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**The following presentation, originally presented at the 2010 NREP Conference (slide 2), has been slightly adapted for presentation at an IAEA Consultancy in June beginning on slide 3.**

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# RASCAL 4.0

Radiological Assessment System for Consequence Analysis

National Radiological Emergency Preparedness Conference

March 30, 2010

**Part 1 - George Athey, Athey Consulting**

James (Van) Ramsdell, Pacific Northwest National Laboratory

Lou Brandon, Nuclear Regulatory Commission

Paul Holland, Exelon Energy

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# RASCAL 4.0

Radiological Assessment System for Consequence Analysis

International Atomic Energy Agency

Consultancy on Developing a Technical Solution for Assessing the Radiological Consequences of a Nuclear Accident or Radiological Emergency

June 21 & 22, 2010

Lou Brandon, Nuclear Regulatory Commission

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# RASCAL 4

- Released beta version March 1st
- Presentation goals:
  - Highlight the big changes
  - Demonstrate new capabilities
  - Discuss the future

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# A presentation in 4 parts:

1. Data and user interface changes
2. Transport & diffusion, decay, and mixture methods
3. Dose differences & future plans
4. New interface for utilities

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# Data and User Interface Changes

- What has changed?
- Why was it changed?
- How does the change impact results?

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# Updated Core Inventory

- Old core inventory – RASCAL 3
  - Taken from NUREG-1228 / WASH-1400
  - Selected for early health effects + likely noble gases
- New core inventory – RASCAL 4
  - Based on normalizes SCALE/ORIGEN run
  - Increased number of nuclides from 33 to 58
  - No longer select for early health effects
- Impact – small changes to source term

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# Updated Coolant Inventory

- From ANSI/ANS 18.1-1999
- Old inventory (RASCAL 3) excluded:
  - nuclides with half-life < 50 minutes, and
  - noble gases for BWRs
- New inventory (RASCAL 4) includes all
- A more complete set; nuclide number increased from 36 to 63
- Impact – small changes to source term

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# Improvements to Source Term and Release Path methods

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

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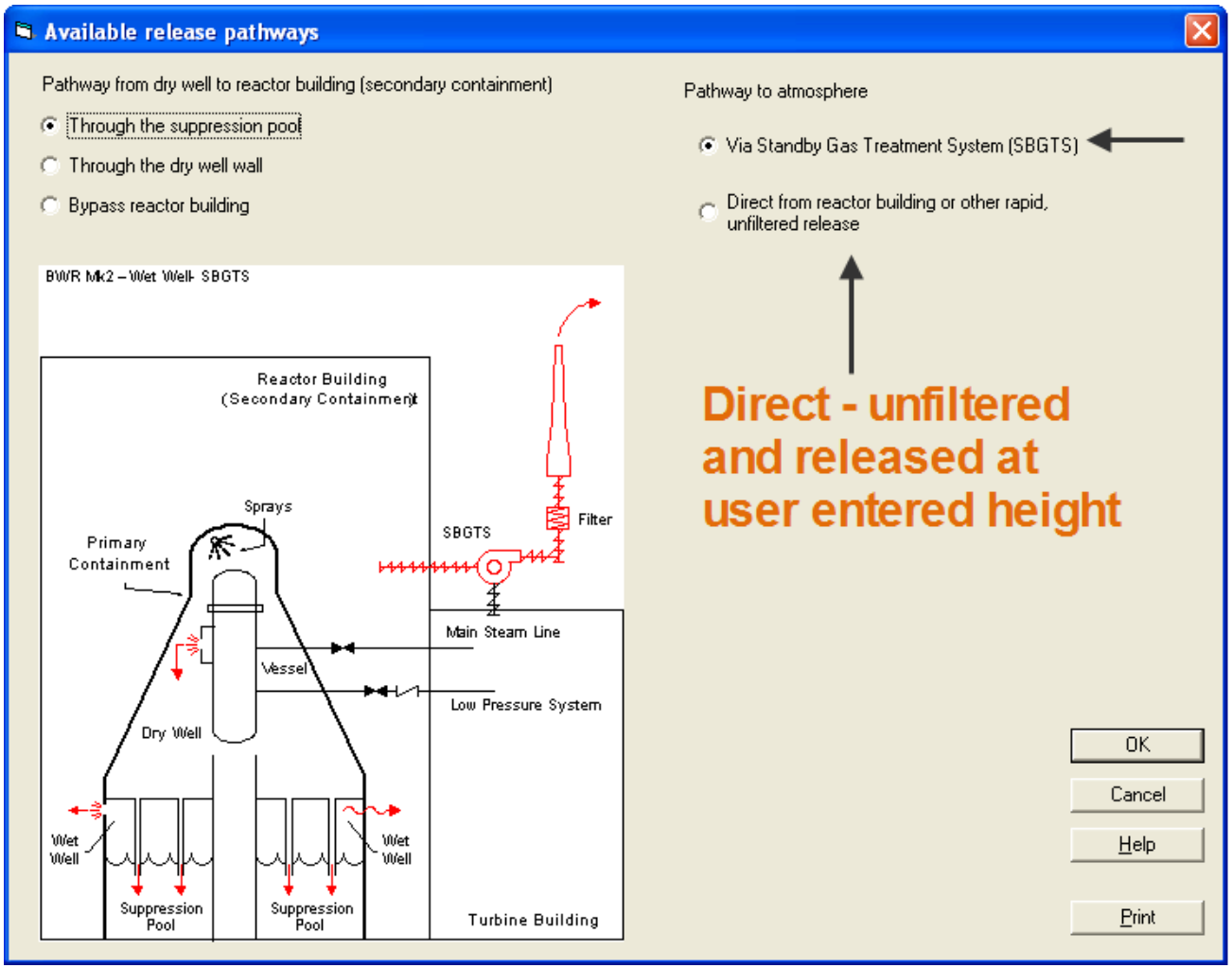
# BWR release options




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

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

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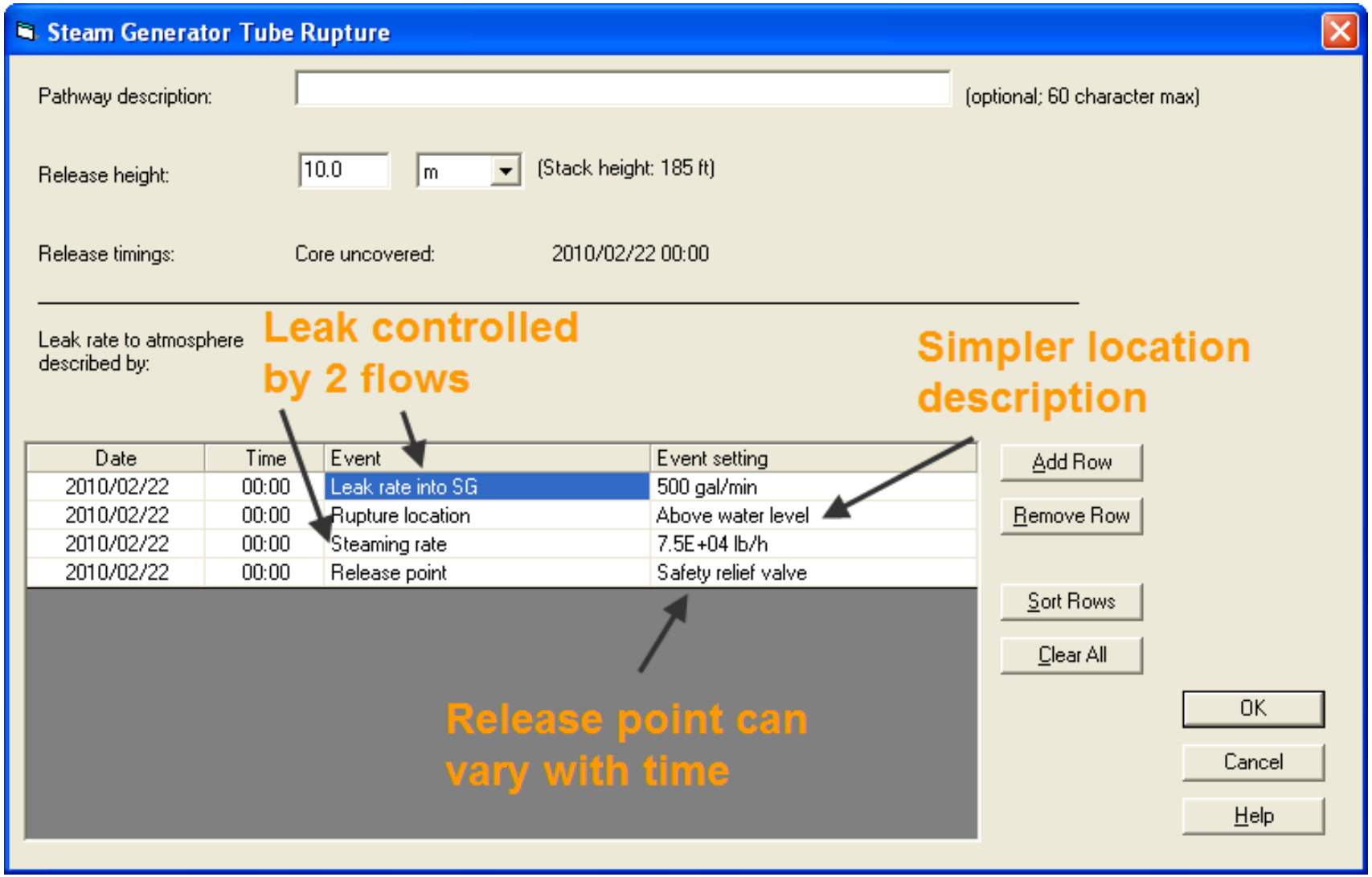
# SGTR Changes



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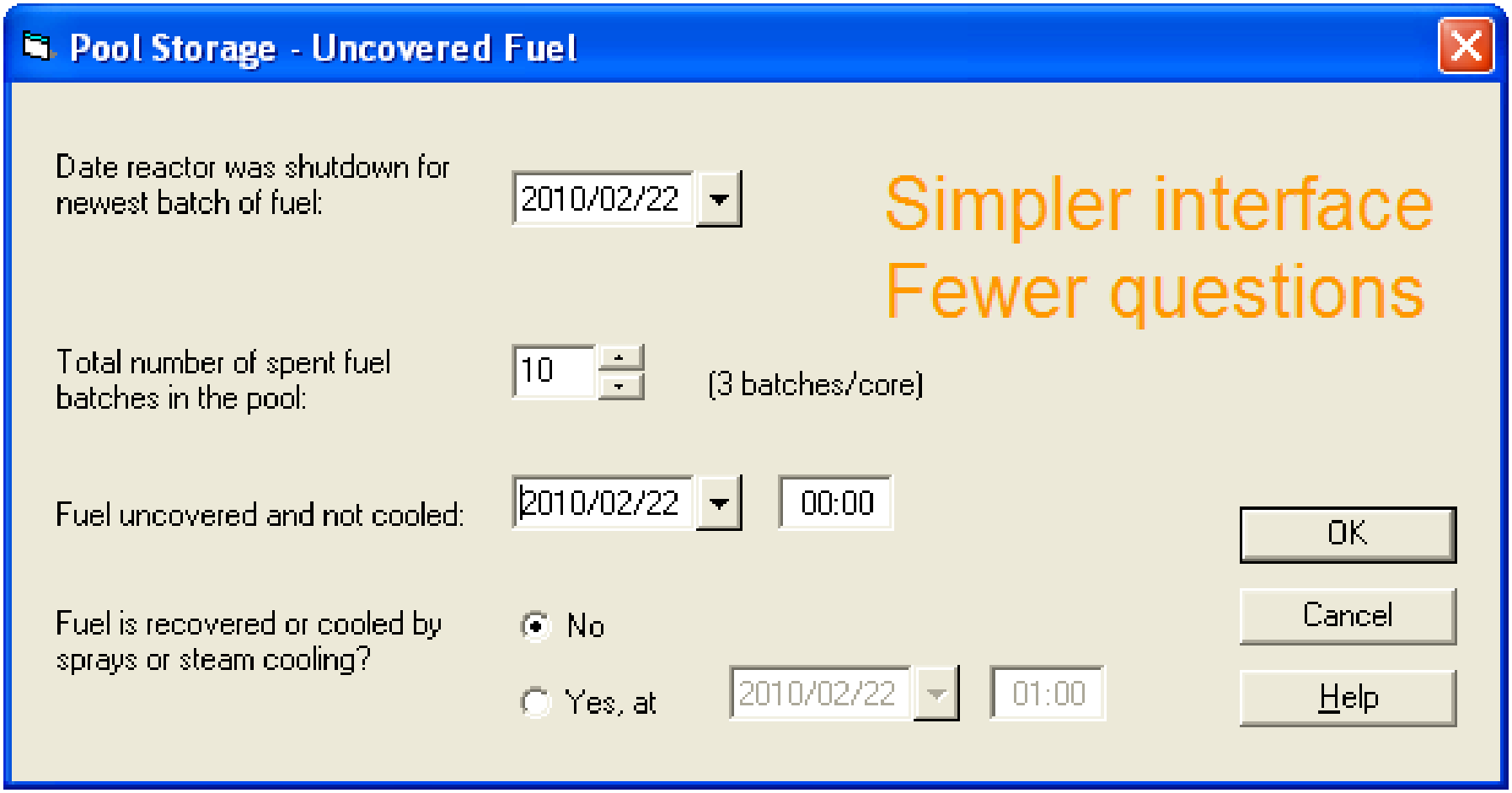
# Spent Fuel Pool Uncovered



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# 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

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# Part 2
# Transport & diffusion, decay, and mixture methods

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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?

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# The Changes

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

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# Radioactive Decay: What Is New?

- The decay scheme has been revised in the source term, environmental and dose calculations
- The decay scheme uses simplified chains that include short-lived daughters implicitly and are truncated at long-lived daughters
- Decay calculations are made using the Bateman Equations for 0 to 3 daughters and include branching.
- The RASCAL v4 radionuclide library is based on the radionuclide list in Appendix A of Federal Guidance Report 12
- The library lists 800 isotopes; only 15 short-lived isotopes are not Included either explicitly or implicitly.
  - The library also Includes $U_{natural}$, $U_{enriched}$, and $UF_6$

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# Radioactive Decay

- Why the Change?
  - Consistency
    - RASCAL v3.0.5 uses 3 different decay schemes
    - RASCAL v 4 uses just one
  - Traceability
    - RASCAL v4 decay schemes are documented
    - Appendices in the technical documentation will list the chains, decay parameters and implicit daughters

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# 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 << 1%
  - Addition of implicit daughters and simplification of chains that include branching increases doses slightly at short times

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# Monitored Release

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

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# Monitored Release

- Assumptions
  - RASCAL v3.0.5
    - Particle activity is 50% Cs-137 and 50% I-131
  - RASCAL v4
    - Particle activity is distributed among all radioactive and stable Cs and I isotopes based on stoichiometric proportions

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# Monitored Release

- Why the Change?
  - RASCAL 3.0.5 significantly overestimated the long-term consequences of a release by exaggerating the Cs-137 activity
  - RASCAL 3.0.5 significantly underestimated the short-term consequences of a release by minimizing the I-131 activity

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# Monitored Release

- What are the Implications of the Change?
  - In RASCAL v4, >99.6% of the activity is in iodine isotopes; <0.4% of the activity is in Cesium Isotopes.
  - Doses are also reduced because most of the activity is in isotopes having dose factors that are lower than those for I-131 and Cs-137.

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# 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 |

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# Atmospheric Dispersion

- What is New?
  - RASCAL v4 has changed from distance-based dispersion parameters to time-based parameters
  - Gone are the Pasquill-Gifford parameters
  - Dispersion is now a function of:
    - time since release
    - wind speed
    - atmospheric stability
    - surface roughness

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# 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.

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# Atmospheric Dispersion

- What are the Implications of the Changes?
  - The RASCAL v4 dispersion parameters tend to be larger than the RASCAL v3.0.5 parameters
  - X/Qs and doses for ground-level releases will tend to be lower
  - X/Qs and doses for elevated releases will tend to be higher near the release point

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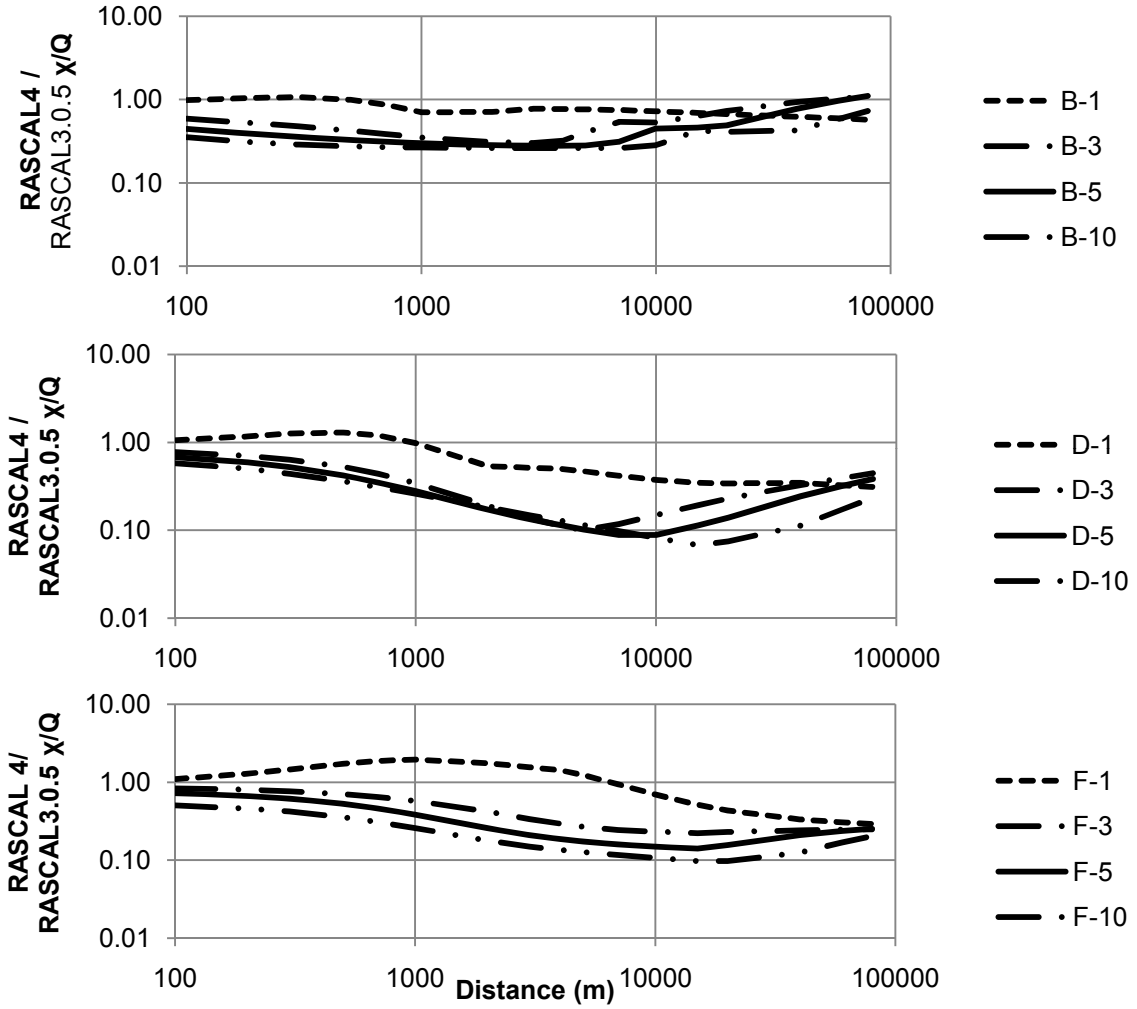
# Atmospheric Dispersion



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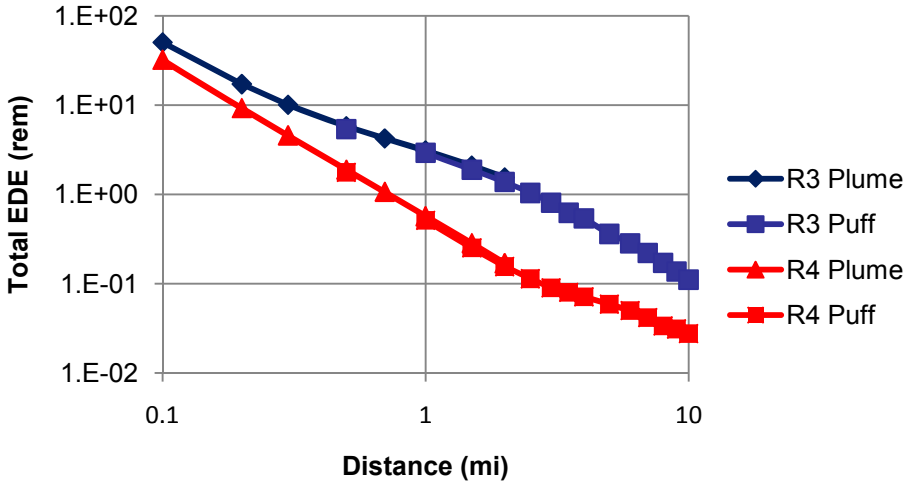
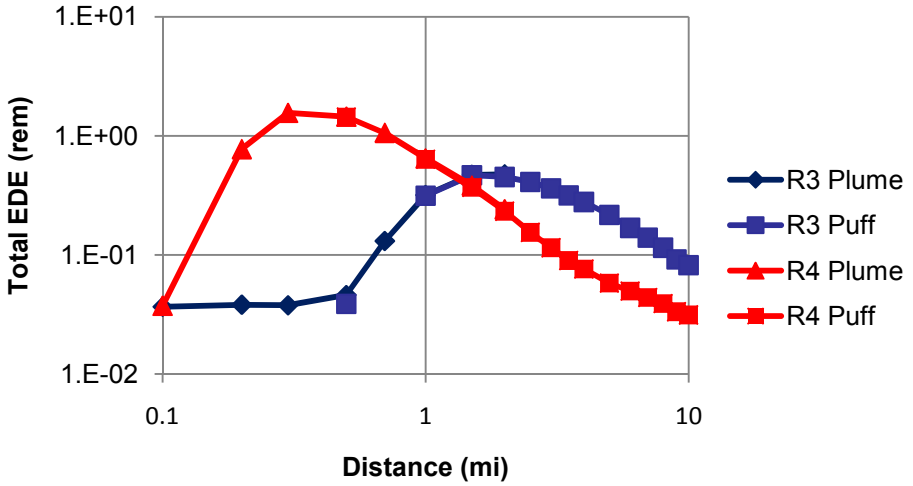
# Atmospheric Dispersion

Ground Level,
D Stability, 3 m/s




Elevated,
D Stability, 3 m/s



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# Atmospheric Deposition

- Why the Changes?
  - The RASCAL v3.0.5 parameters were developed in the 1950s and early 1960s.
  - Research on atmospheric processes in the 1960s, 1970s, and 1980s provide better methods of estimating atmospheric deposition.

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# Atmospheric Dry Deposition

- What is New?
  - RASCAL v4 has changed from constant dry deposition velocities to dry deposition velocities that are a function of atmospheric conditions including wind speed, stability, and surface roughness.
  - RASCAL v4 treats iodine (halogens) as three species having different deposition characteristics for purposes of calculating deposition ($I_2$, particles, and $CH_3I$)

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# Atmospheric Dry and Wet Deposition

- What is New?
  - RASCAL v4 iodine speciation is 25% Particles, 30% $I_2$, and 45% $CH_3I$; $CH_3I$ is assumed not to deposit.
  - RASCAL v4 uses a wet deposition velocity for wet deposition of gases and a washout model for wet deposition of particles. These parameters are functions of wind speed, atmospheric stability, surface roughness, and precipitation rate

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# Atmospheric Deposition

- What are the Implications of the Changes?
  - The RASCAL v4 deposition parameters, while not constant, tend to be within a factor of 2 of the RASCAL v3.0.5 parameters.
  - RASCAL v4 deposition velocities for iodine tend to be lower than the RASCAL 3.0.5 value in low wind speed conditions and higher in high wind speeds.
  - Deposition of iodine is generally lower in RASCAL v4 because 45% of the iodine does not deposit.

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# Atmospheric Deposition

## Iodine Dry Deposition Velocities (m/s)

| | Wind Speed (m/s) | | | | |
|---|---|---|---|---|---|
| Stability | 1 | 2 | 3 | 5 | 10 |
| B | 0.0023 | 0.0035 | 0.0043 | 0.0055 | 0.0072 |
| D | 0.0018 | 0.0028 | 0.0035 | 0.0046 | 0.0063 |
| F | 0.0014 | 0.0023 | 0.0030 | 0.0039 | 0.0055 |

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# 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.

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# 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)

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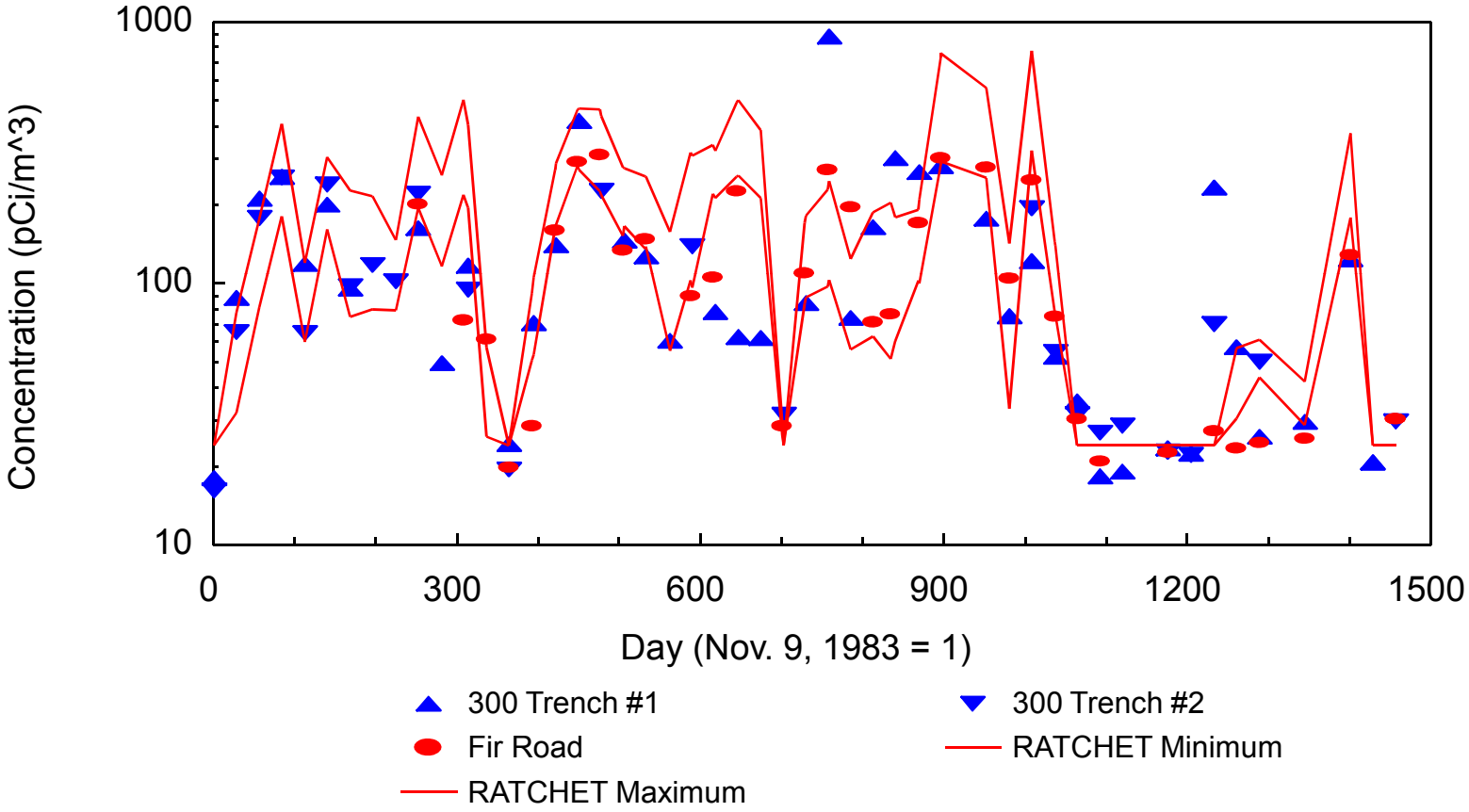
# Atmospheric Dispersion

## Kr-85 Predictions for Routine Releases at Hanford



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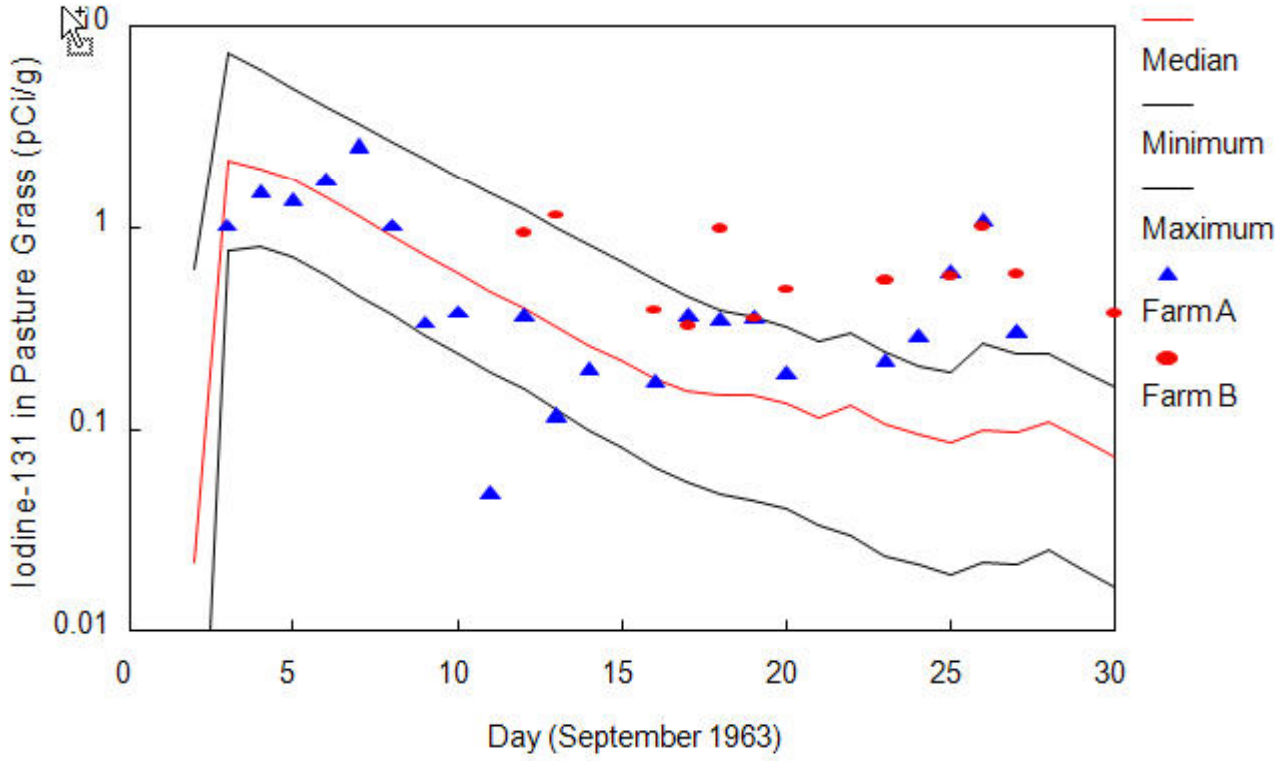
# Atmospheric Dispersion and Deposition

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



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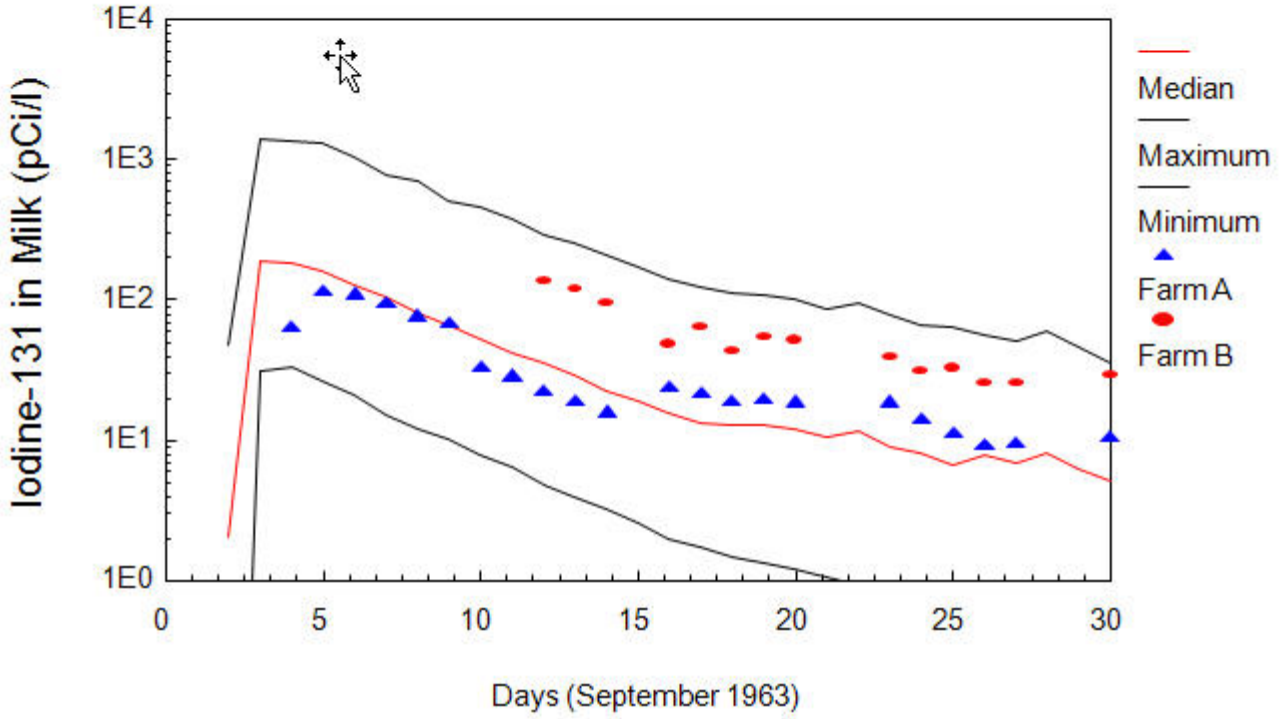
# Atmospheric Dispersion and Deposition

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



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# 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 |

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# Part 3
# Dose differences, GIS Shape File Export, Future plans

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# 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

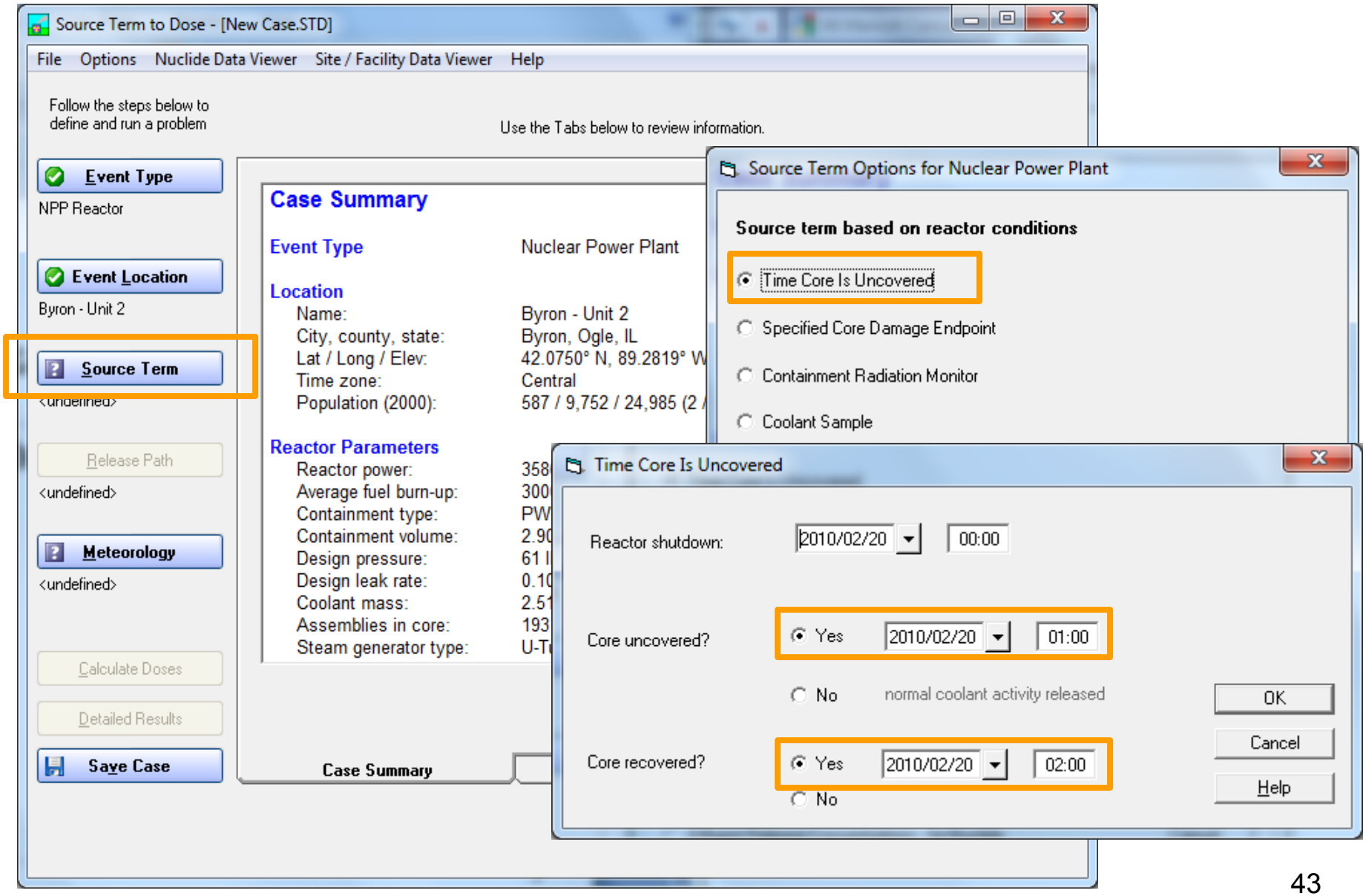
  activity released – 9.5 E5 Curies 3.0.5

  -- 8.9 E5 Curies 4.0
- Case Study – Varying Parameters

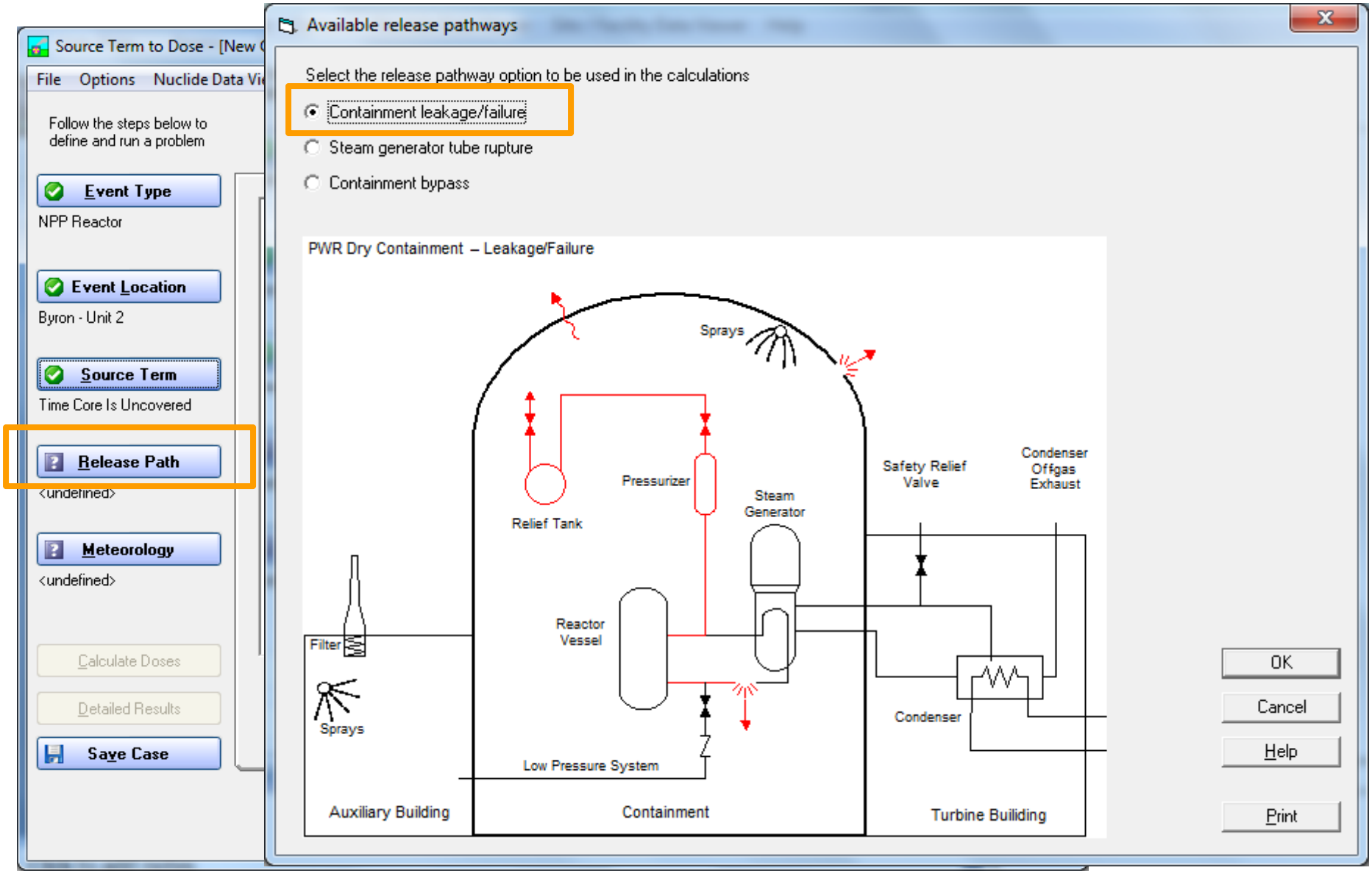
  Stability Classes B and E

  2 & 8 mph wind speeds, no precip

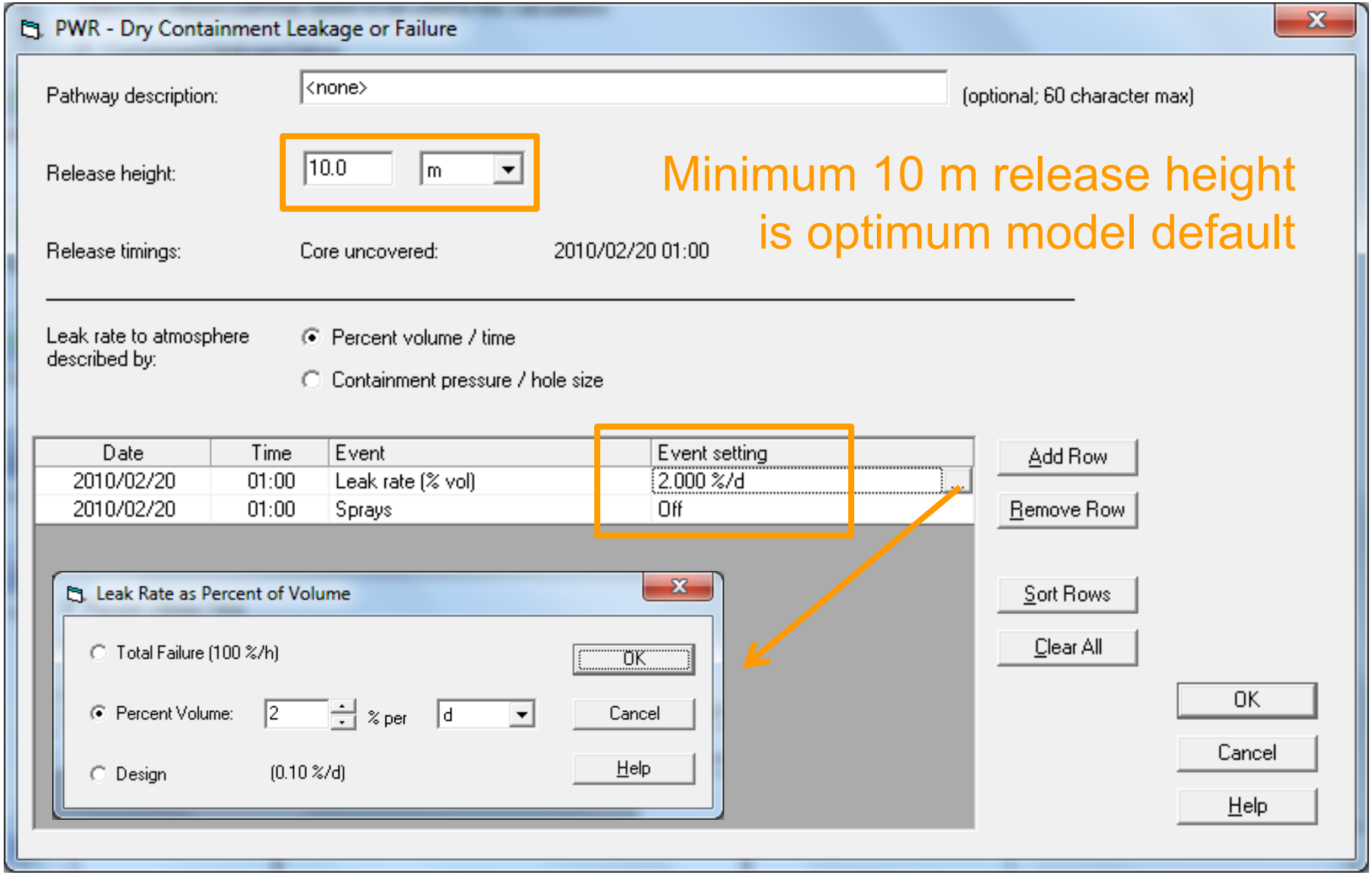
# Byron Unit 2: Source Term

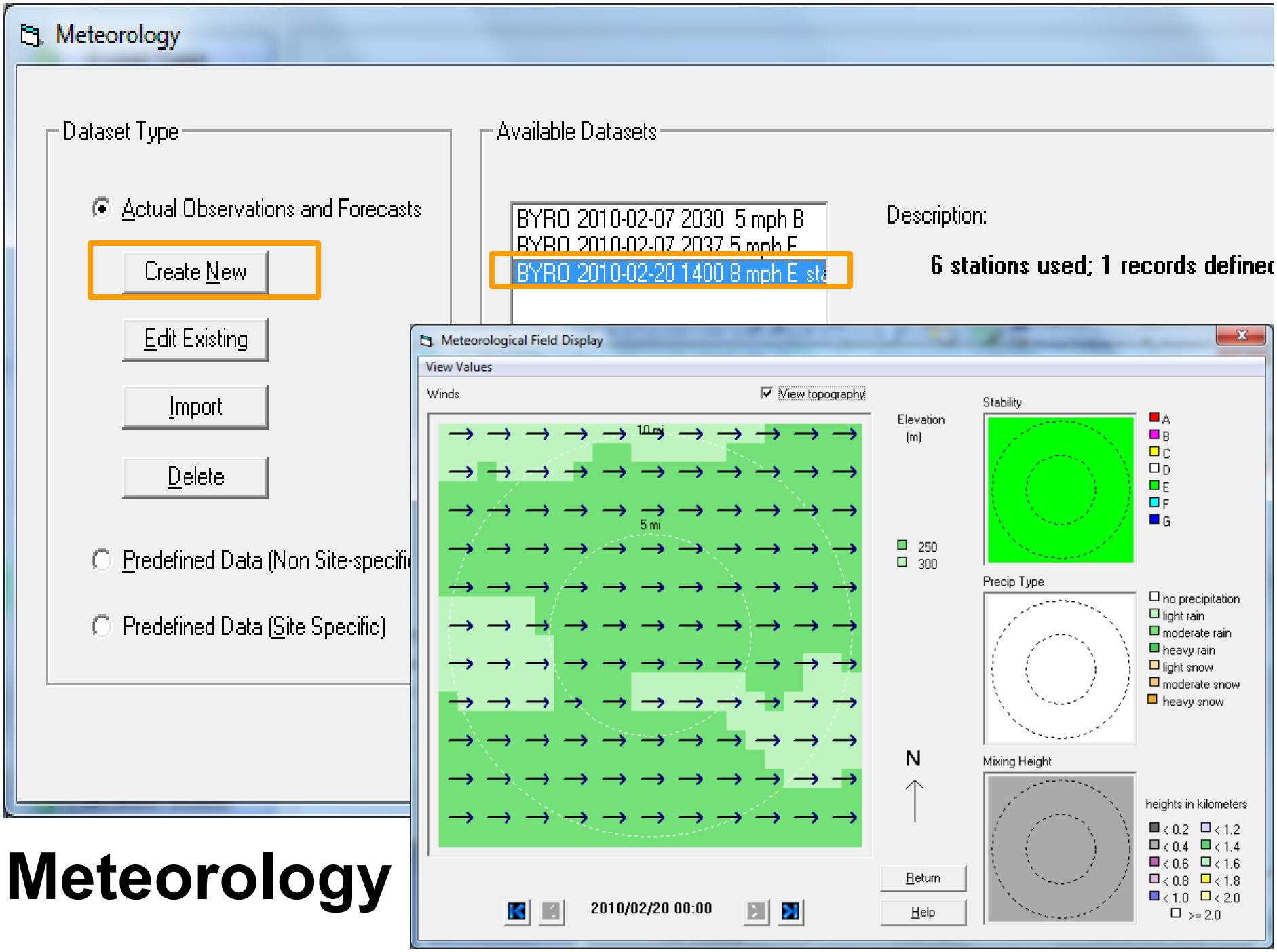


# Release Pathway



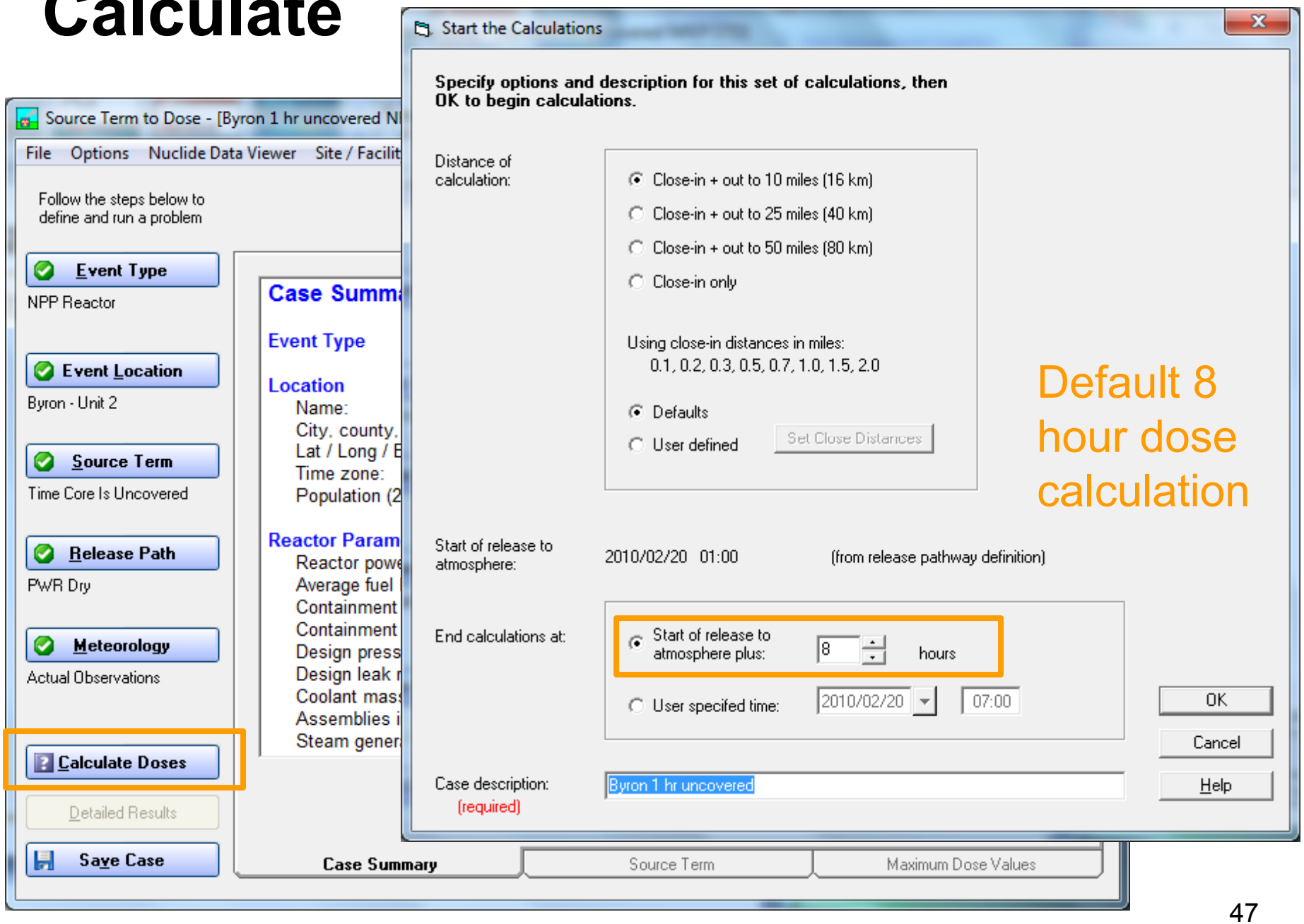
# Release Pathway Options

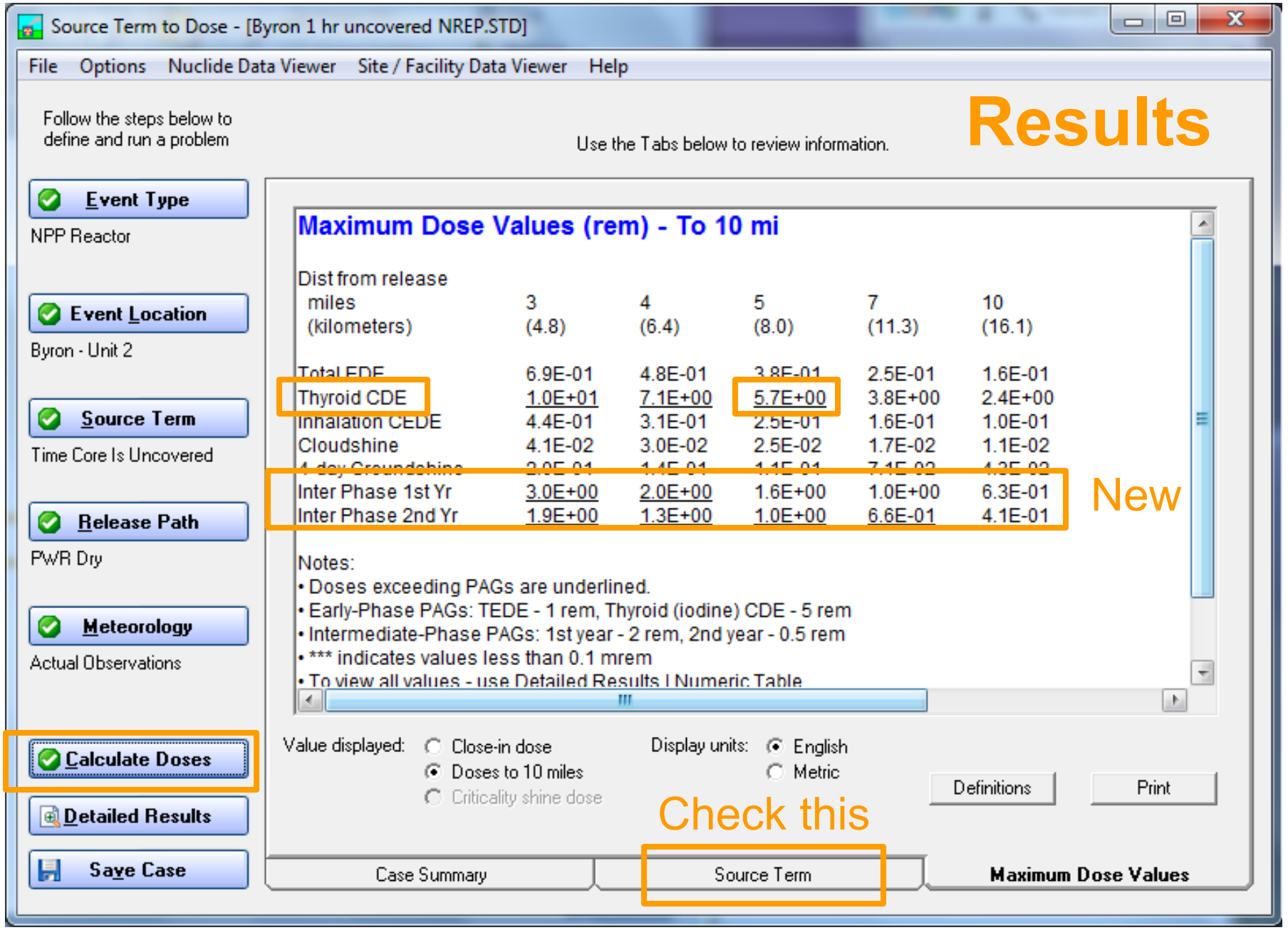


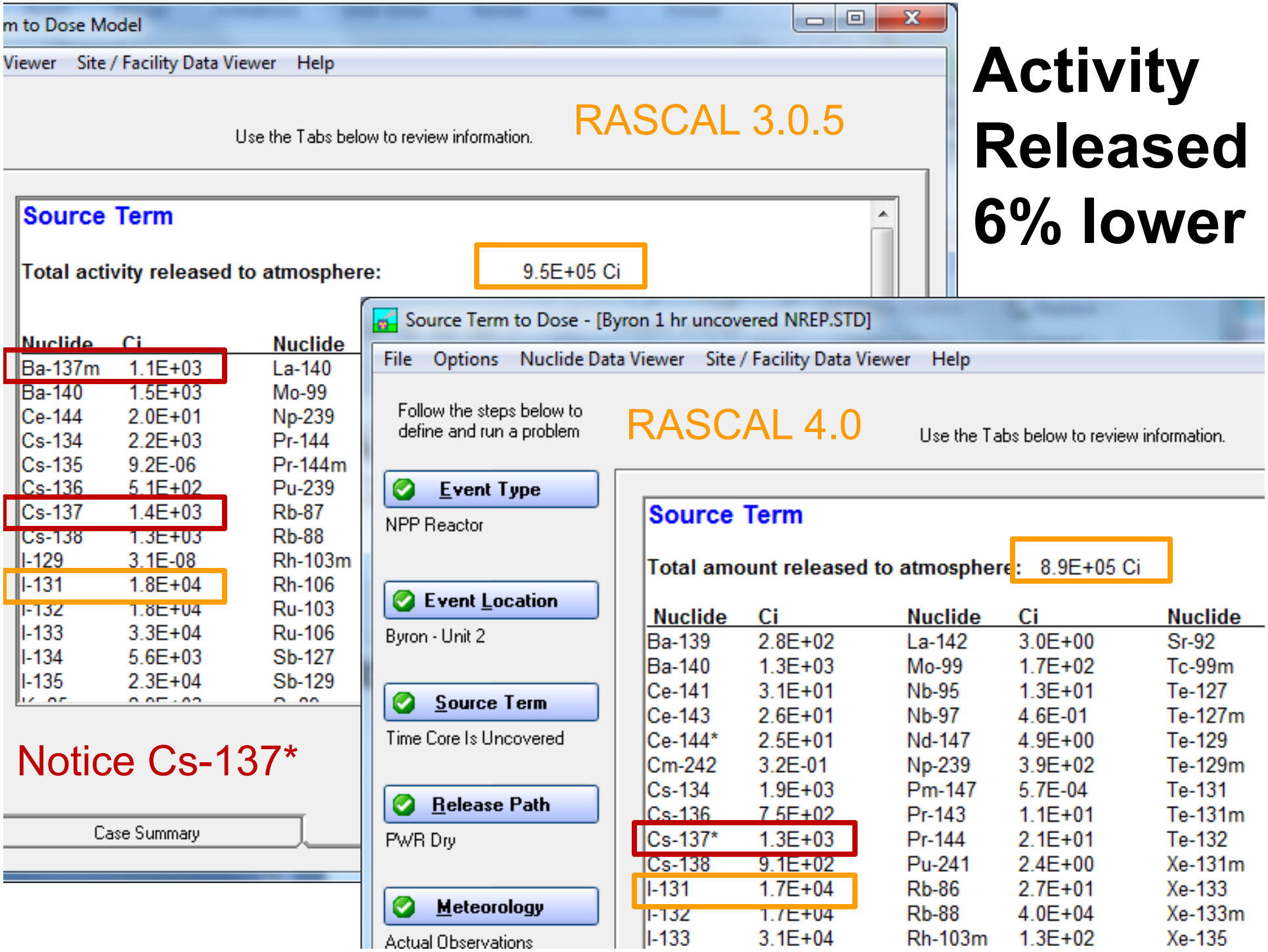



# Meteorology

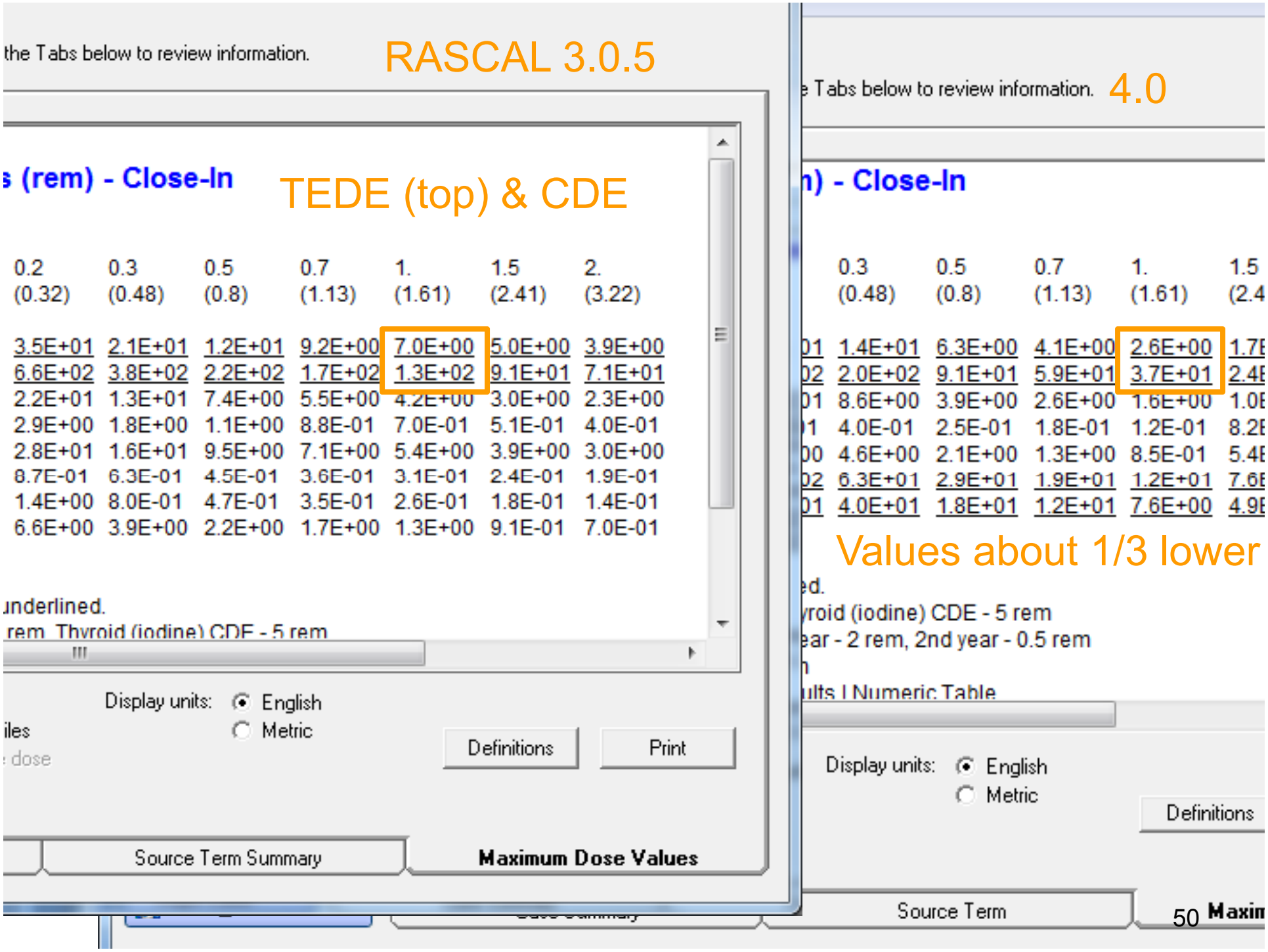
# Calculate

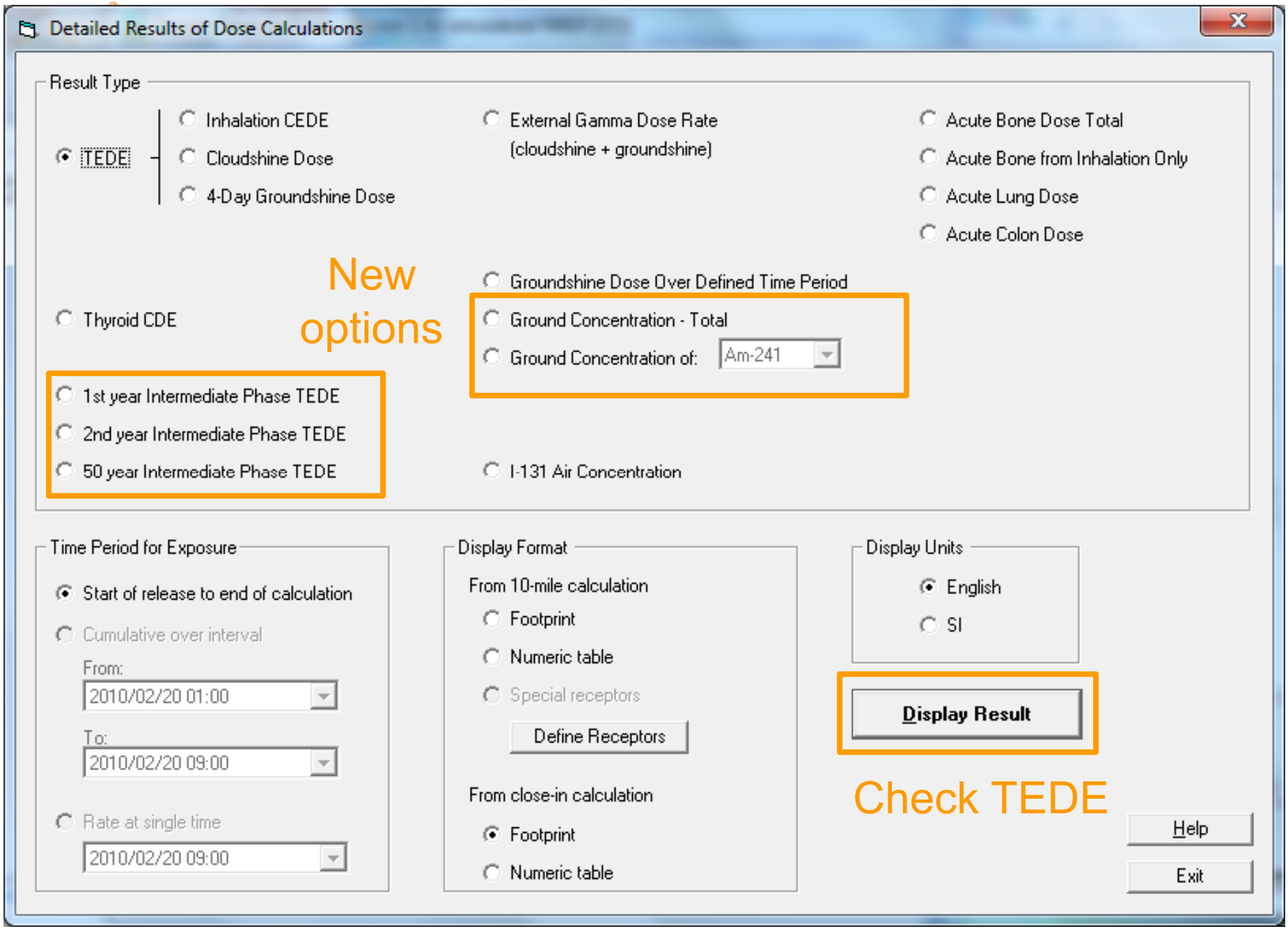

Source Term to Dose - [Byron 1 hr uncovered
File
Options
Nuclide Data Viewer
Site / Facilit
Follow the steps below to define and run a problem
Event Type
NPP Reactor
Event Location
Byron - Unit 2
Source Term
Time Core Is Uncovered
Release Path
PWR Dry
Meteorology
Actual Observations
Calculate Doses
Detailed Results
Save Case
Case Summa
Event Type
Location
Name:
City, county,
Lat / Long / E
Time zone:
Population (2
Reactor Param
Reactor powe
Average fuel
Containment
Containment
Design press
Design leak r
Coolant mass
Assemblies i
Steam gener
Case Summary
Source Term
Maximum Dose Values
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
Set Close Distances
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 specifed time:
2010/02/20
07:00
Case description:
(required)
Byron 1 hr uncovered
OK
Cancel
Help
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 3 4 5 7 10
(kilometers) (4.8) (6.4) (8.0) (11.3) (16.1)
Total EDE 6.9E-01 4.8E-01 3.8E-01 2.5E-01 1.6E-01
Thyroid CDE 1.0E+01 7.1E+00 5.7E+00 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
4-day Groundshine 2.0E-01 1.4E-01 1.1E-01 7.1E-02 4.3E-02
Inter Phase 1st Yr 3.0E+00 2.0E+00 1.6E+00 1.0E+00 6.3E-01
Inter Phase 2nd Yr 1.9E+00 1.3E+00 1.0E+00 6.6E-01 4.1E-01
New
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
Check this
Case Summary
Source Term
Maximum Dose Values




# Activity Released 6% lower


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)
3.5E+01 2.1E+01 1.2E+01 9.2E+00 7.0E+00 5.0E+00 3.9E+00
6.6E+02 3.8E+02 2.2E+02 1.7E+02 1.3E+02 9.1E+01 7.1E+01
2.2E+01 1.3E+01 7.4E+00 5.5E+00 4.2E+00 3.0E+00 2.3E+00
2.9E+00 1.8E+00 1.1E+00 8.8E-01 7.0E-01 5.1E-01 4.0E-01
2.8E+01 1.6E+01 9.5E+00 7.1E+00 5.4E+00 3.9E+00 3.0E+00
8.7E-01 6.3E-01 4.5E-01 3.6E-01 3.1E-01 2.4E-01 1.9E-01
1.4E+00 8.0E-01 4.7E-01 3.5E-01 2.6E-01 1.8E-01 1.4E-01
6.6E+00 3.9E+00 2.2E+00 1.7E+00 1.3E+00 9.1E-01 7.0E-01
underlined.
rem, Thyroid (iodine) CDE - 5 rem
Display units: English Metric
Definitions
Print
Source Term Summary
Maximum Dose Values
e 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 (2.4
01 1.4E+01 6.3E+00 4.1E+00 2.6E+00 1.7E
02 2.0E+02 9.1E+01 5.9E+01 3.7E+01 2.4E
01 8.6E+00 3.9E+00 2.6E+00 1.6E+00 1.0E
01 4.0E-01 2.5E-01 1.8E-01 1.2E-01 8.2E
00 4.6E+00 2.1E+00 1.3E+00 8.5E-01 5.4E
02 6.3E+01 2.9E+01 1.9E+01 1.2E+01 7.6E
01 4.0E+01 1.8E+01 1.2E+01 7.6E+00 4.9E
Values about 1/3 lower
ed.
yroid (iodine) CDE - 5 rem
ear - 2 rem, 2nd year - 0.5 rem
ults | Numeric Table
Display units: English Metric
Definitions
Source Term
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
New options
Thyroid CDE
Groundshine Dose Over Defined Time Period
Ground Concentration - Total
Ground Concentration of:
Am-241
1st year Intermediate Phase TEDE
2nd year Intermediate Phase TEDE
50 year Intermediate Phase TEDE
I-131 Air Concentration
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
Check TEDE
Help
Exit

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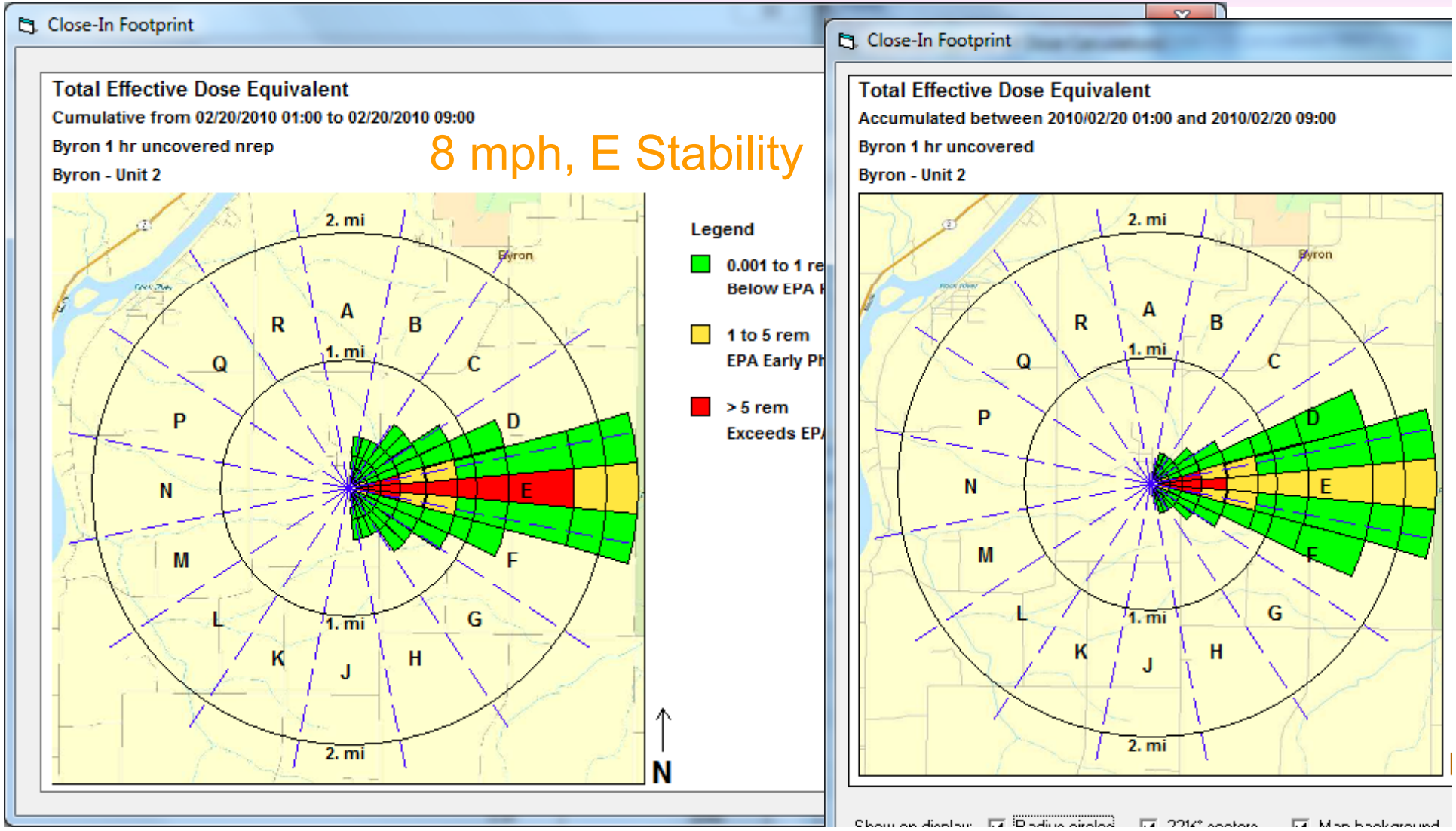
# 3.0.5 (left) vs 4.0 TEDE

## 3.9 rem vs 1.2 rem at 2 mi

## 1.3 rem vs 0.38 at 5 mi



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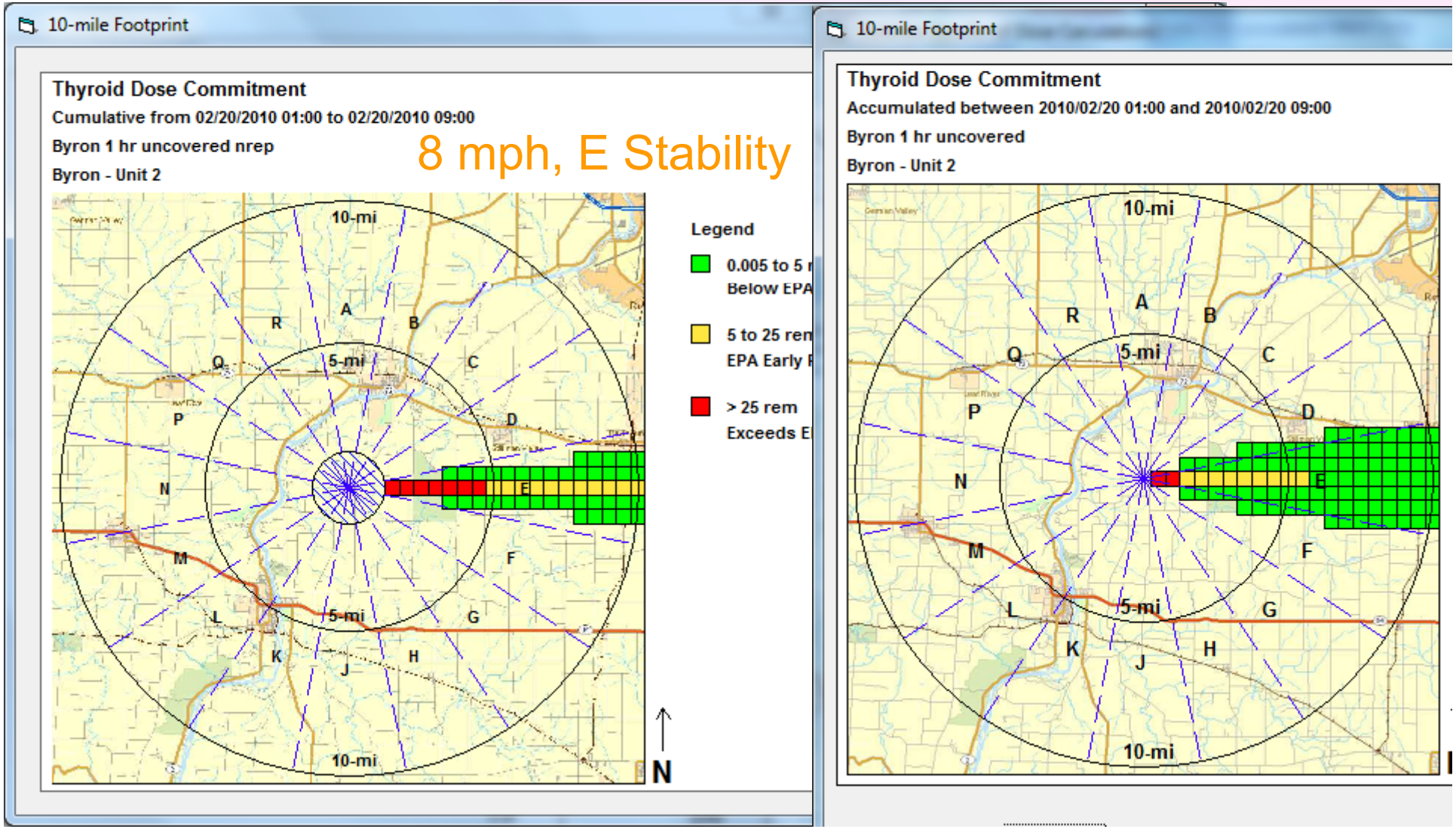
# 3.0.5 (left) vs 4.0 Thyroid

## 23 rem vs 5.7 rem at 5 mi

## 8.9 rem vs 2.4 rem at 10 mi



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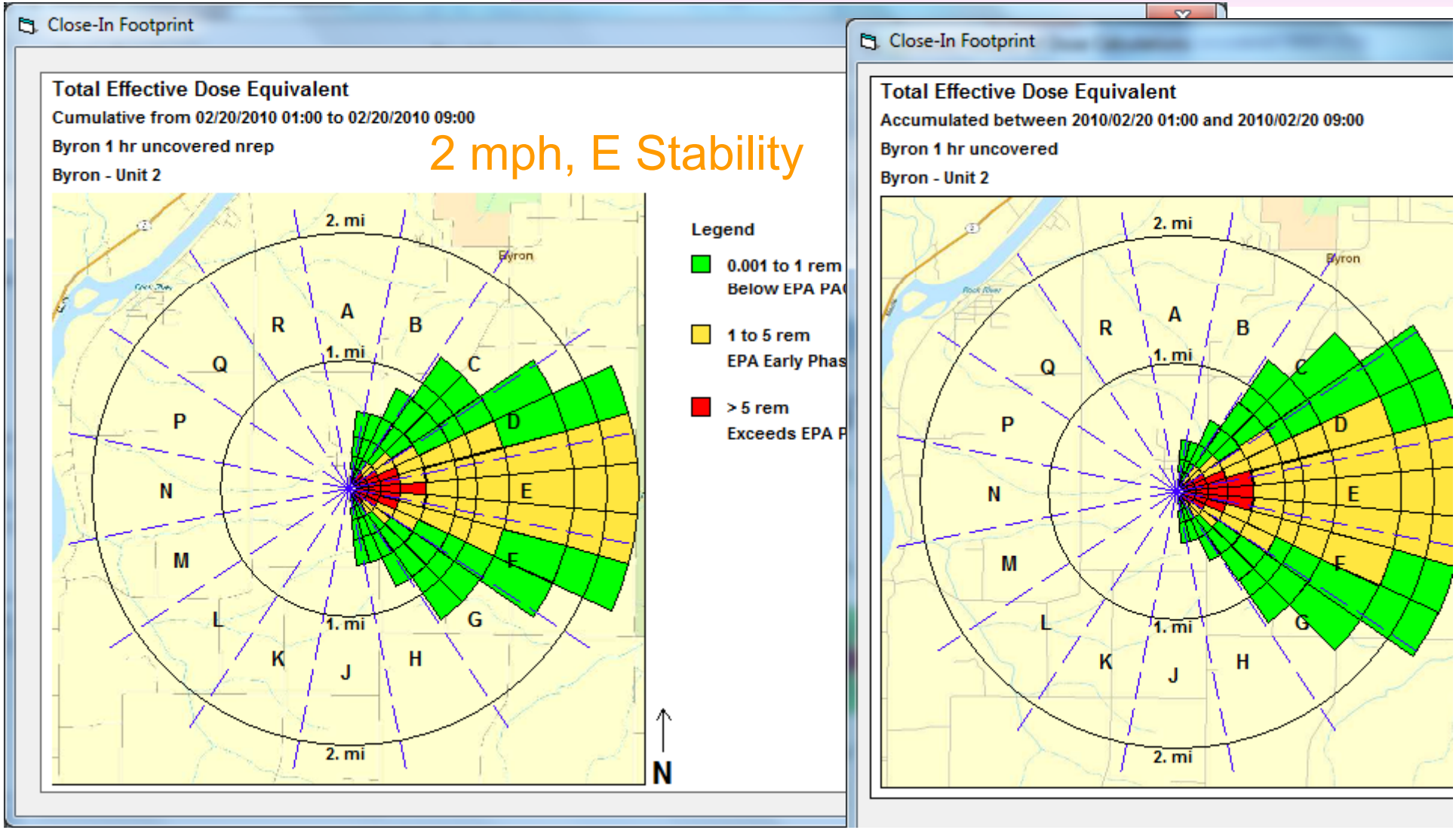
# 3.0.5 (left) vs 4.0 TEDE

## 3.3 rem vs 2.3 rem at 2 mi

## 1.9 rem vs 0.65 at 5 mi



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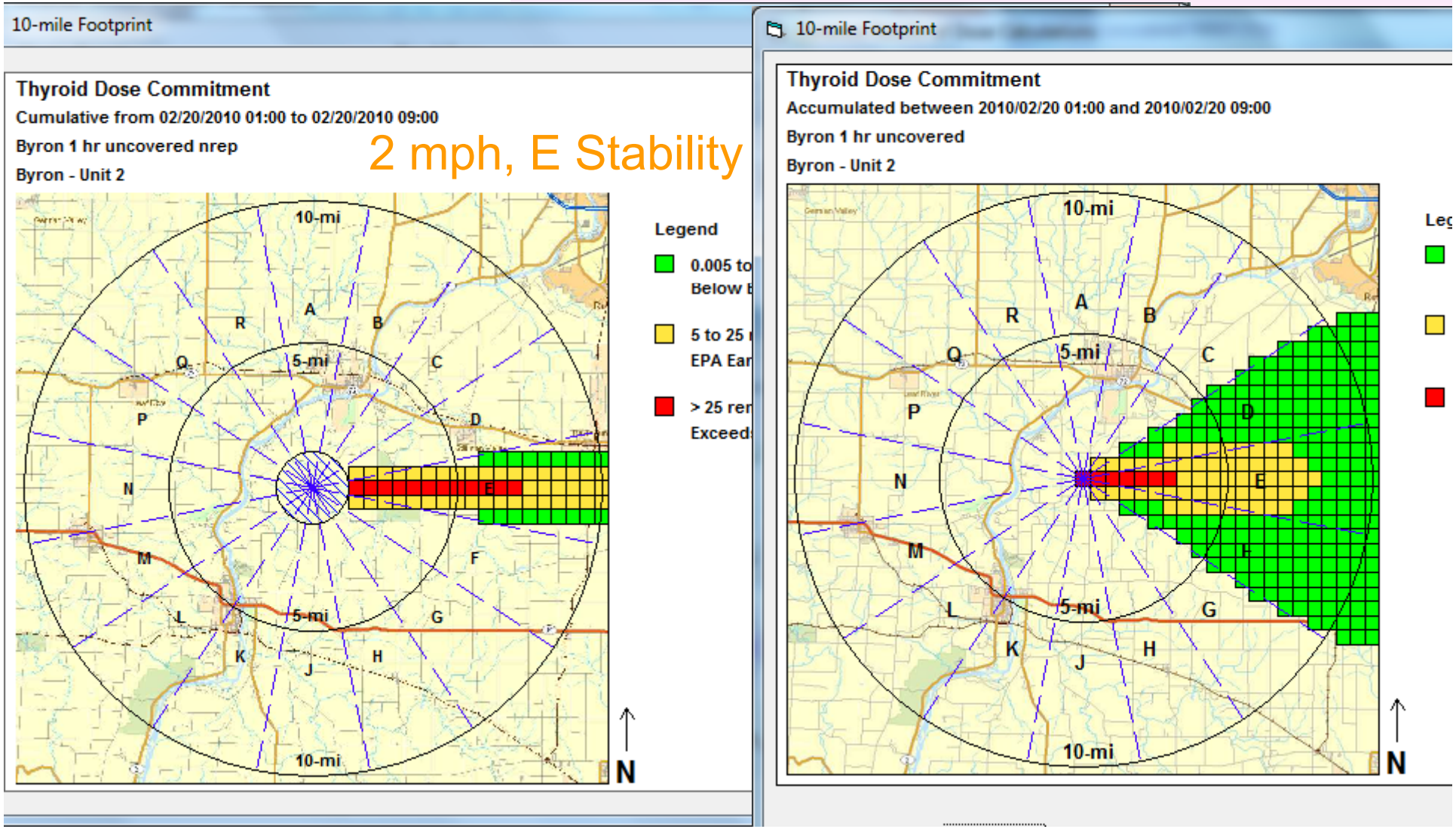
# 3.0.5 (left) vs 4.0 Thyroid

## 36 rem vs 13 at 5 mi

## 15 rem vs 3.2 at 10 mi



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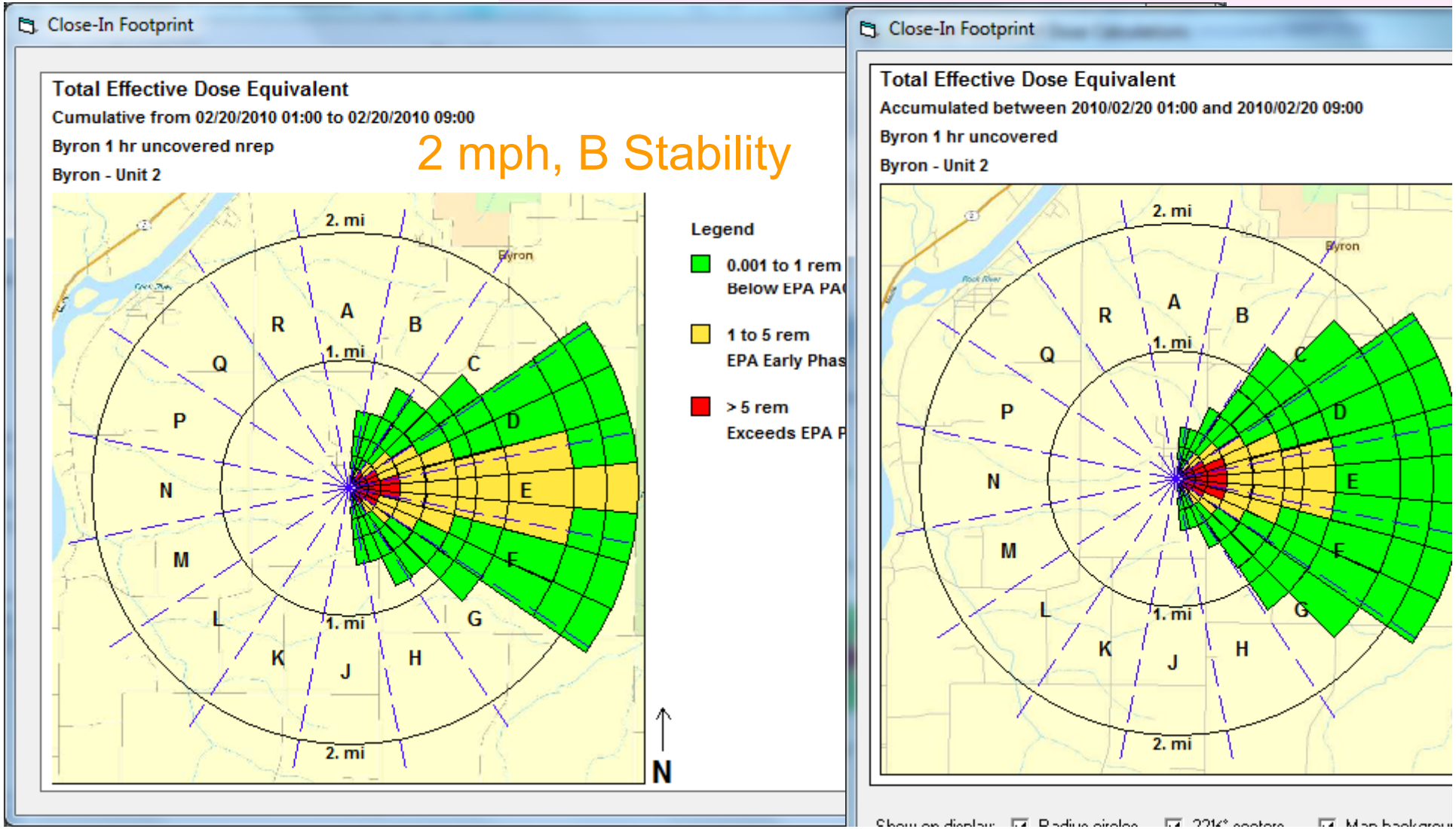
# 3.0.5 (left) vs 4.0 TEDE

## 2.1 rem vs 0.44 rem at 2 mi

## 0.88 rem vs 0.23 at 5 mi



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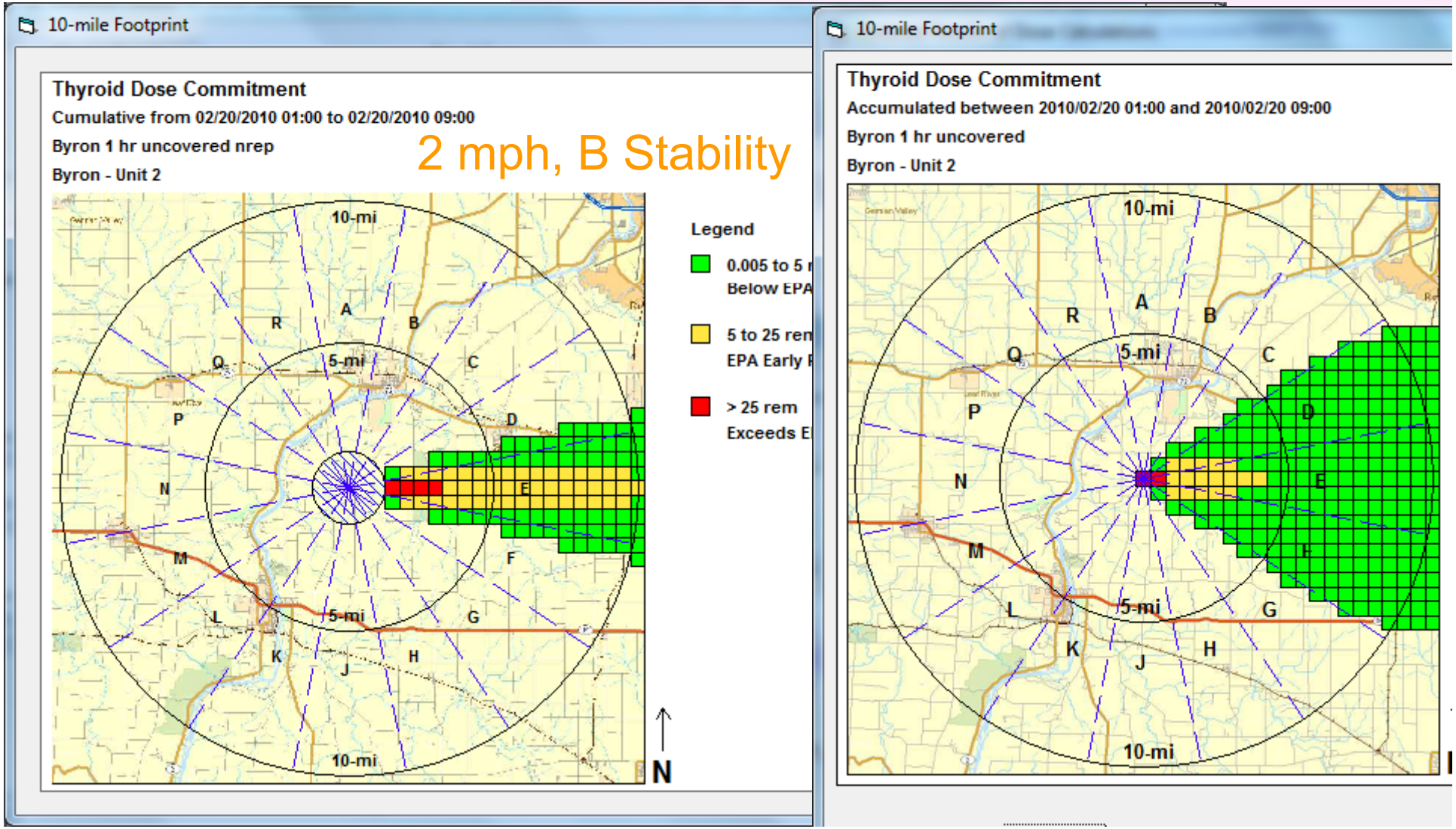
# 3.0.5 (left) vs 4.0 Thyroid

## 16 rem vs 3.9 at 5 mi

## 5.9 rem vs 1.2 at 10 mi



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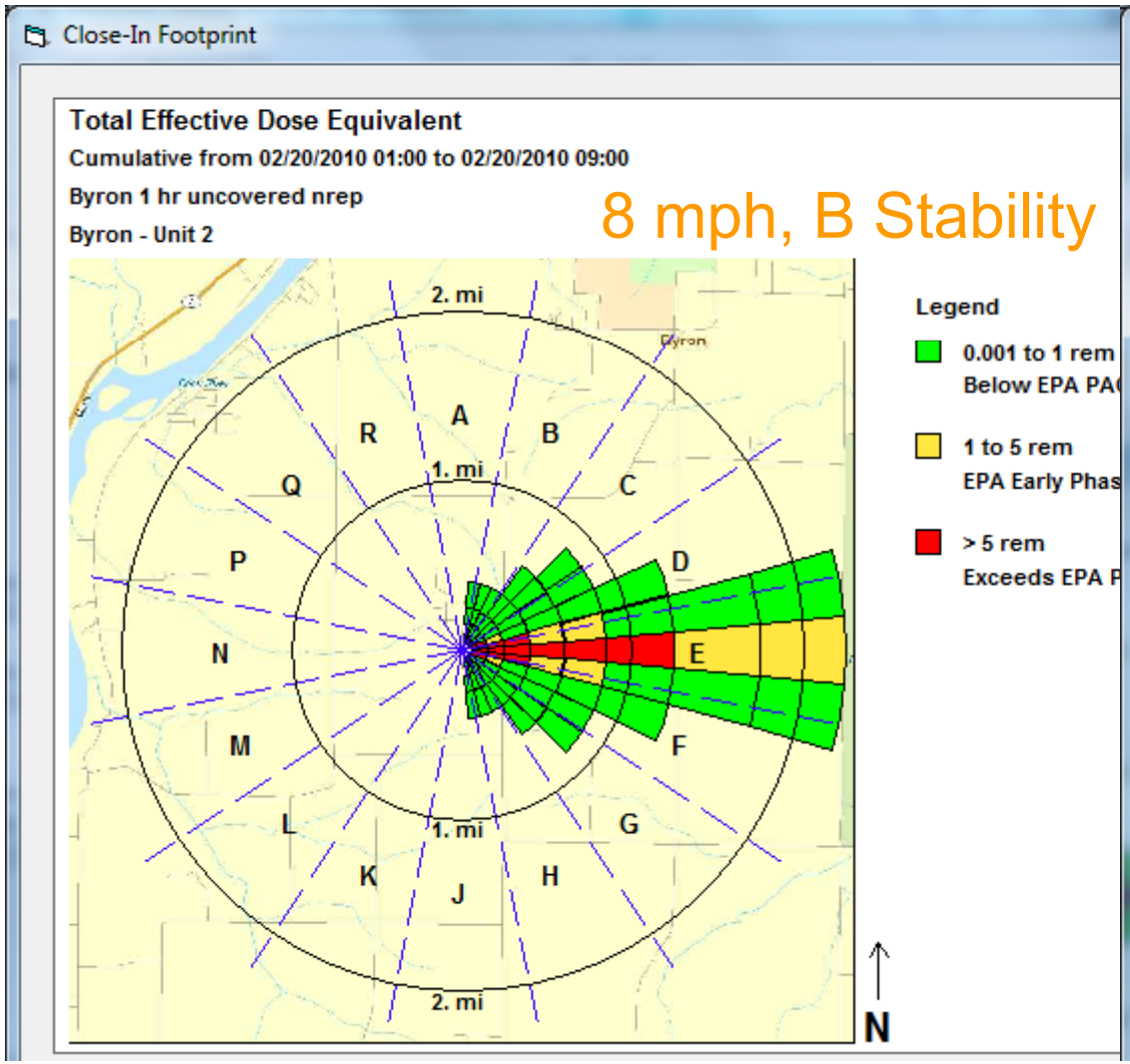
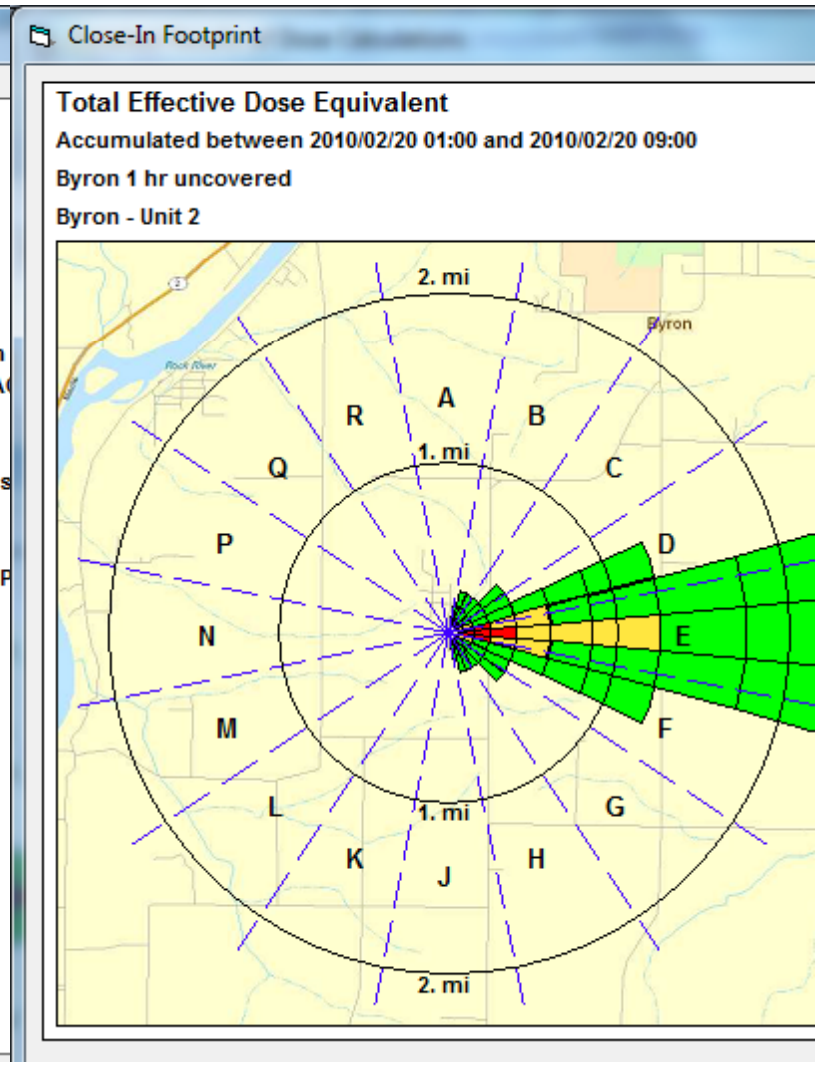
# 3.0.5 (left) vs 4.0 TEDE

## 2.4 rem vs 0.33 rem at 2 mi

## 0.64 rem vs 0.11 at 5 mi



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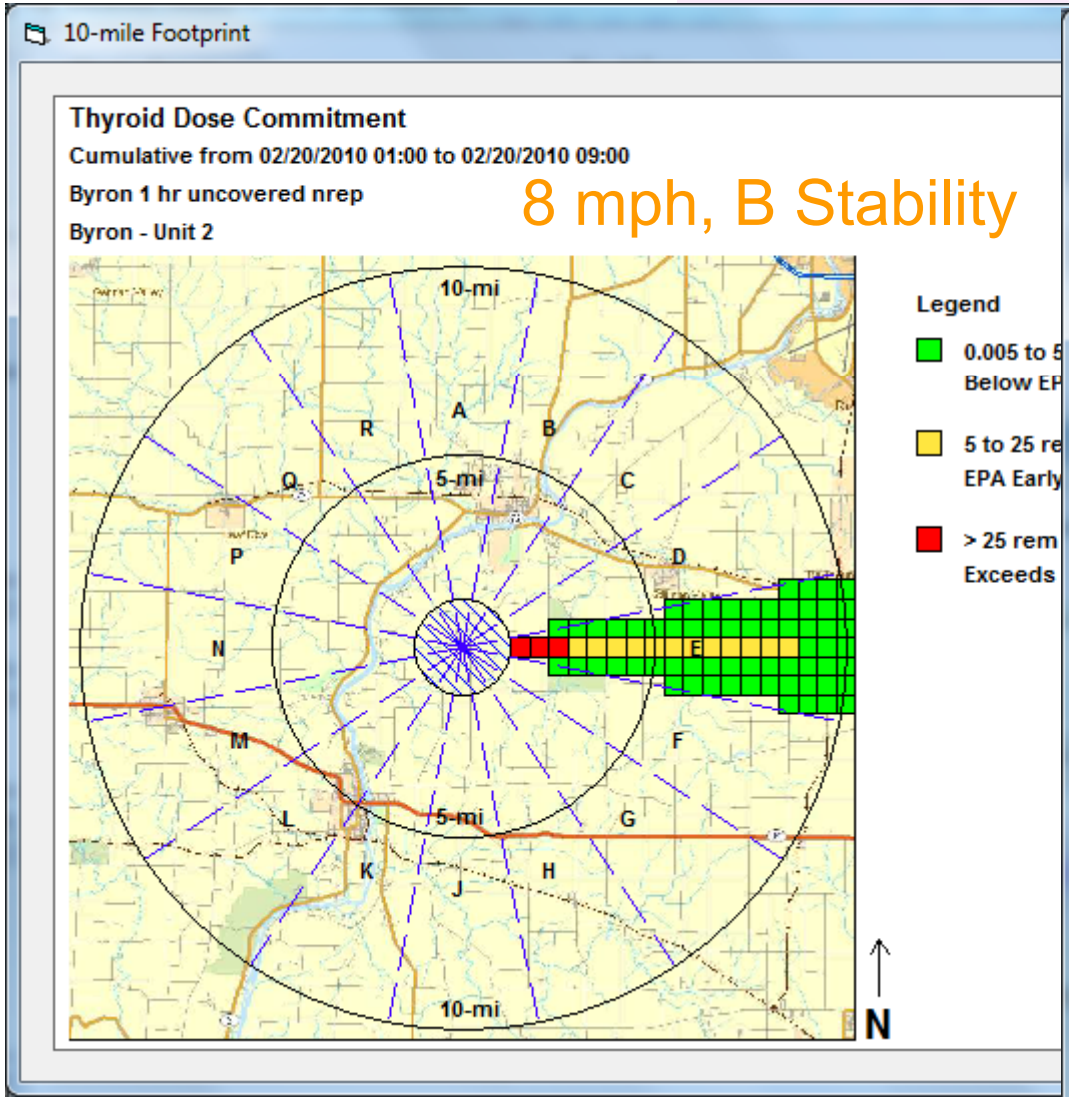
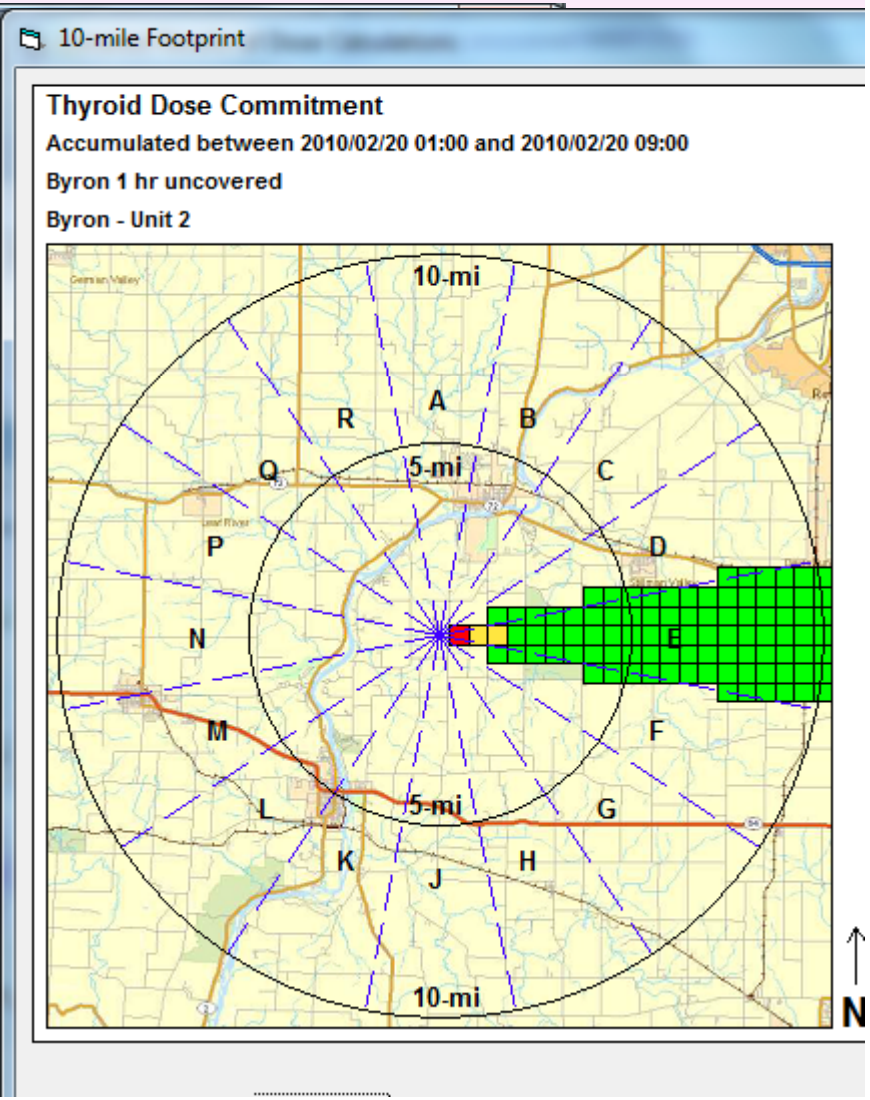
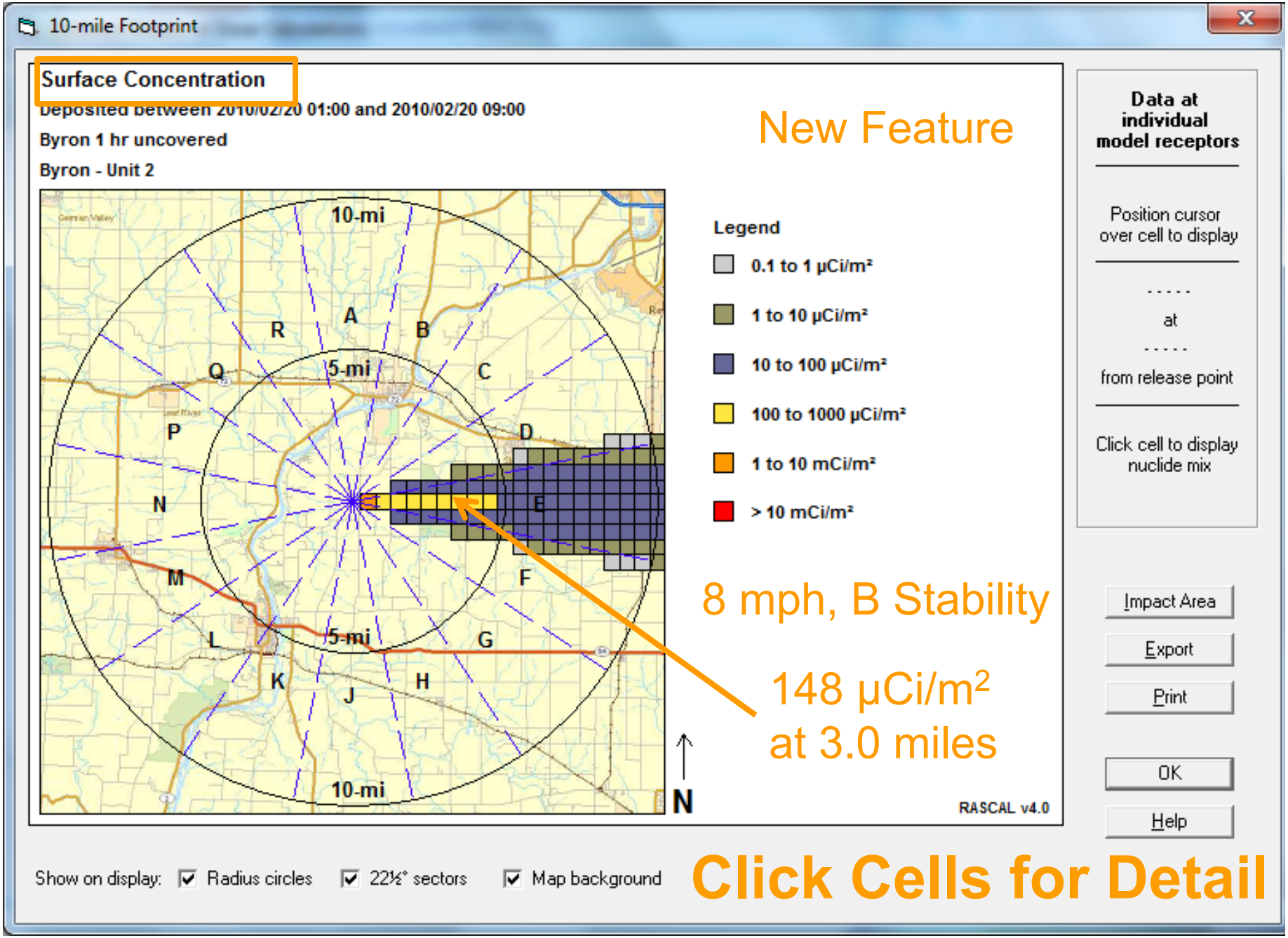
# 3.0.5 (left) vs 4.0 Thyroid

## 11 rem vs 1.6 at 5 mi

## 4.0 rem vs 0.83 at 10 mi




10-mile Footprint
Surface Concentration
Deposited between 2010/02/20 01:00 and 2010/02/20 09:00
Byron 1 hr uncovered
Byron - Unit 2
New Feature
10-mi
5-mi
5-mi
10-mi
A
B
C
D
E
F
G
H
J
K
L
M
N
P
Q
R
N
Legend
0.1 to 1 µCi/m²
1 to 10 µCi/m²
10 to 100 µCi/m²
100 to 1000 µCi/m²
1 to 10 mCi/m²
> 10 mCi/m²
8 mph, B Stability
148 µCi/m²
at 3.0 miles
RASCAL v4.0
Data at individual model receptors
Position cursor over cell to display
at
from release point
Click cell to display nuclide mix
Impact Area
Export
Print
OK
Help
Show on display:
Radius circles
22½° sectors
Map background
Click Cells for Detail

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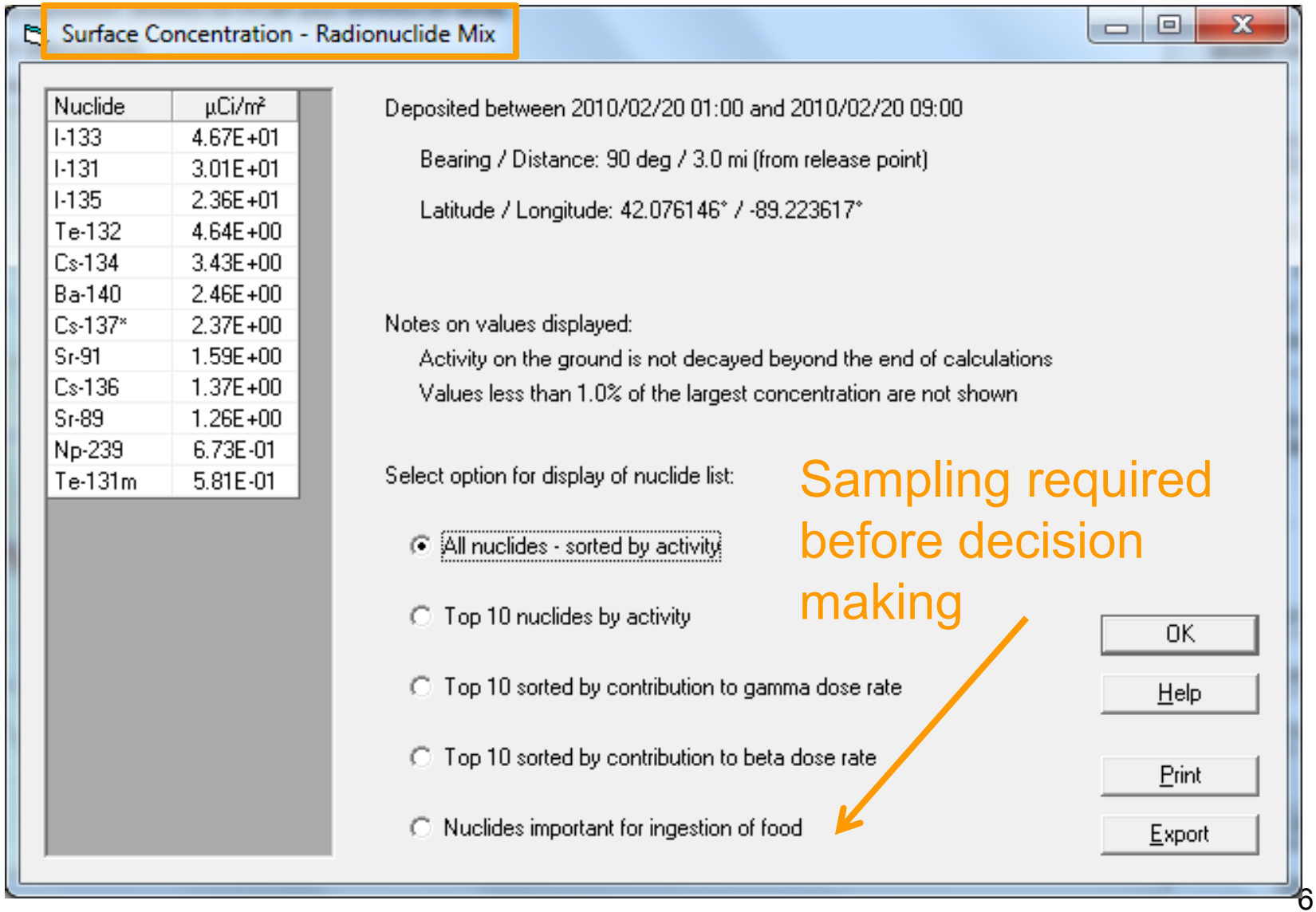
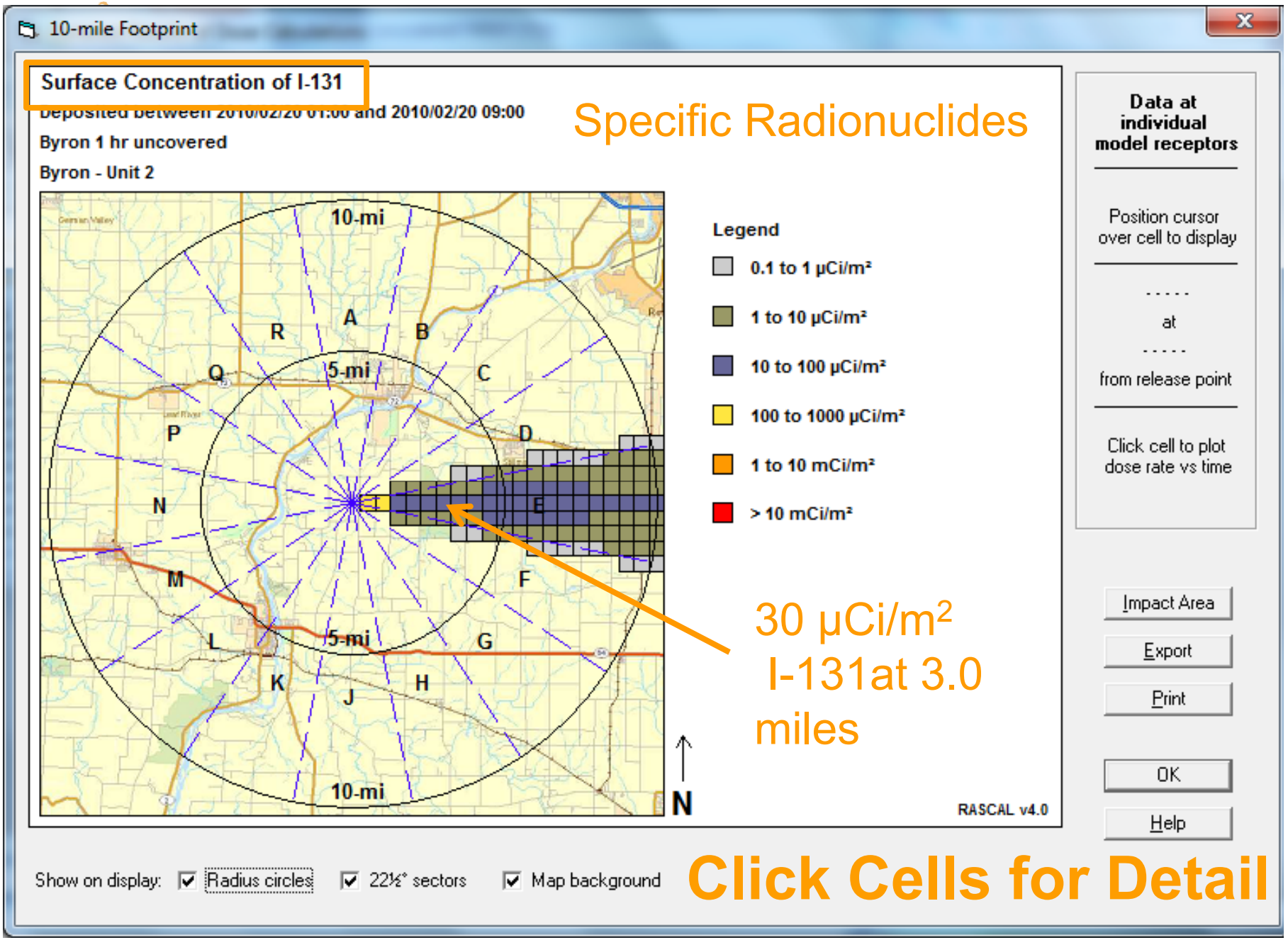
# Radionuclide Deposition




10-mile Footprint
Surface Concentration of I-131
Byron 1 hr uncovered
Byron - Unit 2
Specific Radionuclides
10-mi
5-mi
5-mi
10-mi
A
B
C
D
E
F
G
H
J
K
L
M
N
P
Q
R
I
Legend
0.1 to 1 µCi/m²
1 to 10 µCi/m²
10 to 100 µCi/m²
100 to 1000 µCi/m²
1 to 10 mCi/m²
> 10 mCi/m²
30 µCi/m² I-131at 3.0 miles
N
RASCAL v4.0
Data at individual model receptors
Position cursor over cell to display
at
from release point
Click cell to plot dose rate vs time
Impact Area
Export
Print
OK
Help
Show on display:
Radius circles
22½° sectors
Map background
Click Cells for Detail

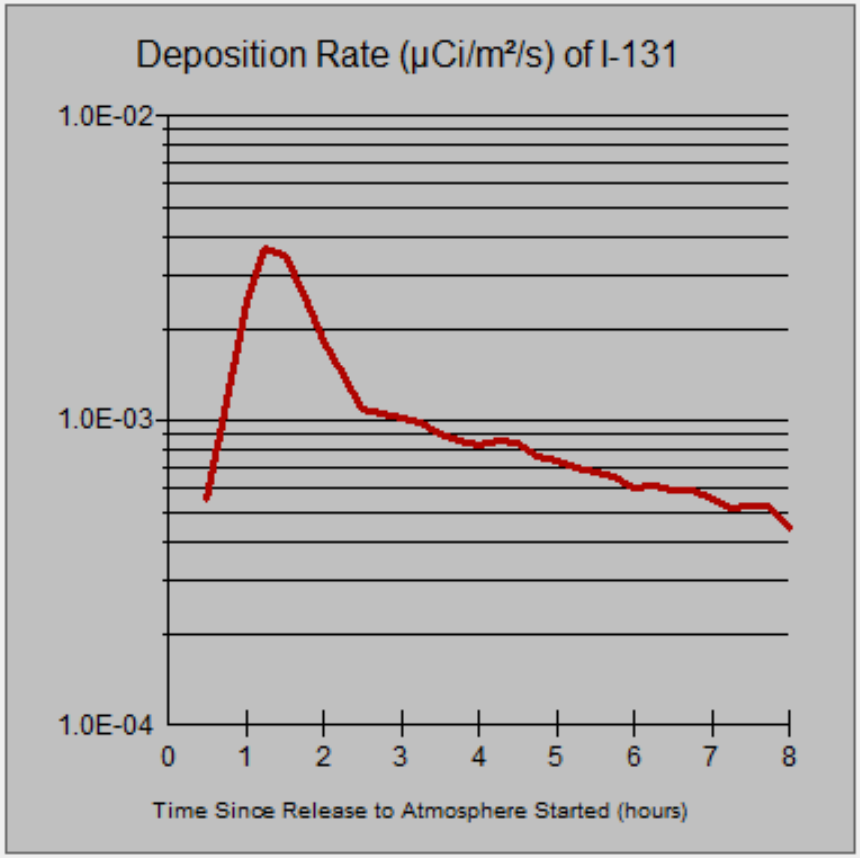
Dose vs Time Plot - 10 mile Calculations

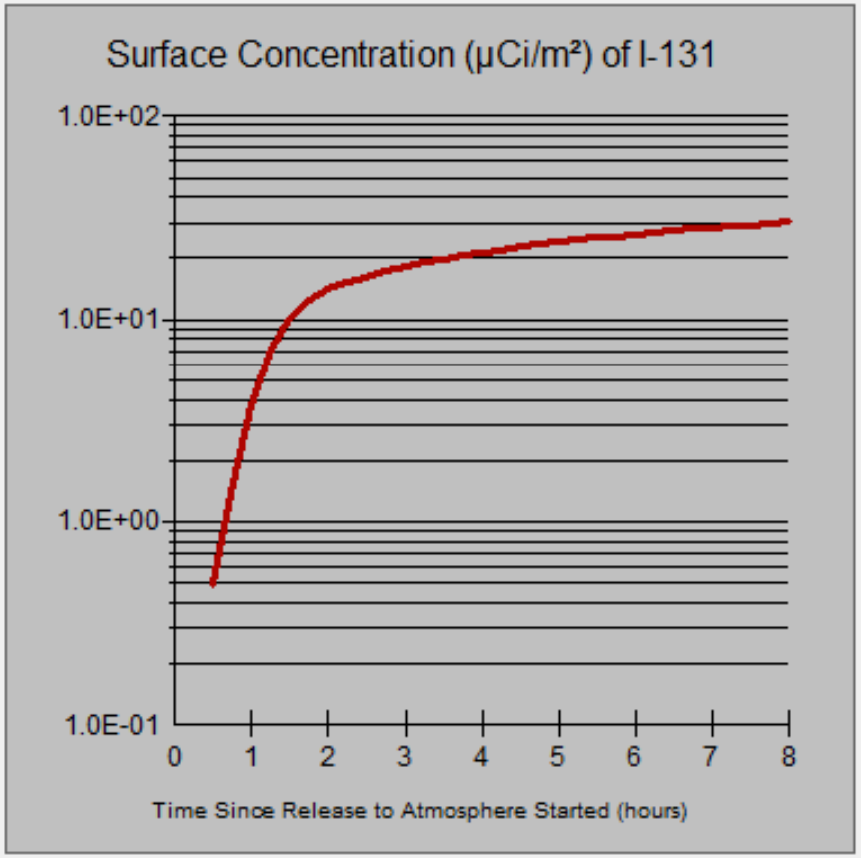
Case description: **Byron 1 hr uncovered**

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.




Print OK Help

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# Export Footprint to Shapefile

- Requires the MapWindow GIS open source software
- www.mapwindow.org
- Separate installation required for this feature to work
- Latest installation available with RASCAL installation

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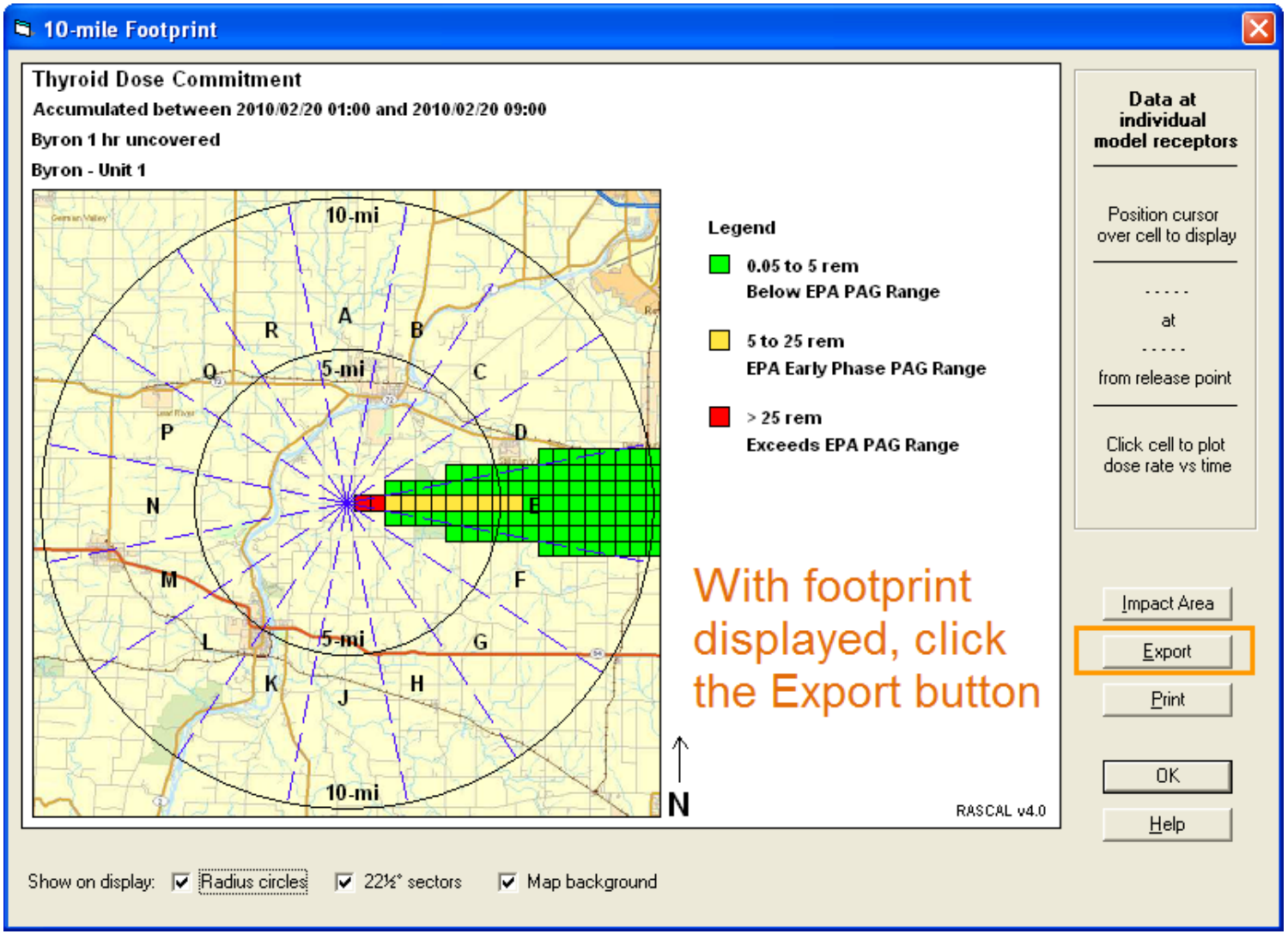

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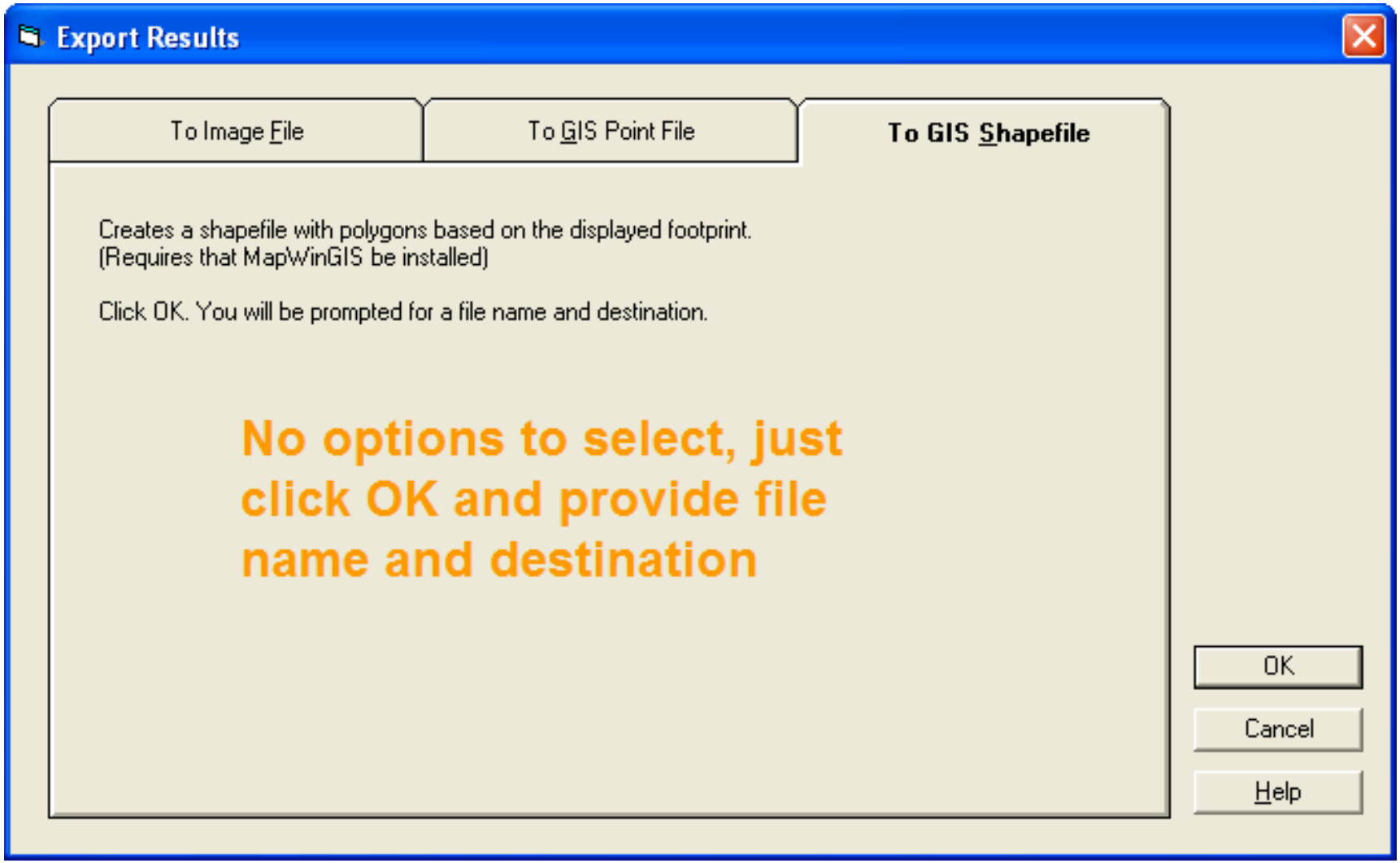

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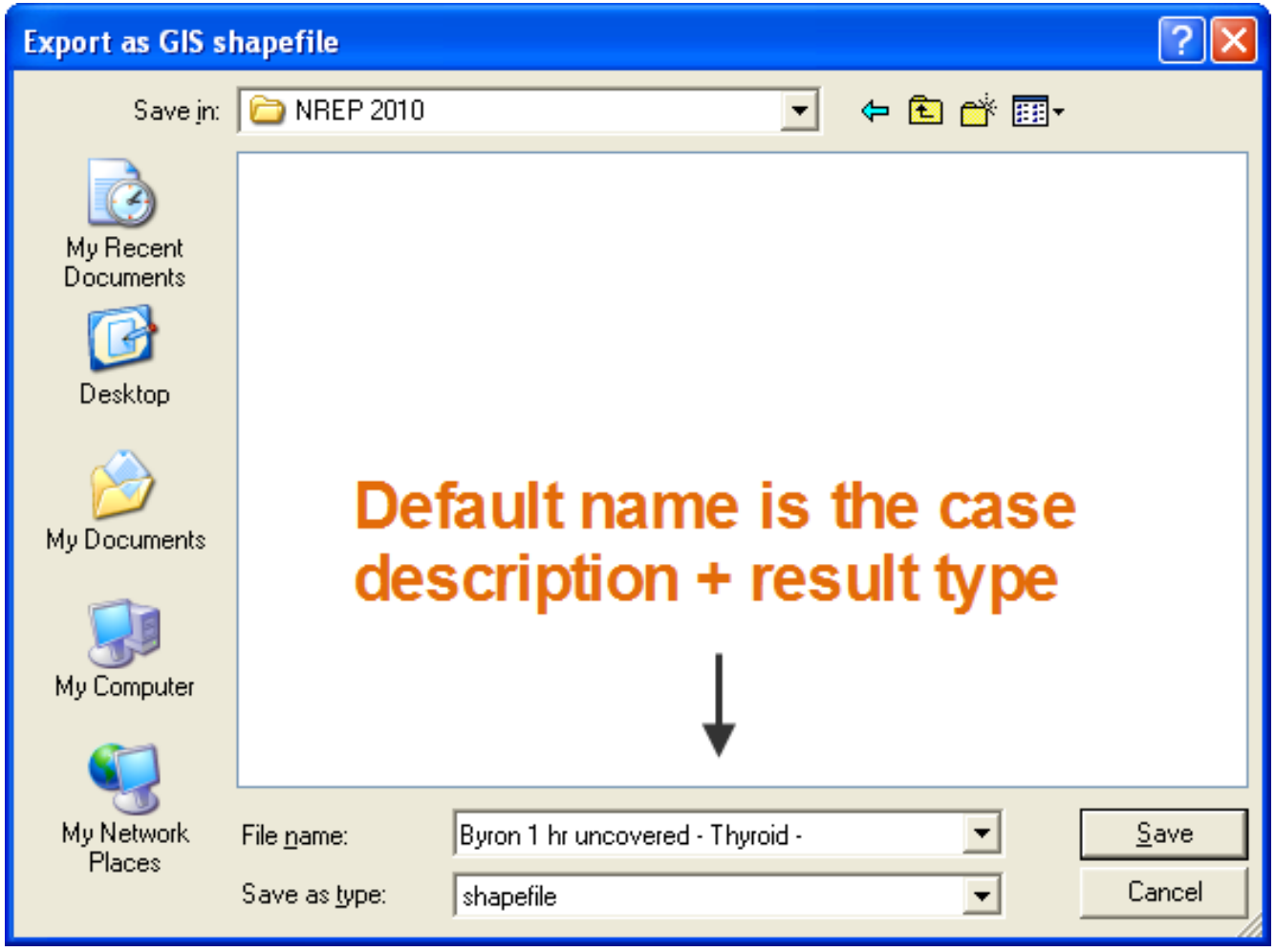

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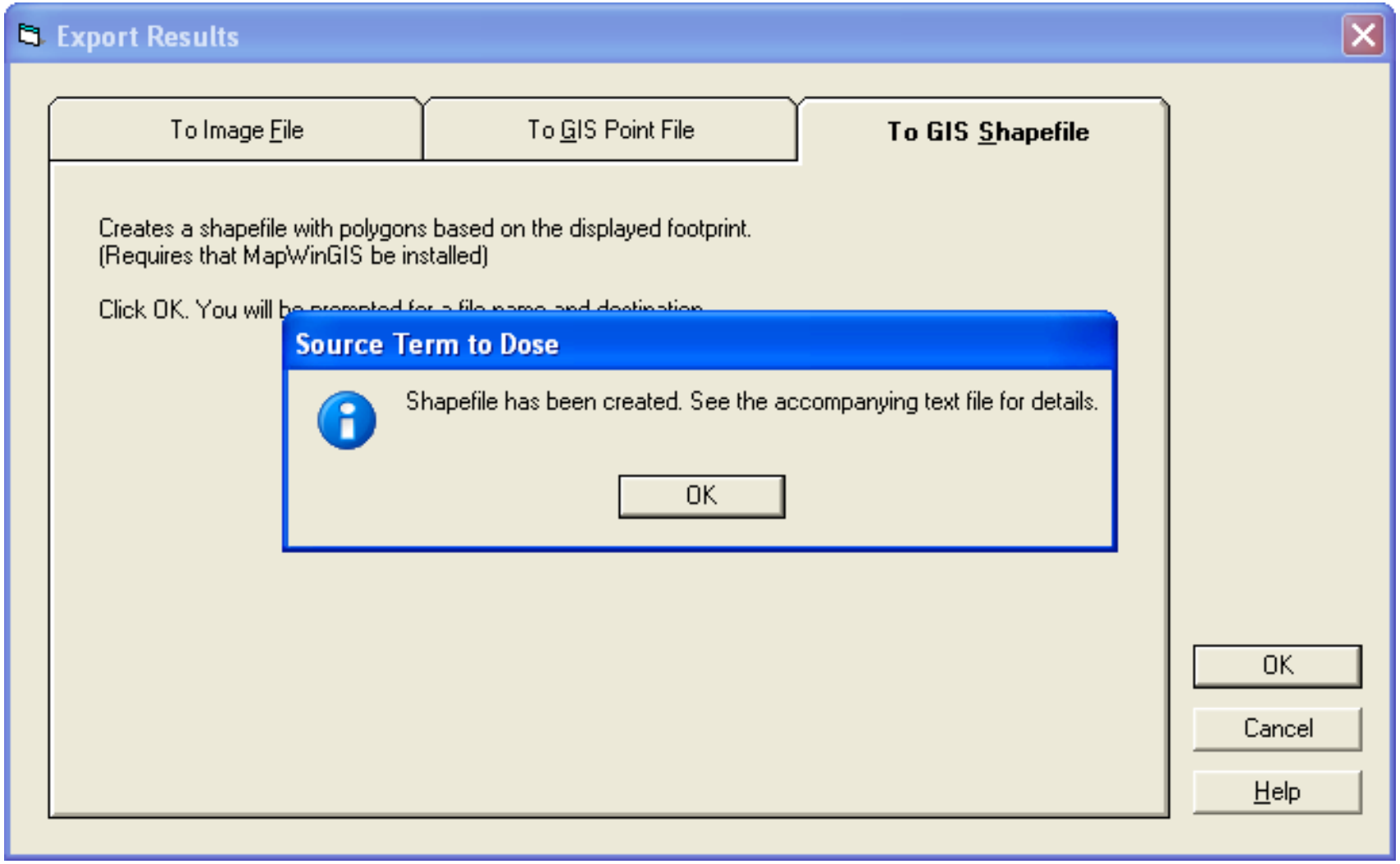

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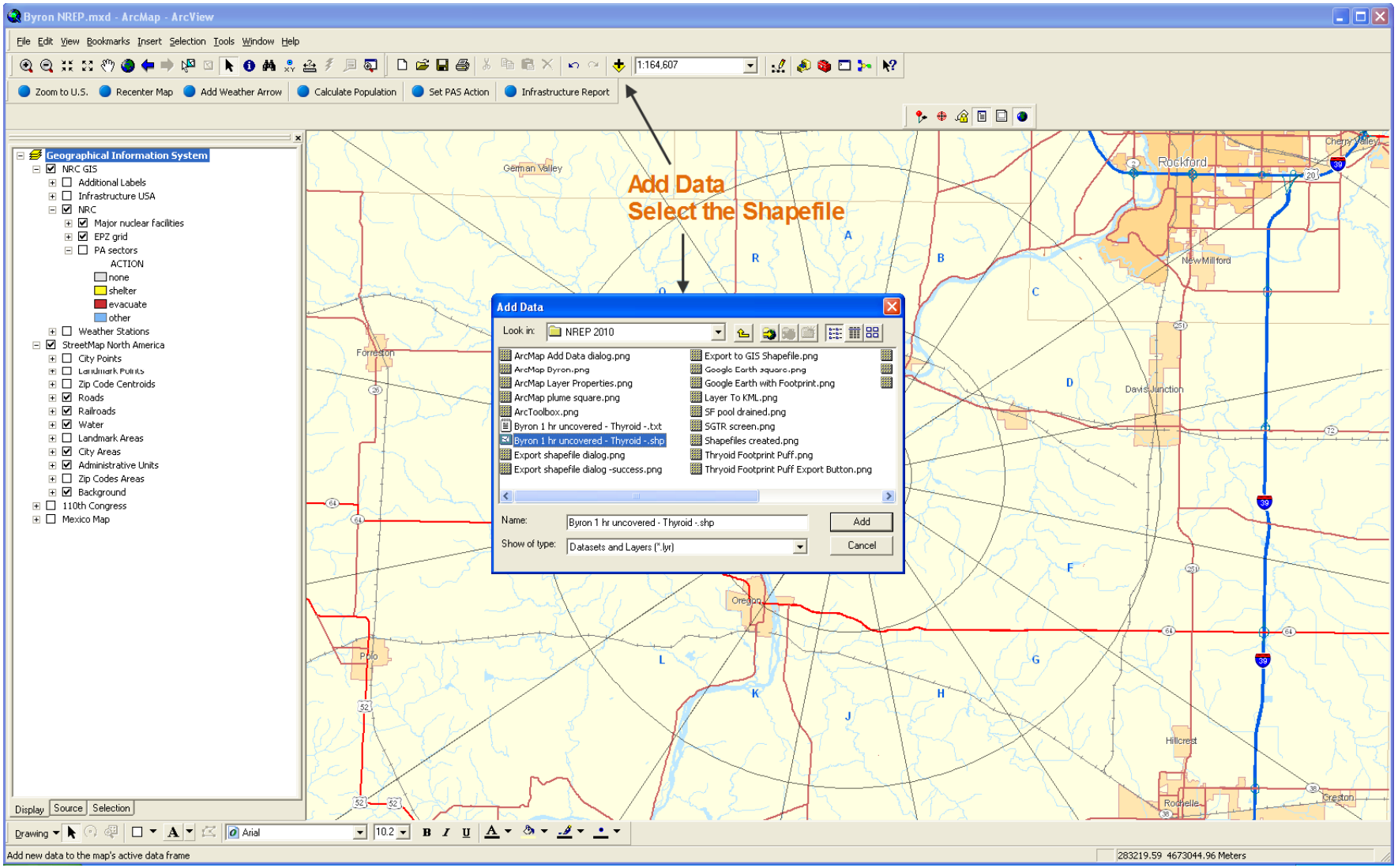
# Add Shapefile to GIS



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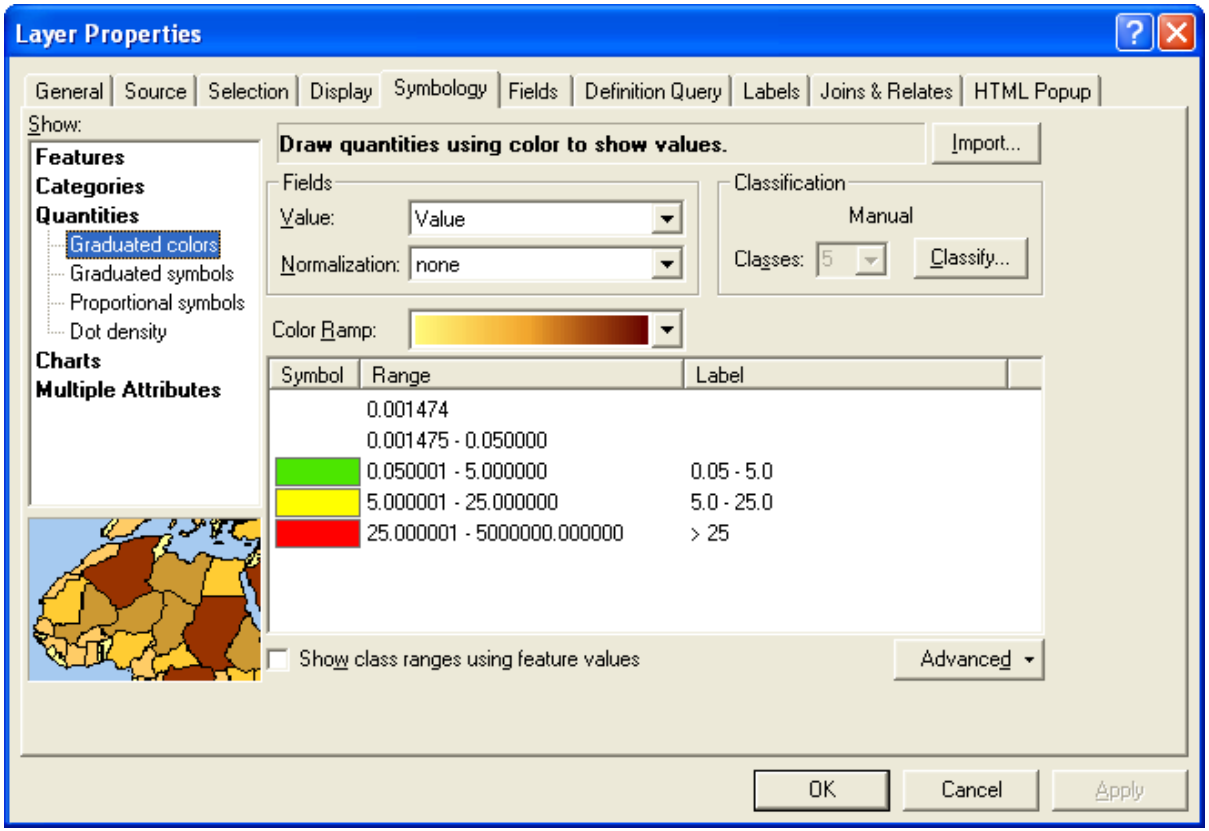
# Adjust symbology to match the RASCAL legend



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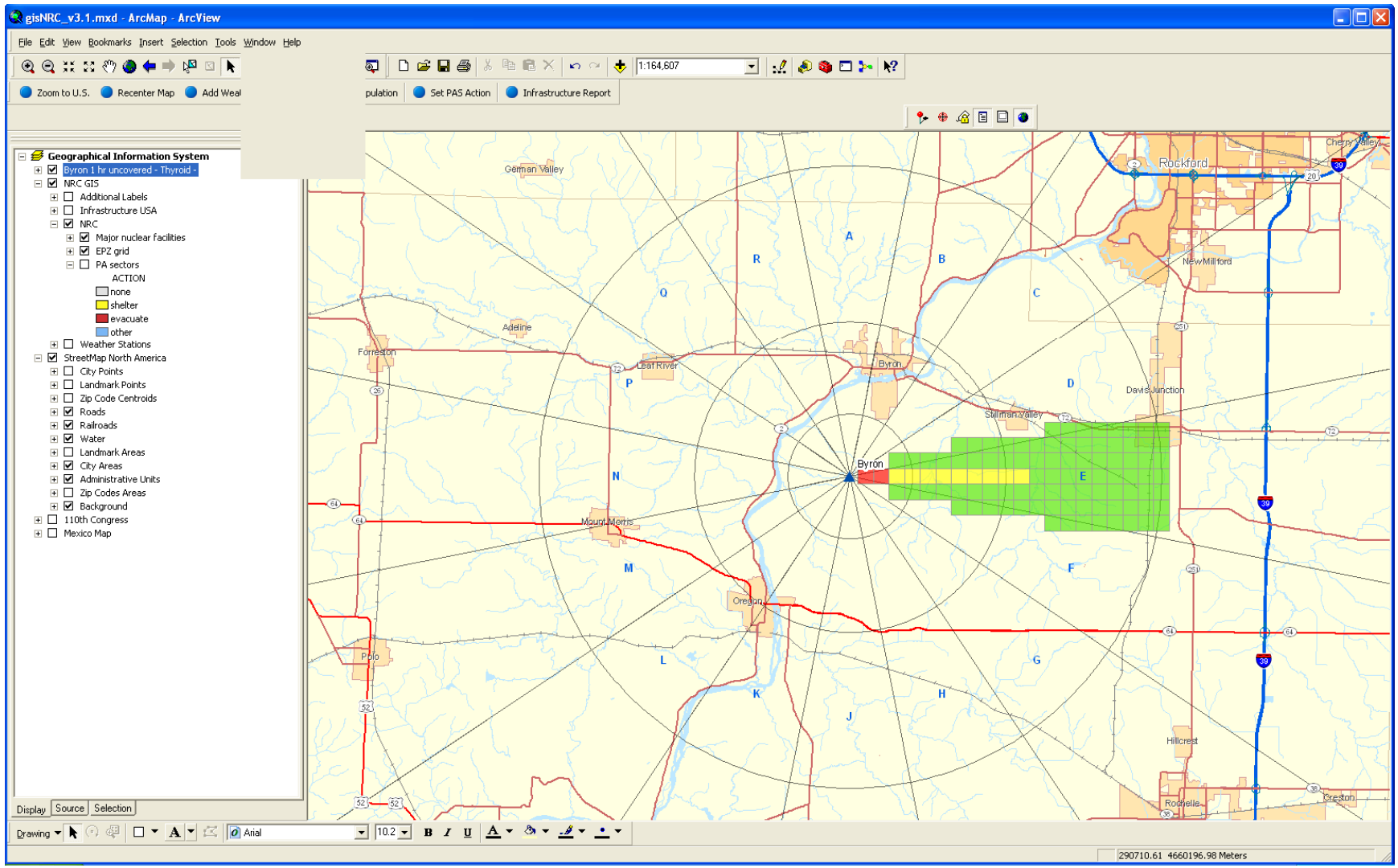
# Adjust Transparency



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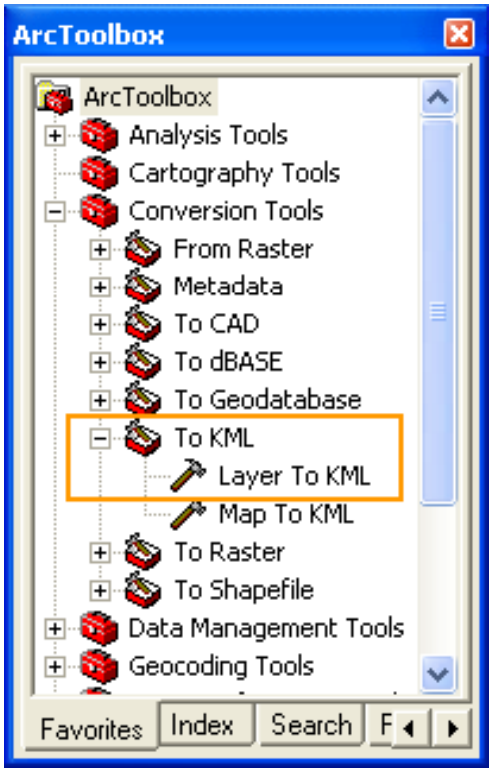
# ArcMap to Google Earth




Use the conversion tool "Layer to KML" in the ArcToolbox

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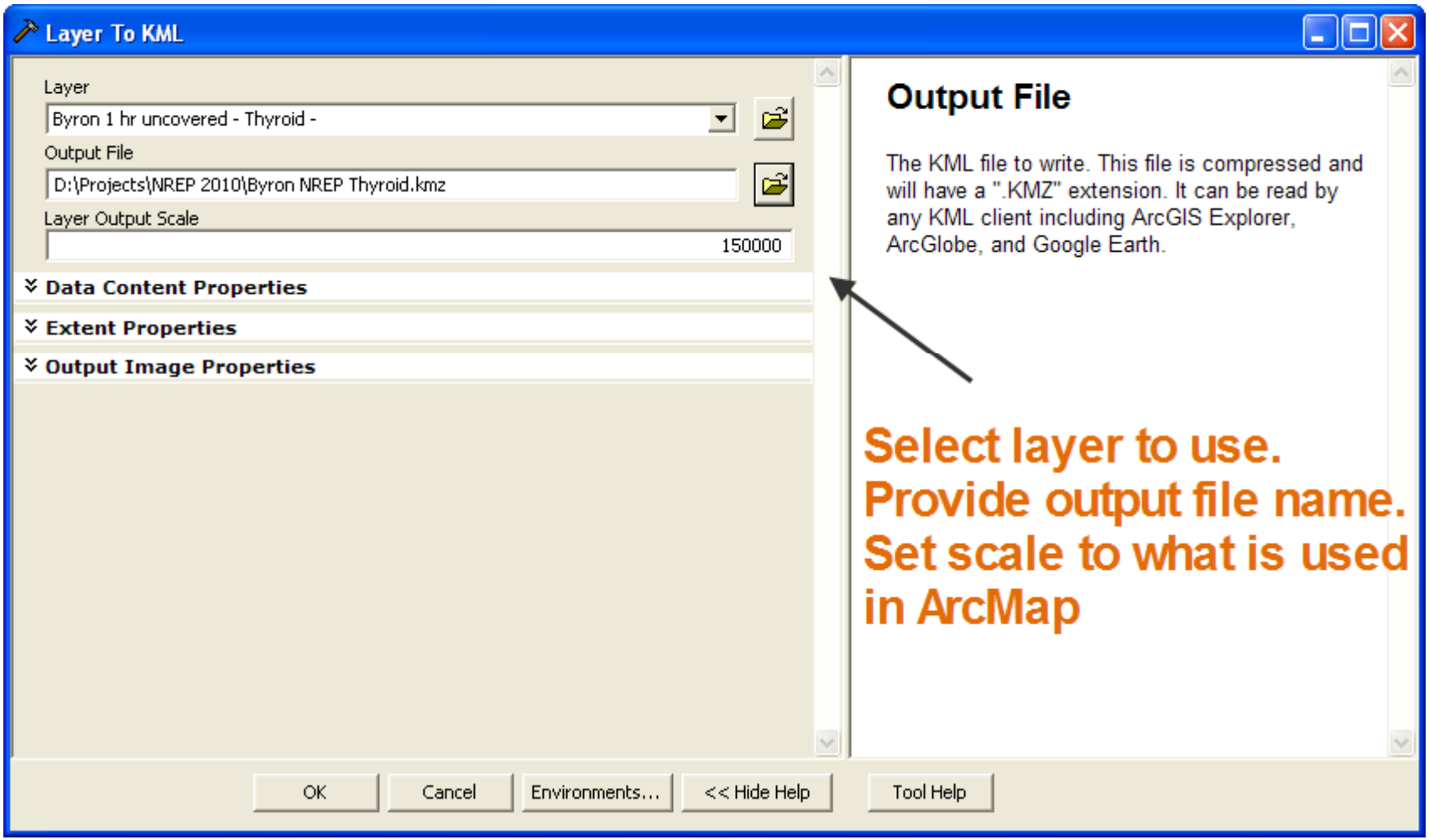
# Layer to KML



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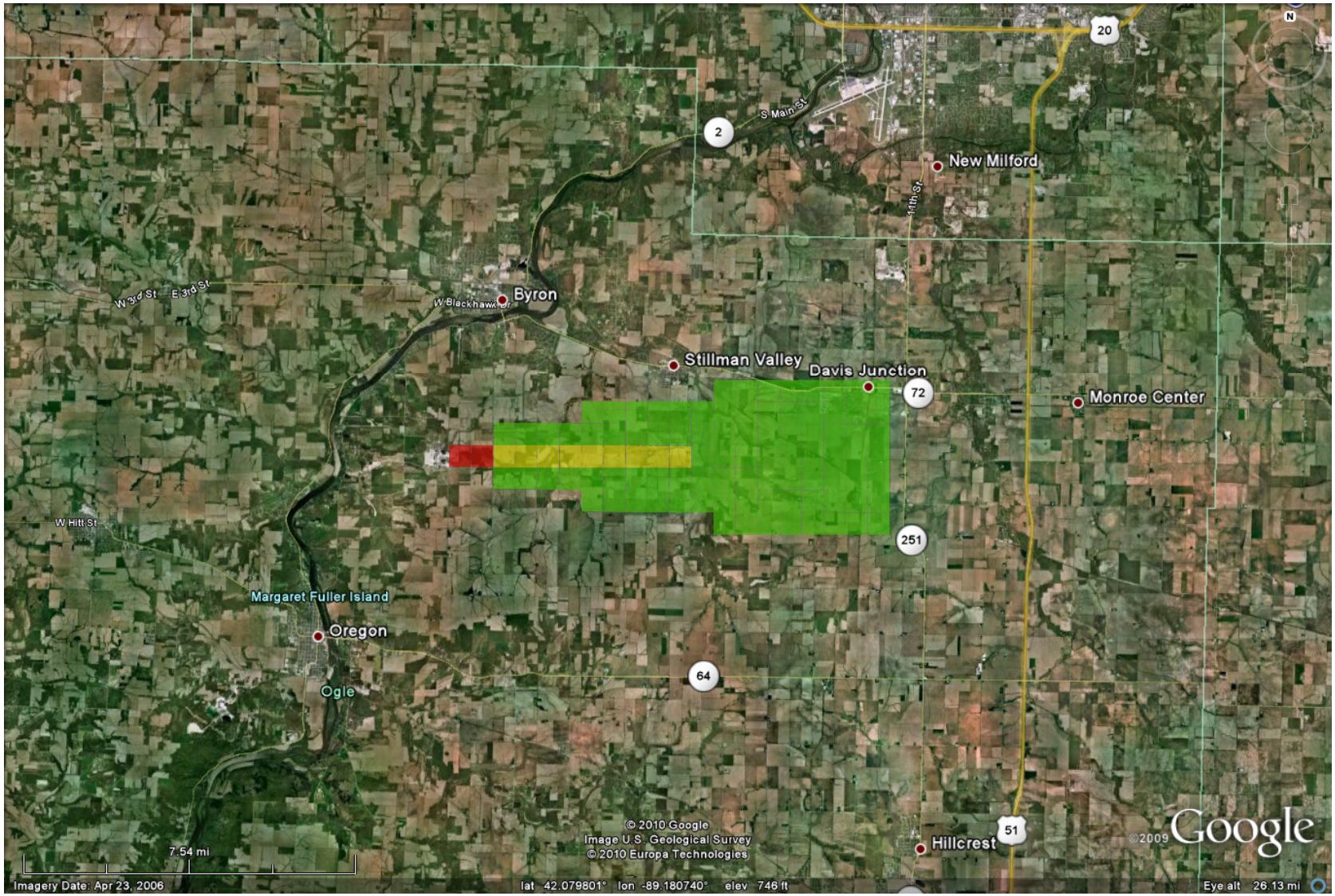
# Drag KML into Google Earth



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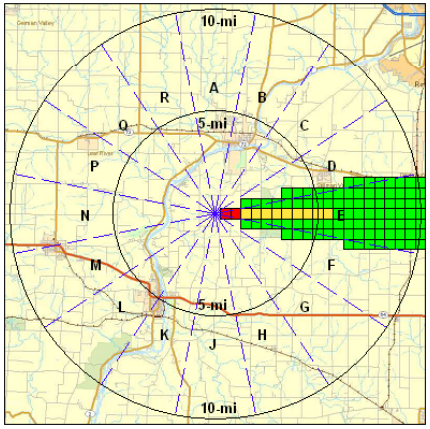
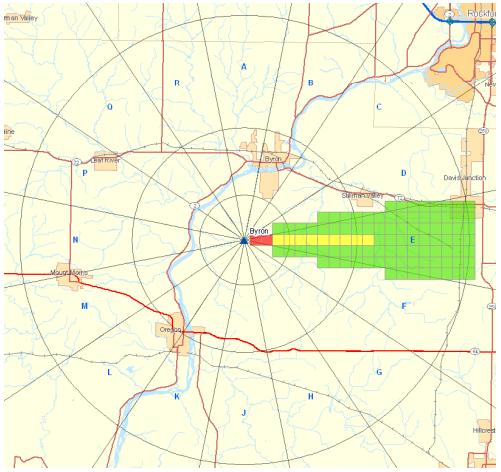
# Display Plume in:

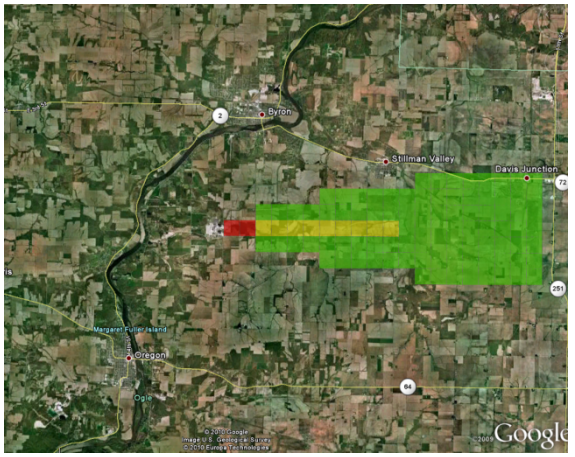
RASCAL



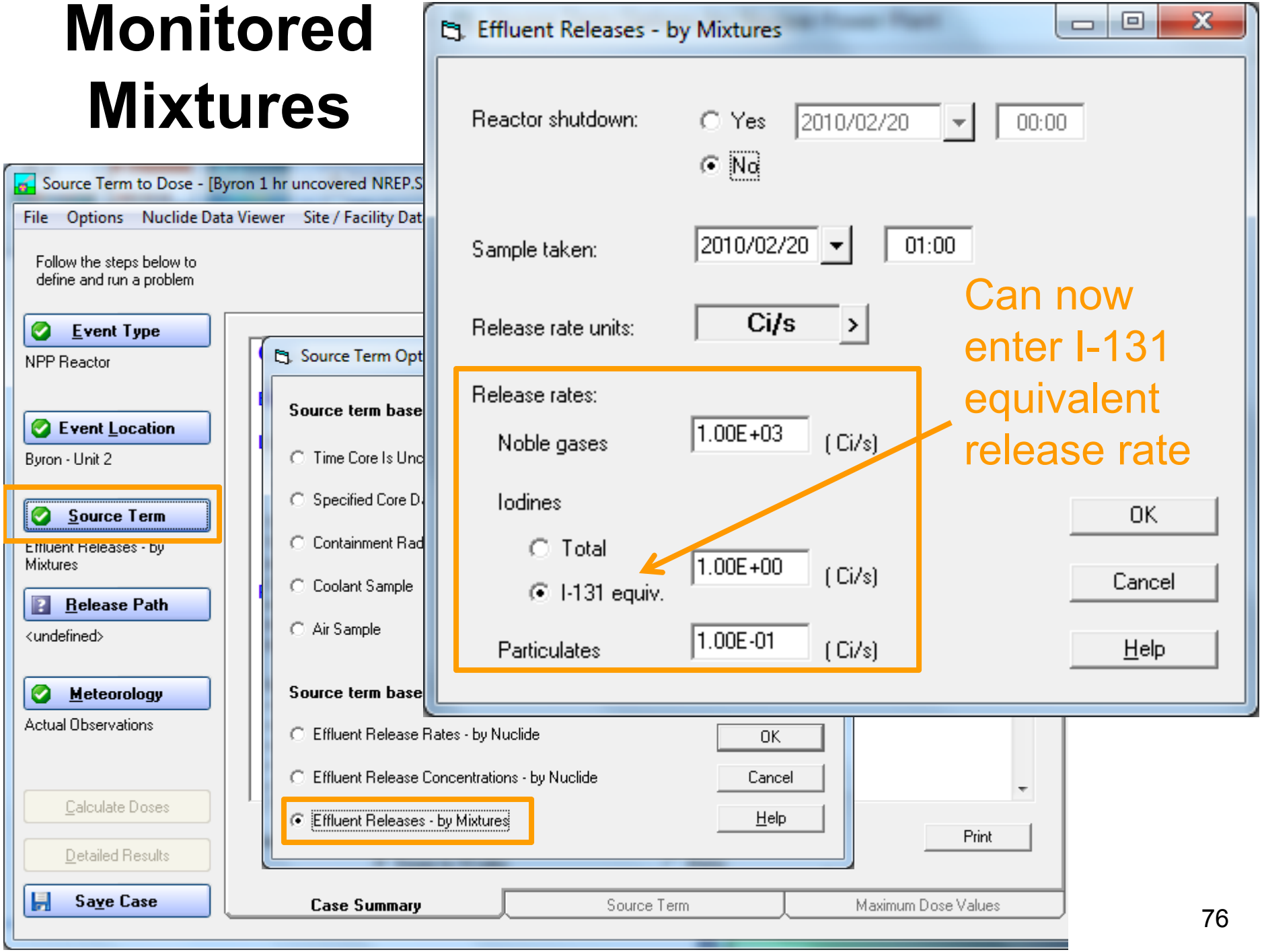

ArcMap



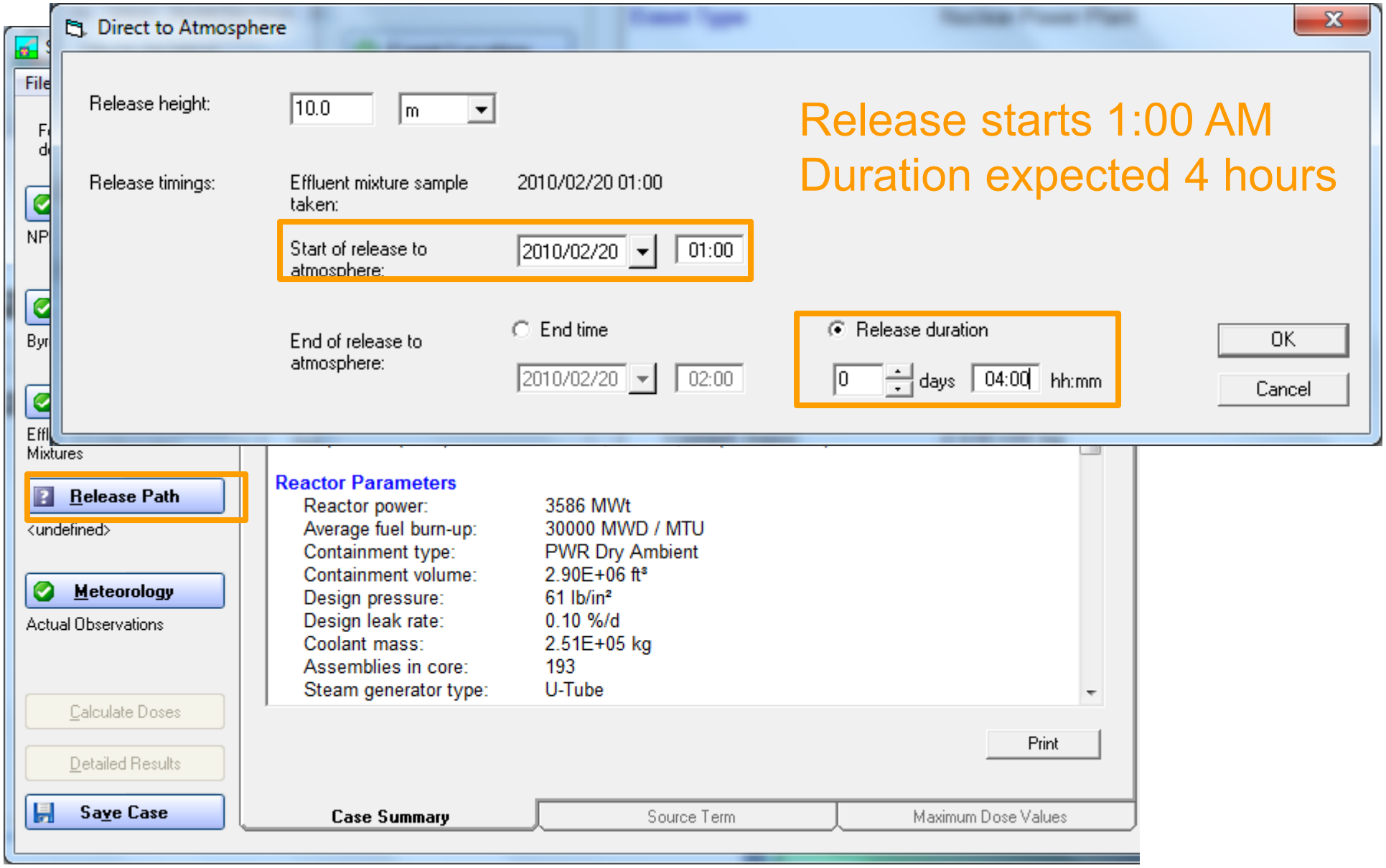

Google Earth



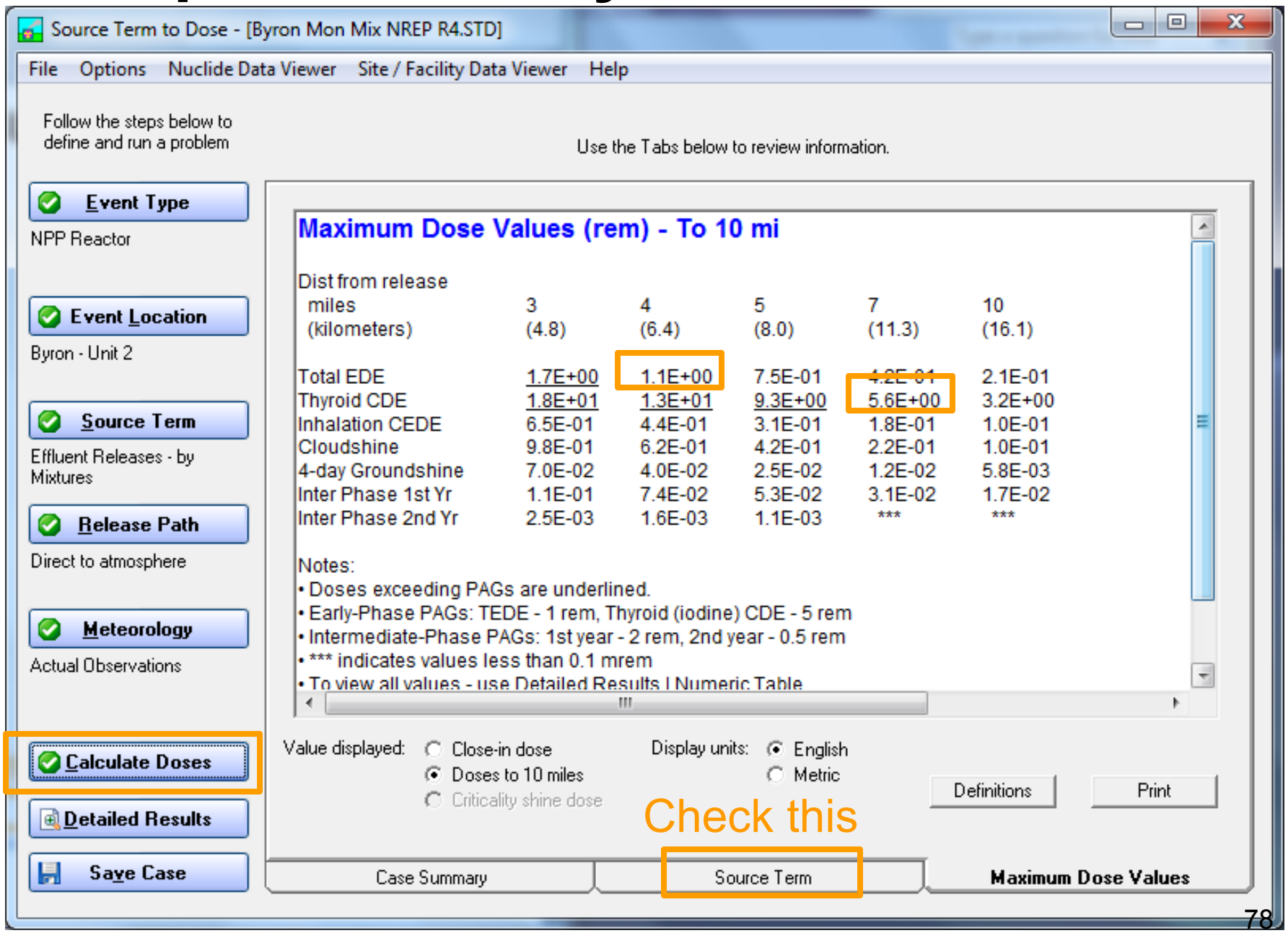
# Monitored Mixtures

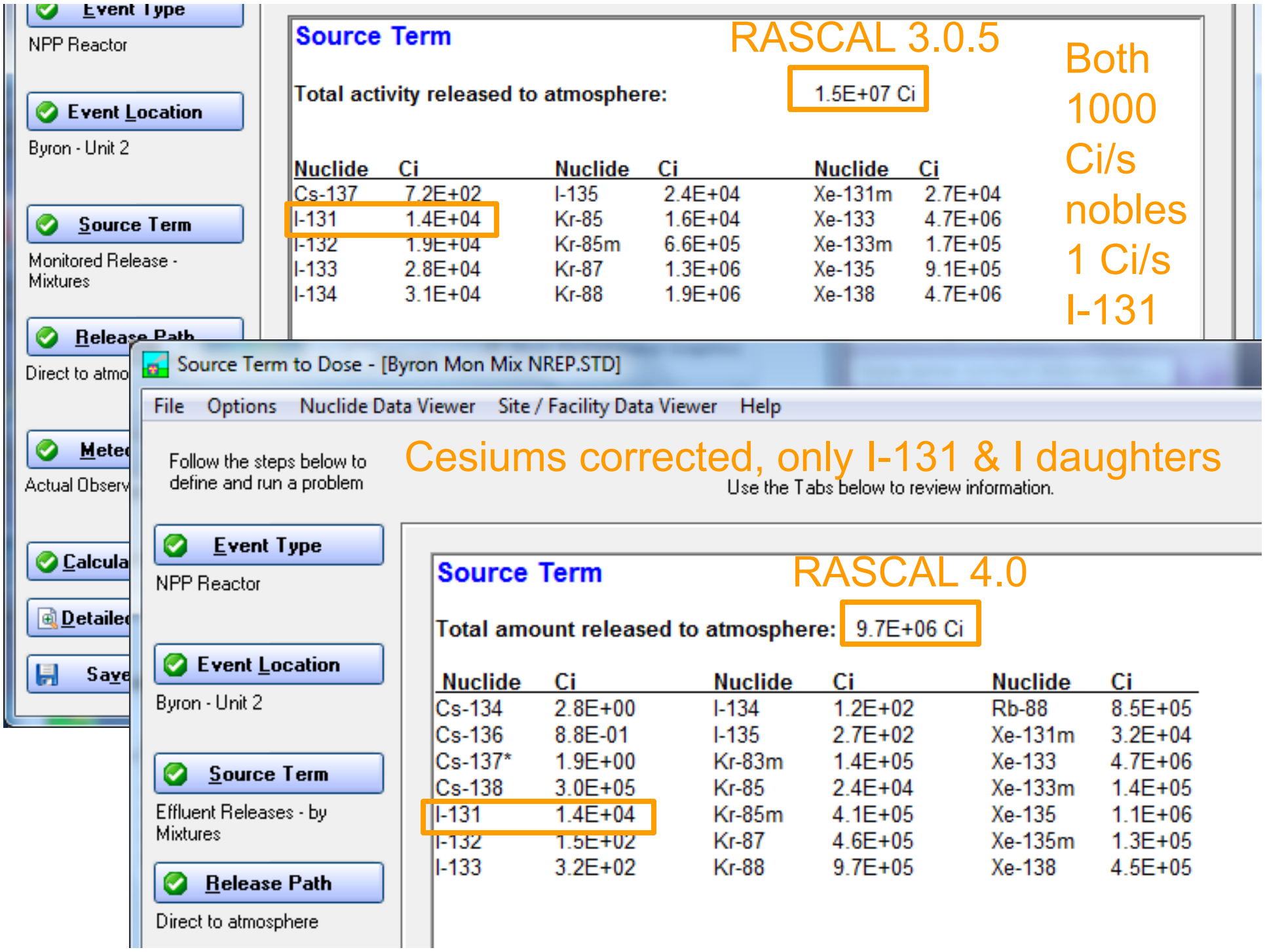


# Release Pathway – Monitored, Filtered

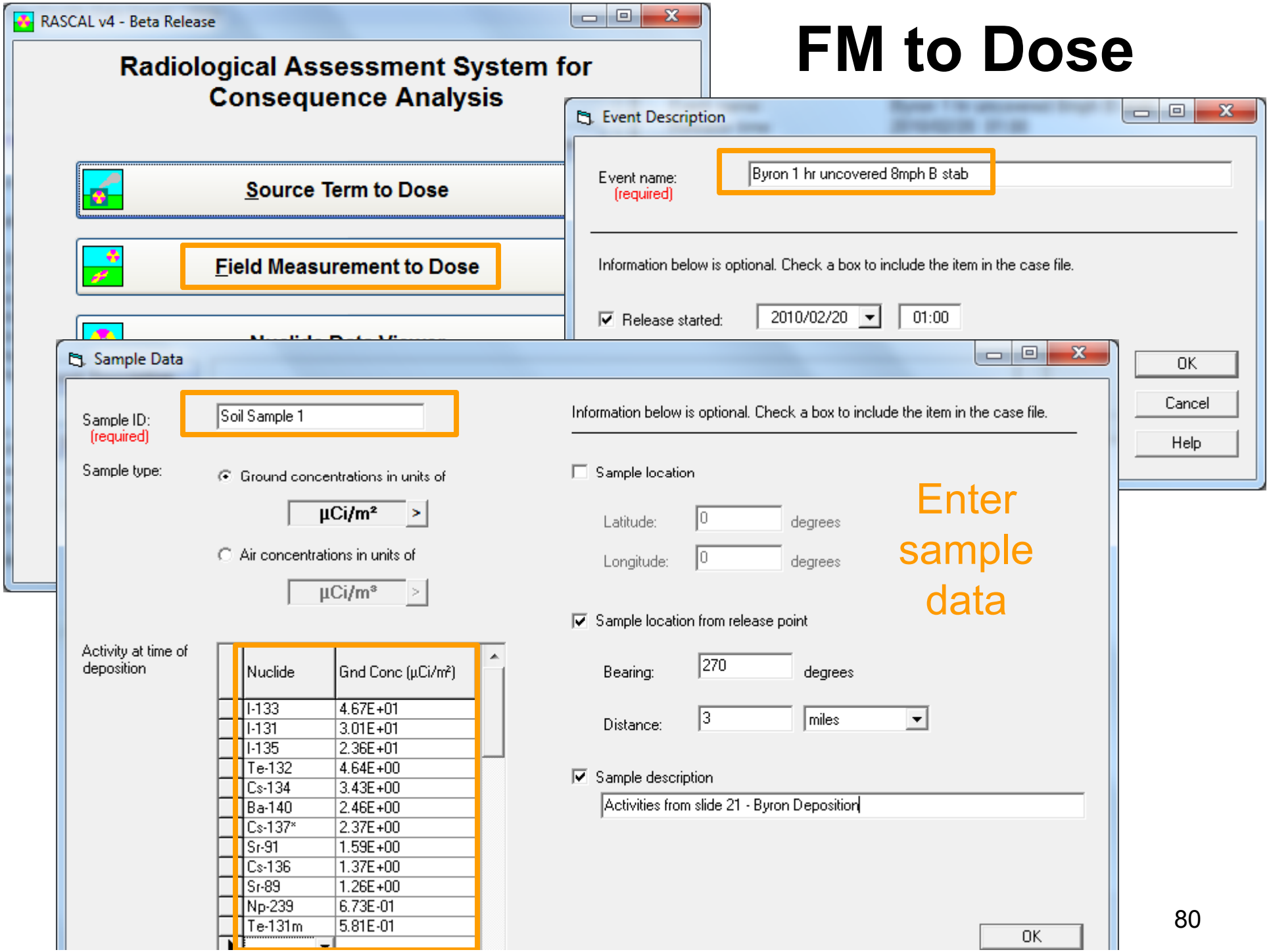


# 2 mph, E Stability, Results

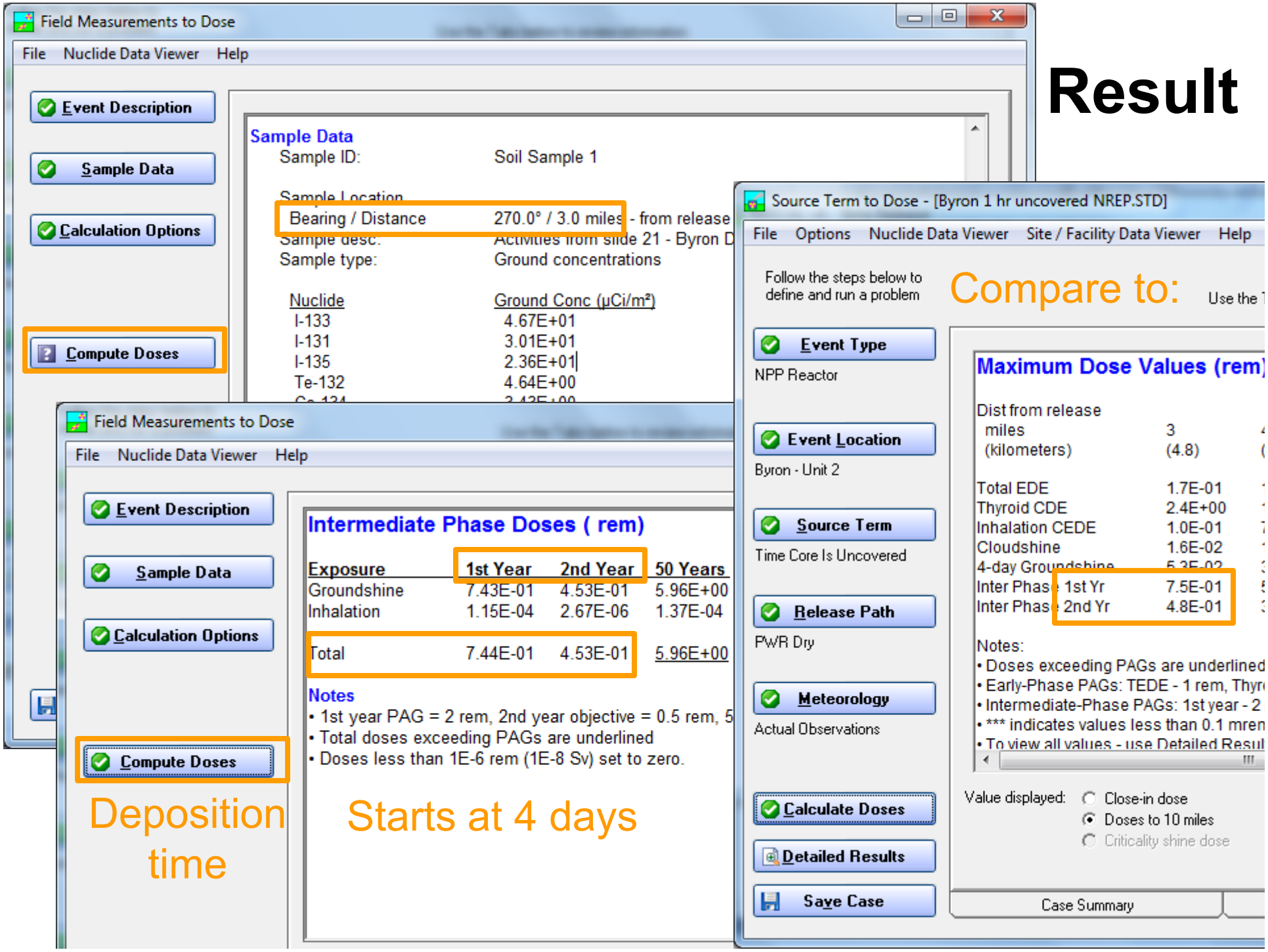



Event Type
NPP Reactor
Event Location
Byron - Unit 2
Source Term
Monitored Release - Mixtures
Release Path
Direct to atmo
Meteo
Actual Observ
Calcula
Detailed
Save
Source Term
RASCAL 3.0.5
Total activity released to atmosphere:
1.5E+07 Ci
Both 1000 Ci/s nobles 1 Ci/s I-131
Nuclide Ci Nuclide Ci Nuclide 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
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
Cesiums corrected, only I-131 & I daughters
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
RASCAL 4.0
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

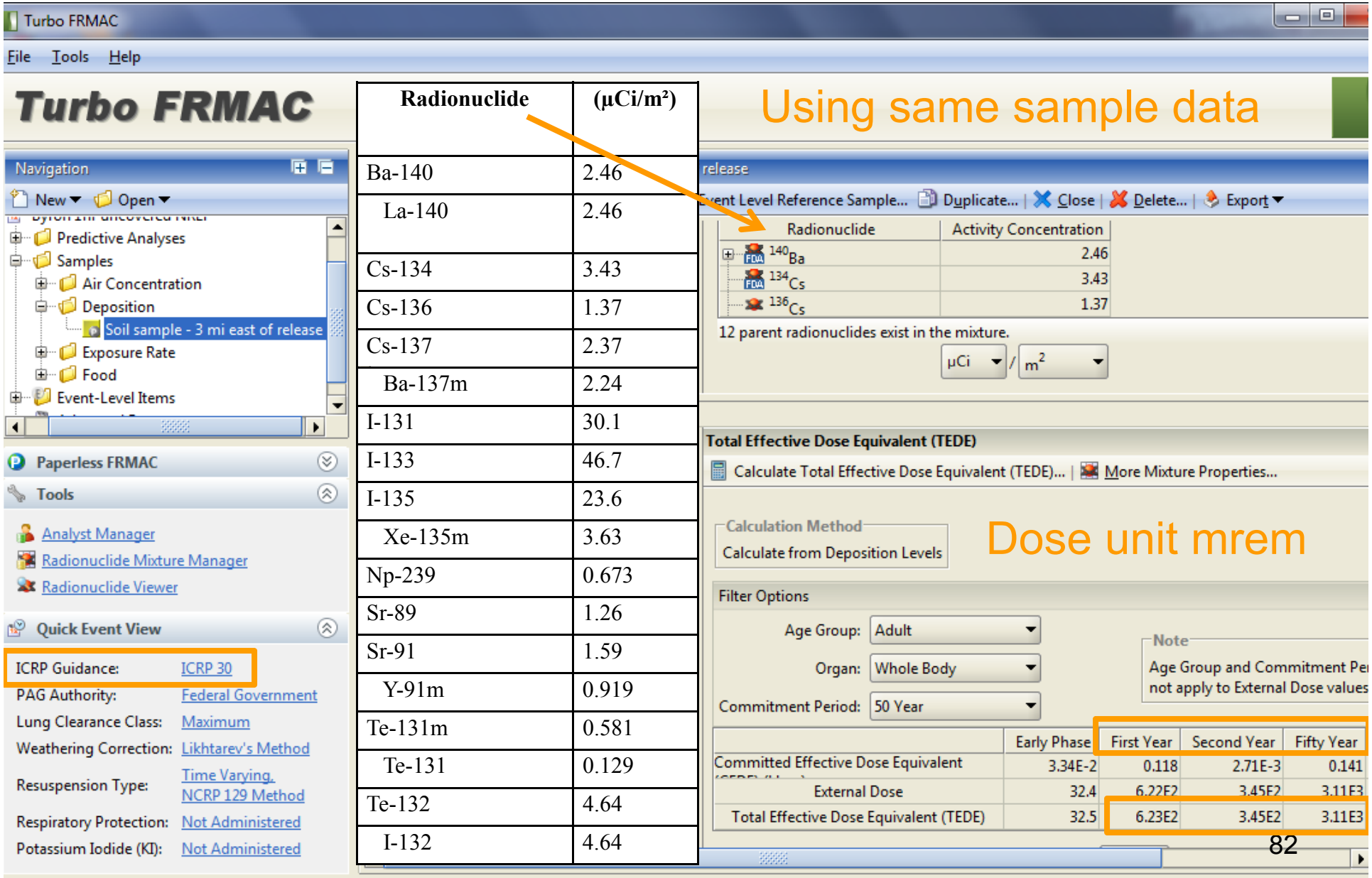
# FM to Dose


RASCAL v4 - Beta Release
Radiological Assessment System for Consequence Analysis
Source Term to Dose
Field Measurement to Dose
Event Description
Event name: (required)
Byron 1 hr uncovered 8mph B stab
Information below is optional. Check a box to include the item in the case file.
Release started:
2010/02/20
01:00
OK
Cancel
Help
Sample Data
Sample ID: (required)
Soil Sample 1
Sample type:
Ground concentrations in units of
µCi/m²
Air concentrations in units of
µCi/m³
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
Information below is optional. Check a box to include the item in the case file.
Sample location
Latitude: 0 degrees
Longitude: 0 degrees
Sample location from release point
Bearing: 270 degrees
Distance: 3 miles
Sample description
Activities from slide 21 - Byron Deposition
OK
Enter sample data

# 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
Bearing / Distance 270.0° / 3.0 miles - from release
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
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:
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
(kilometers) (4.8)
Total EDE 1.7E-01
Thyroid CDE 2.4E+00
Inhalation CEDE 1.0E-01
Cloudshine 1.6E-02
Inter Phase 1st Yr 7.5E-01
Inter Phase 2nd Yr 4.8E-01
Notes:
• Doses exceeding PAGs are underlined
• Early-Phase PAGs: TEDE - 1 rem, Thyr
• Intermediate-Phase PAGs: 1st year - 2
• *** indicates values less than 0.1 mren
• To view all values - use Detailed Resul
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
Deposition time
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, 5
• Total doses exceeding PAGs are underlined
• Doses less than 1E-6 rem (1E-8 Sv) set to zero.
Starts at 4 days

# TF values about 80% RASCAL values




| Radionuclide | (µCi/m²) |
|---|---|
| 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 |

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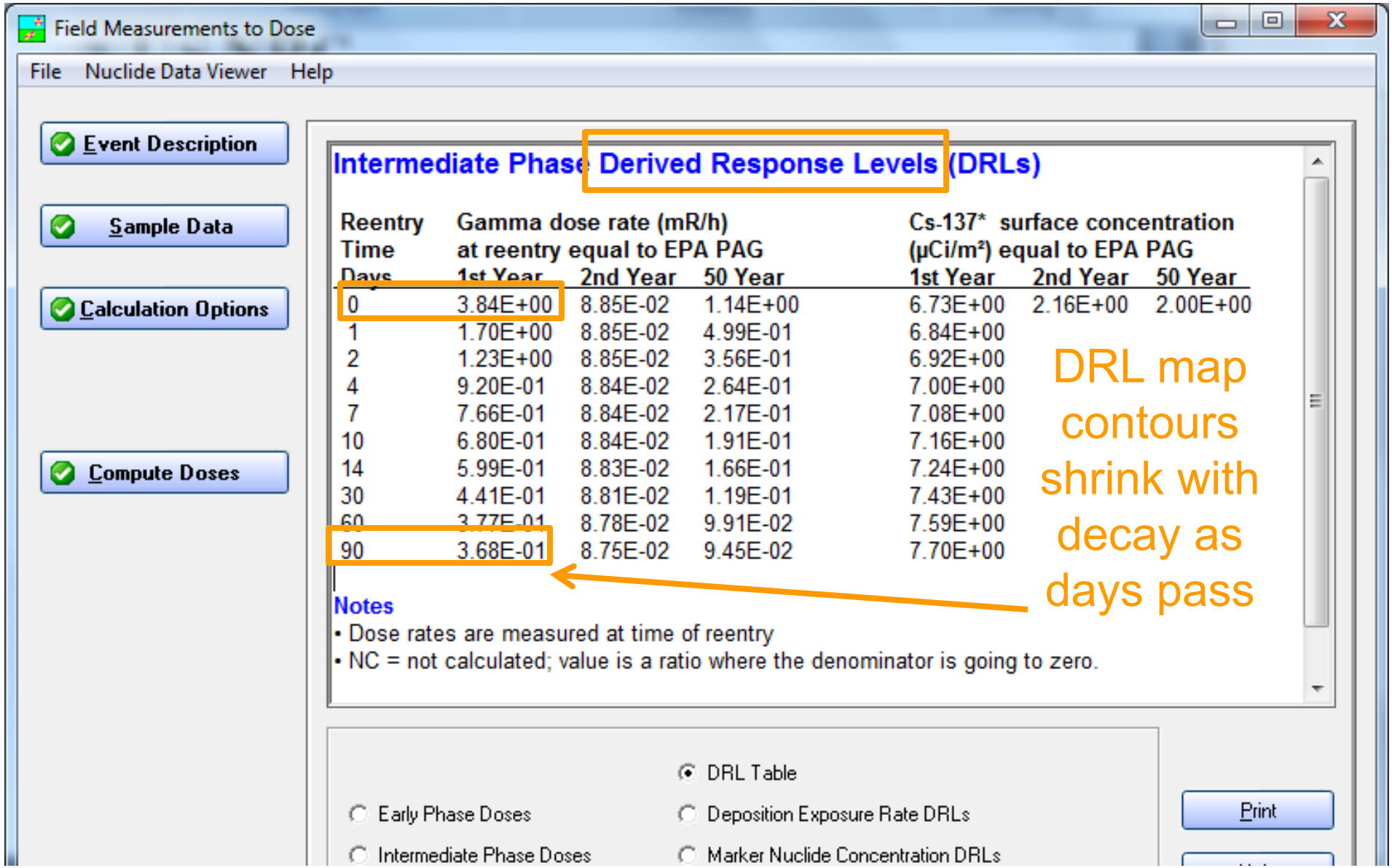
# Relocation DRLs (mR/h)



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# 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

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# 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

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# Part 4
# New Interface for Utilities

**Exelon and Entergy, using RASCAL source code via Non-Disclosure Agreement, are building interfaces.**

## Their 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.

# Their 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