeric Table

Value displayed: ☐ Close-in dose ☒ Doses to 10 miles ☐ Criticality shine dose

Display units: ☒ English ☐ Metric

Definitions Print

Case Summary **Source Term** Maximum Dose Values

Check this

Event Type
NPP Reactor

Event Location
Byron - Unit 2

Source Term
Monitored Release - Mixtures

Release Path
Direct to atmosphere

Meter
Actual Observations

Calculate

Detailed

Save

Source Term

Total activity released to atmosphere: 1.5E+07 Ci

Nuclide	Ci	Nuclide	Ci	Nuclide	Ci
Cs-137	7.2E+02	I-135	2.4E+04	Xe-131m	2.7E+04
I-131	1.4E+04	Kr-85	1.6E+04	Xe-133	4.7E+06
I-132	1.9E+04	Kr-85m	6.6E+05	Xe-133m	1.7E+05
I-133	2.8E+04	Kr-87	1.3E+06	Xe-135	9.1E+05
I-134	3.1E+04	Kr-88	1.9E+06	Xe-138	4.7E+06

Both
1000
Ci/s
nobles
1 Ci/s
I-131

Source Term to Dose - [Byron Mon Mix NREP.STD]

File Options Nuclide Data Viewer Site / Facility Data Viewer Help

Follow the steps below to define and run a problem
Use the Tabs below to review information.

Event Type
NPP Reactor

Event Location
Byron - Unit 2

Source Term
Effluent Releases - by Mixtures

Release Path
Direct to atmosphere

Source Term

Total amount released to atmosphere: 9.7E+06 Ci

Nuclide	Ci	Nuclide	Ci	Nuclide	Ci
Cs-134	2.8E+00	I-134	1.2E+02	Rb-88	8.5E+05
Cs-136	8.8E-01	I-135	2.7E+02	Xe-131m	3.2E+04
Cs-137*	1.9E+00	Kr-83m	1.4E+05	Xe-133	4.7E+06
Cs-138	3.0E+05	Kr-85	2.4E+04	Xe-133m	1.4E+05
I-131	1.4E+04	Kr-85m	4.1E+05	Xe-135	1.1E+06
I-132	1.5E+02	Kr-87	4.6E+05	Xe-135m	1.3E+05
I-133	3.2E+02	Kr-88	9.7E+05	Xe-138	4.5E+05

Cesiums corrected, only I-131 & I daughters

FM to Dose

RASCAL v4 - Beta Release

Radiological Assessment System for Consequence Analysis

Source Term to Dose

Field Measurement to Dose

Sample Data

Sample ID: (required)

Sample type:

☒ Ground concentrations in units of

☐ Air concentrations in units of

Activity at time of deposition

Nuclide	Gnd Conc (μCi/m²)
I-133	4.67E+01
I-131	3.01E+01
I-135	2.36E+01
Te-132	4.64E+00
Cs-134	3.43E+00
Ba-140	2.46E+00
Cs-137*	2.37E+00
Sr-91	1.59E+00
Cs-136	1.37E+00
Sr-89	1.26E+00
Np-239	6.73E-01
Te-131m	5.81E-01

Event Description

Event name: (required)

Information below is optional. Check a box to include the item in the case file.

☒ Release started:

Information below is optional. Check a box to include the item in the case file.

☐ Sample location

Latitude: degrees

Longitude: degrees

☒ Sample location from release point

Bearing: degrees

Distance:

☒ Sample description

OK Cancel Help

Enter sample data

OK

Result

Field Measurements to Dose

File Nuclide Data Viewer Help

☒ Event Description

☒ Sample Data

☒ Calculation Options

☒ Compute Doses

Sample Data

Sample ID: Soil Sample 1

Sample Location: Bearing / Distance 270.0° / 3.0 miles - from release

Sample desc.: Activities from slide 21 - Byron D

Sample type: Ground concentrations

Nuclide	Ground Conc (μCi/m²)
I-133	4.67E+01
I-131	3.01E+01
I-135	2.36E+01
Te-132	4.64E+00
Cs-134	2.42E+00

Source Term to Dose - [Byron 1 hr uncovered NREP.STD]

File Options Nuclide Data Viewer Site / Facility Data Viewer Help

Follow the steps below to define and run a problem

Compare to: Use the

☒ Event Type

NPP Reactor

☒ Event Location

Byron - Unit 2

☒ Source Term

Time Core Is Uncovered

☒ Release Path

PWR Dry

☒ Meteorology

Actual Observations

☒ Calculate Doses

☐ Detailed Results

☐ Save Case

Maximum Dose Values (rem)

Dist from release		
miles	3	4
(kilometers)	(4.8)	(6.4)
Total EDE	1.7E-01	1.7E-01
Thyroid CDE	2.4E+00	2.4E+00
Inhalation CEDE	1.0E-01	1.0E-01
Cloudshine	1.6E-02	1.6E-02
4-day Groundshine	5.3E-02	5.3E-02
Inter Phase 1st Yr	7.5E-01	7.5E-01
Inter Phase 2nd Yr	4.8E-01	4.8E-01

Notes:

- Doses exceeding PAGs are underlined
- Early-Phase PAGs: TEDE - 1 rem, Thyroid CDE - 2.4 rem
- Intermediate-Phase PAGs: 1st year - 2 rem, 2nd year - 0.5 rem
- *** indicates values less than 0.1 mrem
- To view all values - use Detailed Results

Value displayed: ☐ Close-in dose ☒ Doses to 10 miles ☐ Criticality shine dose

Case Summary

Field Measurements to Dose

File Nuclide Data Viewer Help

☒ Event Description

☒ Sample Data

☒ Calculation Options

☒ Compute Doses

Intermediate Phase Doses (rem)

Exposure	1st Year	2nd Year	50 Years
Groundshine	7.43E-01	4.53E-01	5.96E+00
Inhalation	1.15E-04	2.67E-06	1.37E-04
Total	7.44E-01	4.53E-01	5.96E+00

Notes

- 1st year PAG = 2 rem, 2nd year objective = 0.5 rem, 50 year objective = 5 rem
- Total doses exceeding PAGs are underlined
- Doses less than 1E-6 rem (1E-8 Sv) set to zero.

Deposition time

Starts at 4 days

TF values about 80% RASCAL values

Turbo FRMAC

File Tools Help

Turbo FRMAC

Navigation

- New
- Open
- Byon 211 discovered 1981
- Predictive Analyses
- Samples
- Air Concentration
- Deposition
- Soil sample - 3 mi east of release
- Exposure Rate
- Food
- Event-Level Items

Paperless FRMAC

Tools

- Analyst Manager
- Radionuclide Mixture Manager
- Radionuclide Viewer

Quick Event View

ICRP Guidance: [ICRP 30](#)

PAG Authority: [Federal Government](#)

Lung Clearance Class: [Maximum](#)

Weathering Correction: [Likhtarev's Method](#)

Resuspension Type: [Time Varying](#)

Resuspension Type: [NCRP 129 Method](#)

Respiratory Protection: [Not Administered](#)

Potassium Iodide (KI): [Not Administered](#)

Radionuclide	($\mu\text{Ci}/\text{m}^2$)
Ba-140	2.46
La-140	2.46
Cs-134	3.43
Cs-136	1.37
Cs-137	2.37
Ba-137m	2.24
I-131	30.1
I-133	46.7
I-135	23.6
Xe-135m	3.63
Np-239	0.673
Sr-89	1.26
Sr-91	1.59
Y-91m	0.919
Te-131m	0.581
Te-131	0.129
Te-132	4.64
I-132	4.64

Using same sample data

release

Event Level Reference Sample... Duplicate... Close Delete... Export

Radionuclide	Activity Concentration
^{140}Ba	2.46
^{134}Cs	3.43
^{136}Cs	1.37

12 parent radionuclides exist in the mixture.

μCi / m^2

Total Effective Dose Equivalent (TEDE)

Calculate Total Effective Dose Equivalent (TEDE)... More Mixture Properties...

Calculation Method

Calculate from Deposition Levels

Dose unit mrem

Filter Options

Age Group: Adult

Organ: Whole Body

Commitment Period: 50 Year

Note

Age Group and Commitment Period not apply to External Dose values

	Early Phase	First Year	Second Year	Fifty Year
Committed Effective Dose Equivalent	3.34E-2	0.118	2.71E-3	0.141
External Dose	32.4	6.22E2	3.45E2	3.11E3
Total Effective Dose Equivalent (TEDE)	32.5	6.23E2	3.45E2	3.11E3

43

Relocation DRLs (mR/h)

Field Measurements to Dose

File Nuclide Data Viewer Help

☒ Event Description

☒ Sample Data

☒ Calculation Options

☒ Compute Doses

Intermediate Phase Derived Response Levels (DRLs)

Reentry Time Days	Gamma dose rate (mR/h) at reentry equal to EPA PAG			Cs-137* surface concentration (μCi/m²) equal to EPA PAG		
	1st Year	2nd Year	50 Year	1st Year	2nd Year	50 Year
0	3.84E+00	8.85E-02	1.14E+00	6.73E+00	2.16E+00	2.00E+00
1	1.70E+00	8.85E-02	4.99E-01	6.84E+00		
2	1.23E+00	8.85E-02	3.56E-01	6.92E+00		
4	9.20E-01	8.84E-02	2.64E-01	7.00E+00		
7	7.66E-01	8.84E-02	2.17E-01	7.08E+00		
10	6.80E-01	8.84E-02	1.91E-01	7.16E+00		
14	5.99E-01	8.83E-02	1.66E-01	7.24E+00		
30	4.41E-01	8.81E-02	1.19E-01	7.43E+00		
60	3.77E-01	8.78E-02	9.91E-02	7.59E+00		
90	3.68E-01	8.75E-02	9.45E-02	7.70E+00		

Notes

- Dose rates are measured at time of reentry
- NC = not calculated; value is a ratio where the denominator is going to zero.

☒ DRL Table

☐ Early Phase Doses

☐ Intermediate Phase Doses

☐ Deposition Exposure Rate DRLs

☐ Marker Nuclide Concentration DRLs

Print

DRL map contours shrink with decay as days pass

Other Improvements to Source Term and Release Path methods

- BWR release pathways
- PWR Steam Generator Tube Ruptures
- Spent Fuel Pool drained

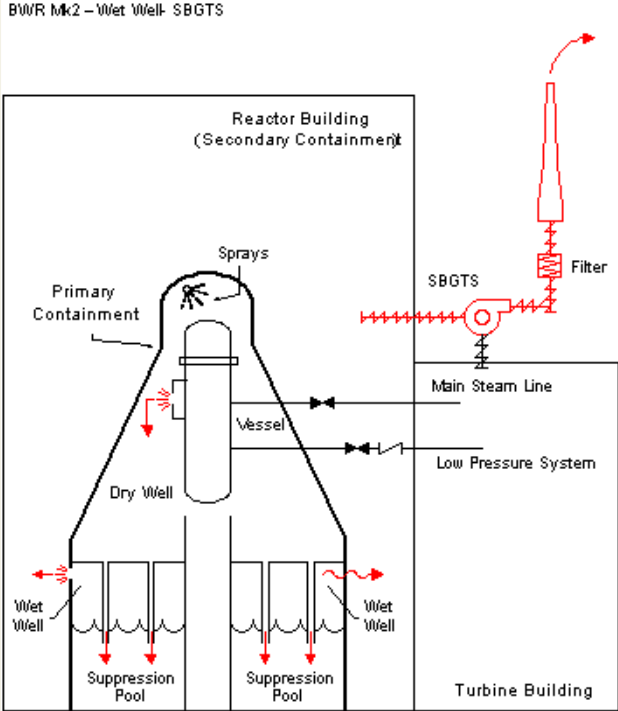
BWR release options

Available release pathways

Pathway from dry well to reactor building (secondary containment)

- ☒ Through the suppression pool
- ☐ Through the dry well wall
- ☐ Bypass reactor building

BWR Mk2 - Wet Well- SBGTS



Pathway to atmosphere

- ☒ Via Standby Gas Treatment System (SBGTS)
- ☐ Direct from reactor building or other rapid, unfiltered release

OK
Cancel
Help
Print

**SBGTS - filtered
and released at
stack height**

**Direct - unfiltered
and released at
user entered height**

SGTR Changes

Steam Generator Tube Rupture

Pathway description:

(optional; 60 character max)

Release height:

10.0

m

(Stack height: 185 ft)

Release timings:

Core uncovered:

2010/02/22 00:00

Leak rate to atmosphere described by:

Leak controlled by 2 flows

Date	Time	Event	Event setting
2010/02/22	00:00	Leak rate into SG	500 gal/min
2010/02/22	00:00	Rupture location	Above water level
2010/02/22	00:00	Steaming rate	7.5E+04 lb/h
2010/02/22	00:00	Release point	Safety relief valve

Release point can vary with time

Simpler location description

Add Row

Remove Row

Sort Rows

Clear All

OK

Cancel

Help

Spent Fuel Pool Uncovered

Pool Storage - Uncovered Fuel [X]

Date reactor was shutdown for newest batch of fuel: 2010/02/22 ▼

Total number of spent fuel batches in the pool: 10 ▼ (3 batches/core)

Fuel uncovered and not cooled: 2010/02/22 ▼ 00:00

Fuel is recovered or cooled by sprays or steam cooling?

☒ No

☐ Yes, at 2010/02/22 ▼ 01:00

OK

Cancel

Help

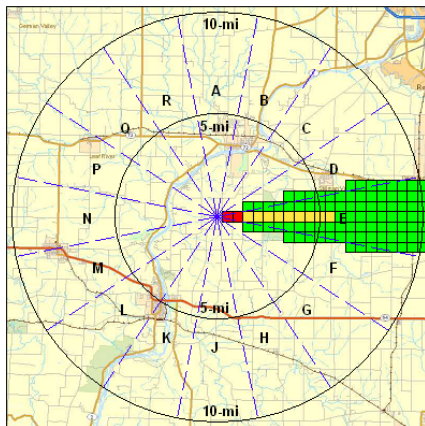
**Simpler interface
Fewer questions**

Changes in SF Pool

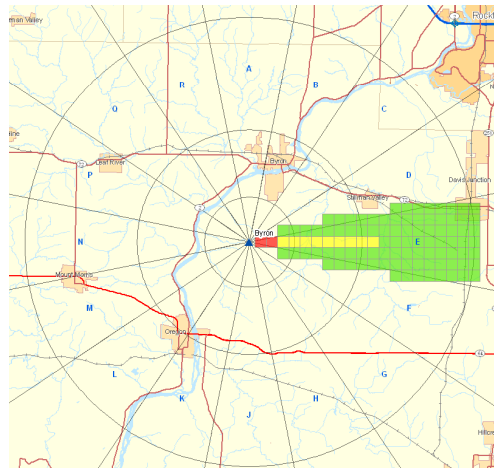
- New version requires only age of newest batch, total batch count, and times for cooling lost and regained
- Assumes a 18 month refuel interval and cladding fire if not cooled for 2 hours
- Release over 24 hours unless recooled
- Impact – generally smaller source terms

Display Plume in:

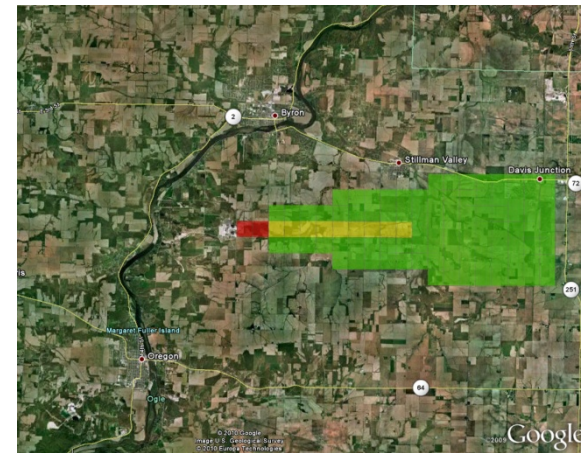
RASCAL



ArcMap



Google Earth



On the Horizon...

- Automated weather entry
- Work with DOE – TurboFRMAC consistency
- Work with DTRA – HPAC consistency
- Detailed verification and validation
- State of the Art Reactor Consequence Analysis (SOARCA) source terms
- Create New Reactor models for RASCAL
- Continued progress on future model improvements

SOARCA Station Blackout

- Based on MELCOR run at Sandia
- PWR Scenario – earthquake – no AC power
1st cladding release - 16 h
Containment design leakage increase – 28 h
- BWR Scenario
1st fuel cladding release – 10 h
iodine release exceeds 1% inventory – 20 h
- Scenario ready to incorporate into RASCAL

Intentionally Blank

Dose Assessment RASCAL Interface

Nuclear Energy Institute Conference

June 15, 2010

Lou Brandon, Nuclear Regulatory Commission

Part 2 – Nicholas Avrakoto, Entergy Energy

Paul Holland, Exelon Energy

Our Goal

To combine the best features of RASCAL with a site specific front end to create a user friendly interface for the occasional end user.

RASCAL

- Provides many methods for performing dose assessments.
- Has new plume dispersion and deposition models
- Is often times the compared “standard” for licensees.
- Is free to the licensee

RASCAL

- Does not have a direct method allowing the use of licensee's effluent monitors
- Is generically written for all sites in the US
- Can be difficult for the occasional user to run with consistency
- Usually requires more extensive procedures and longer training times

Licensee Dose Assessment Programs

- Typically simplified for the licensee's needs
- Users “recognize” terminology, site specific components, release pathways, etc...
- Allow for the use of effluent monitors direct readings.

Licensee Dose Assessment Program

- Typically requires a third party contractor to maintain
- Will probably require extensive upgrades due to the changes with the new modeling used by RASCAL
- Expensive up keep costs.

Our Goal

- Write a site specific front end the user will be comfortable with and calculate an isotopic release rate
- Use RASCAL's "Effluent Release Rates - by Nuclide" methodology to process the assessment.
- Use RASCAL's meteorological, plume and puff modeling programs to calculate the doses
- Read RASCAL's results files to present the doses in a site specific format.

Results

- Created a very adaptable front and back end to RASCAL which will be utilized at Entergy and Exelon sites
- Integrated the RASCAL processors including the new dispersion and deposition models
- Licensee assessments are very close to RASCAL since the dispersion and deposition models are identical

Long term

- The Licensee maintains control of the interface
- Reduced training costs
- Typically the interface will not need significant upgrades or changes
- If the NRC changes the RASCAL processor programs the licensee won't need to change the interface

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RASCAL webpage for files and updates:
atheyconsulting.com/RASCAL_files.html