RESRAD-BIOTA Hands-on Problems Workbook

October 2017

Table of Contents

Hands-On Problem #1: Demonstration of General Screening and Site-Specific Screening Phases

A DOE site is conducting an evaluation to demonstrate protection of biota from the potential effects of ionizing radiation, for subsequent reporting in their Annual Site Environmental Monitoring Report. Measured radionuclide concentrations for Blue Falls Creek at the Poplar Springs Site were available from the site environmental monitoring and surveillance program. Maximum and mean values are summarized.

(1) Using dataset #1, conduct an aquatic system evaluation to determine if maximum measured concentrations of residual radioactivity in Blue Falls Creek are potentially providing a radiation dose to biota above DOE's biota dose limits. Use co-located data where available. Report the total sum of fractions from your evaluation, the limiting media type, the radionuclide that provides the greatest contribution to the total sum of fractions, and the limiting organism type identified for that radionuclide. Why is it recommended to use co-located data where possible?

(2) Repeat the evaluation, using the average concentrations in dataset #1. Use co-located data where available. Report the total sum of fractions from your evaluation, the limiting media type, the radionuclide that provides the greatest contribution to the total sum of fractions, and the limiting organism type identified for that radionuclide. Why is the total sum of fractions lower in this example compared to question (1)?

(3) Repeat the evaluation, using the maximum concentrations in dataset #1, and employing the Cs-137 organism-specific concentration factor (Biv) for a raccoon resident in the evaluation area. Use co-located data where available. Report the total sum of fractions from your evaluation and the limiting media type. Why is the total sum of fractions lower in this example compared to question (1)? Also indicate the potential "upper-bound" dose to an aquatic animal, and to a riparian animal, resulting from this evaluation. Why do we call these an "upper-bound" dose (at level 2 analysis)?

Dataset #1. Blue Falls Creek: Radionuclide Concentration Data

Nuclide	Water (Maximum) Bq/m^3 (pCi/L)	Water (Average) Bq/m^3 (pCi/L)	Sediment (Maximum) pCi/g	Sediment (Average) pCi/g
Co-60	144.3 (3.9)	92.5 (2.5)	N/A	N/A
Cs-137*	1480 (40)	444 (12)	N/A	N/A
H-3	5.18E+06 (140,000)	2.627E+06 (71,000)	N/A	N/A
Sr-90	5,180 (140)	3,700 (100)	N/A	N/A
U-234	303.4 (8.2)	185 (5.0)	N/A	N/A
U-235	2.405 (0.065)	1.073 (0.029)	N/A	N/A
U-238	59.2 (1.6)	35.15 (0.95)	N/A	N/A

Concentration factor for Cs-137 (organism to water value) derived using site data for a raccoon resident in the Blue Falls Creek evaluation area = 3000.

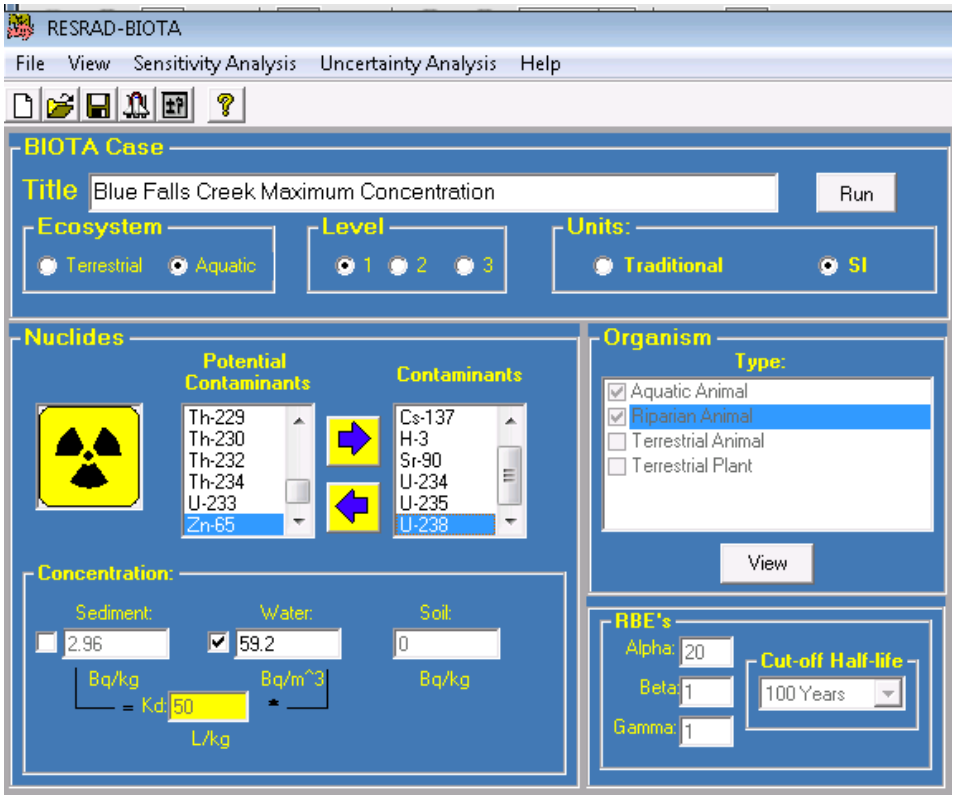
Answers:

(1) Total sum of fractions = 1.51. Water is the limiting media type in this evaluation. Cs-137 appears to be a major contributor to the total potential dose. A riparian animal is indicated as the limiting organism type for Cs-137. Co-located water and sediment data are preferred because where one media is absent the methodology uses a conservatively derived sediment Kd value to back-calculate the missing media concentration, resulting in a conservative estimate of the missing media concentration. Subsequent analysis efforts could focus on re-visiting the radionuclide concentration data for possible use of mean values, and on obtaining site-specific information on riparian animal environmental transfer parameter data for a riparian animal known to be resident in the evaluation area.

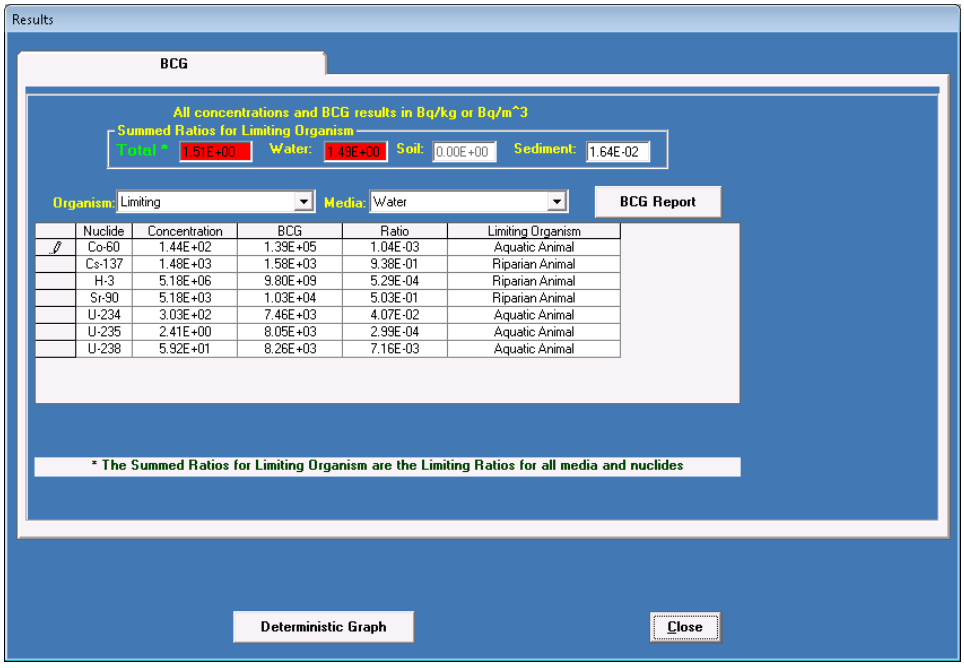
(2) Total sum of fractions = 6.79E-1. Water is the limiting media type in this evaluation. Sr-90, along with Cs-137, appear to be principal contributors to potential dose. A riparian animal is indicated as the limiting organism type for Sr-90 and Cs-137. The total sum of fractions is lower in this example because average media concentrations were used in place of maximum media concentrations.

(3) Total sum of fractions = 6.20E-1. Water is the limiting media type in this evaluation. The total sum of fractions was lower in this example compared to example (1) because a site-specific Cs-137 concentration factor was used in place of the conservatively-derived default concentration factor value provided in the methodology, employing the site-specific screening phase of the graded approach. Doses are considered “upper-bound” (in the site-specific screening phase) in that they are still largely representative of conservatively derived generic organisms.

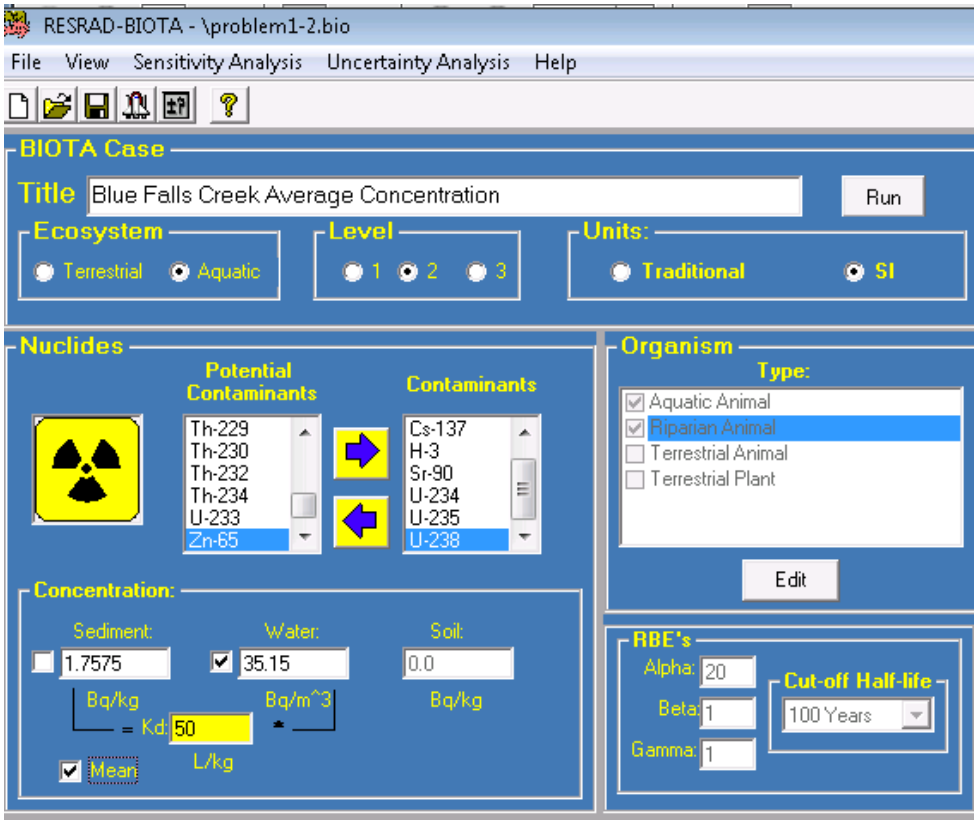
Problem 1; Question 1: Data Input Screen



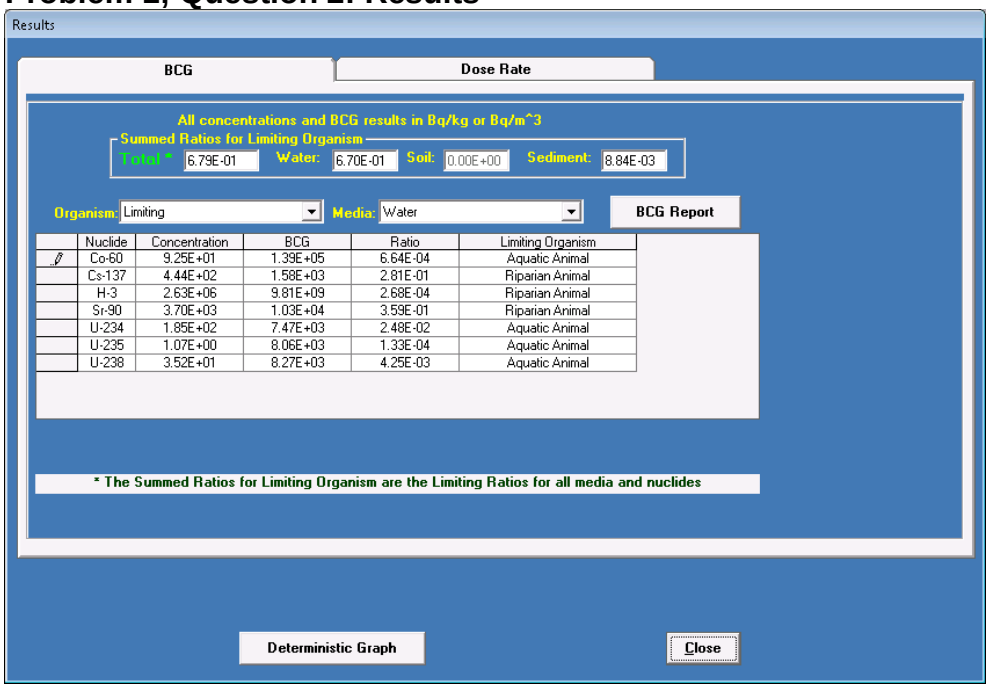
Problem 1, Question 1: Results



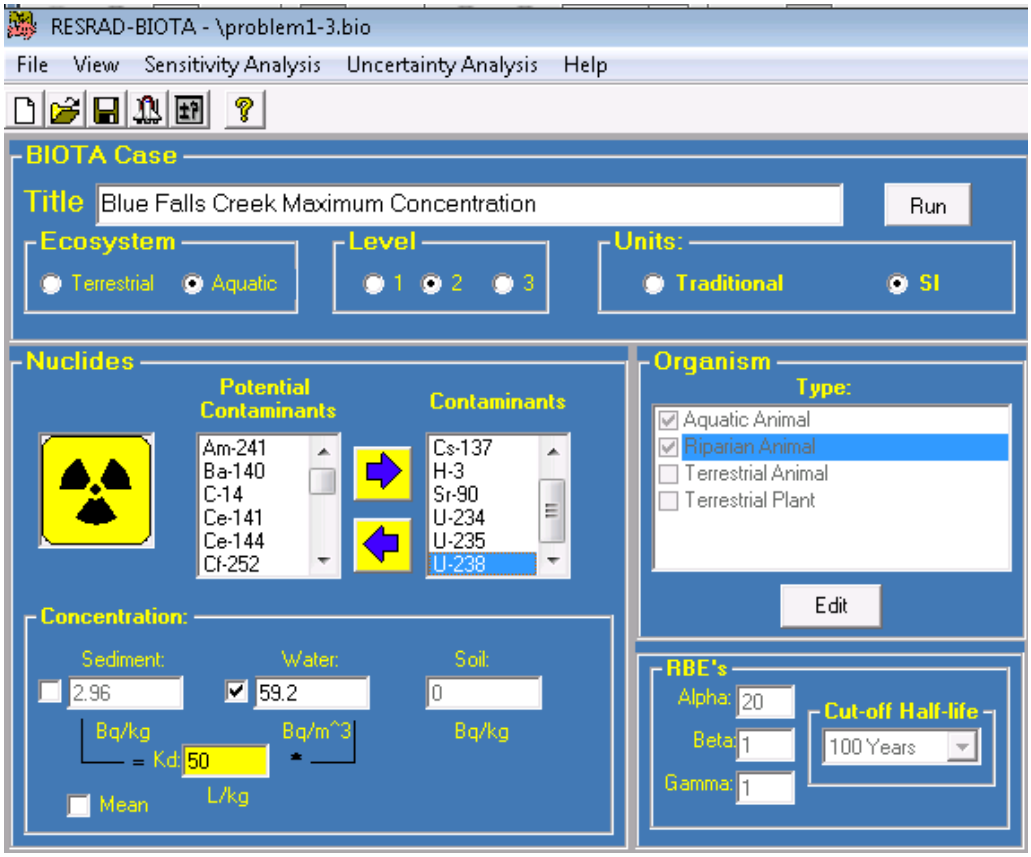
Problem 1; Question 2: Data Input Screen



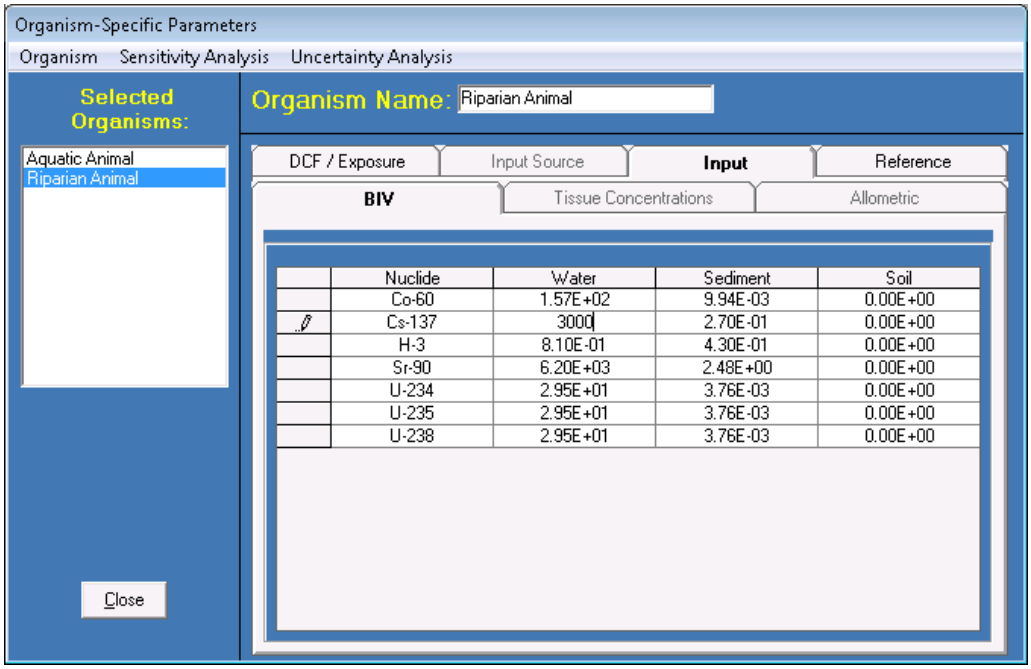
Problem 1; Question 2: Results



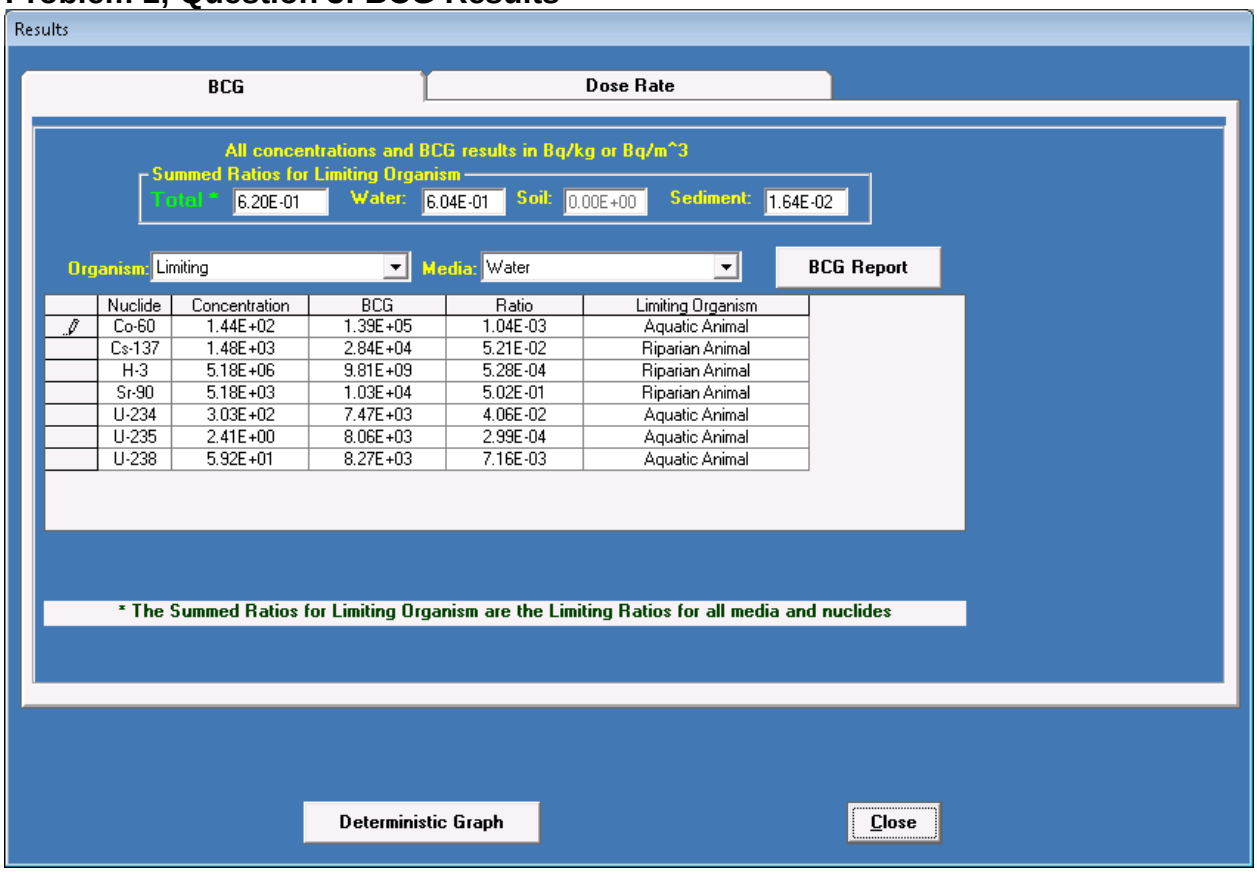
Problem 1; Question 3: Data Input Screen



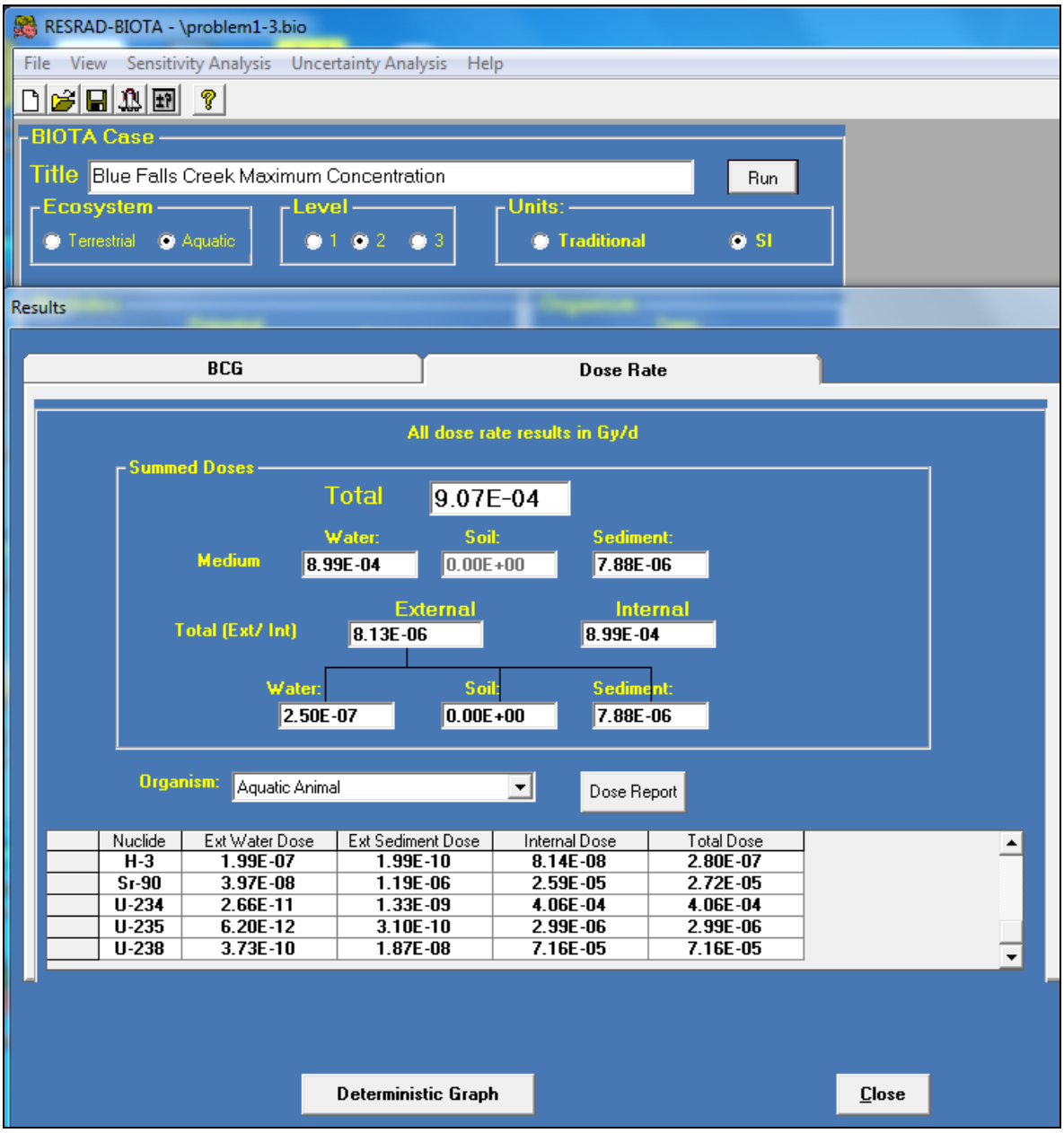
Problem 1; Question 3: Adding Site-Specific Biv for Cs-137, Riparian Animal



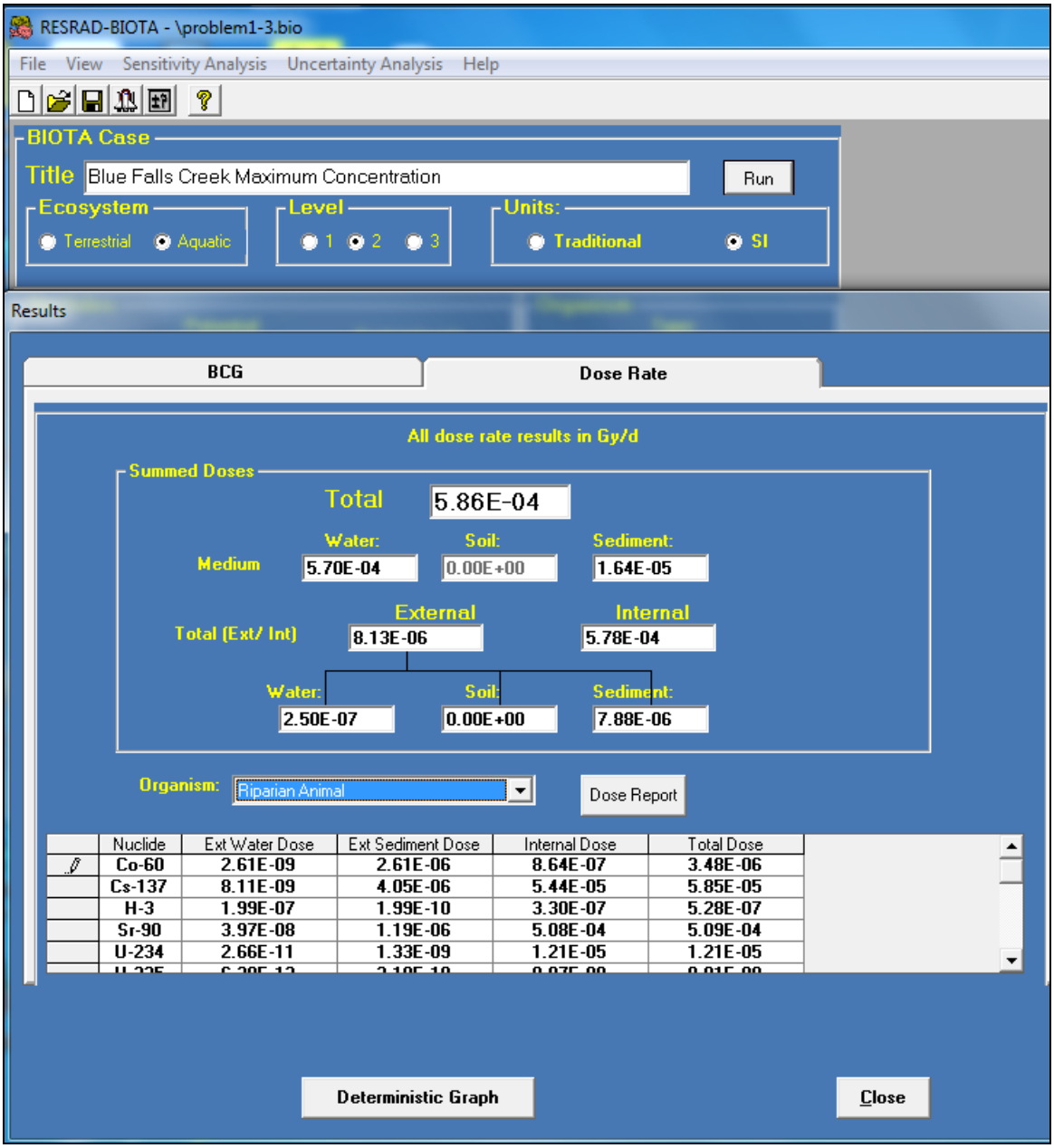
Problem 1; Question 3: BCG Results



Problem 1; Question 3:(Upper-Bound) Dose Results for Aquatic Animal



Problem 1; Question 3: (Upper-Bound) Dose Results for Riparian Animal



Hands-On Problem #2: North Mountain Laboratory

This hands-on problem illustrates the importance of evaluating your monitoring data for applicability to non-human pathways, the importance of establishing well thought-out evaluation areas, and the iterative process of screening.

A large DOE site, the North Mountain Laboratory (NML), conducted its first biota dose evaluation to demonstrate protection of biota from the potential effects of ionizing radiation for subsequent reporting in their Annual Site Environmental Monitoring Report. This initial biota dose evaluation was also used to provide insights on modifications that might be needed in future evaluations, to include: determining the appropriate number and delineation of evaluation areas, and the need for any refinements to the environmental monitoring and surveillance program. Maximum measured radionuclide concentrations available for soil media, and from liquid effluent data, were assembled for the evaluation.

Because of the size and complexity of the NML Site (Fig. 1) and its environs, a conceptual model was constructed (Fig. 2) to better understand the environmental exposure and transport pathways that could potentially contribute a dose to biota at NML. Next, a more detailed conceptual model was constructed that mapped the pathways of exposure from the primary sources of radioactivity, the affected media, transport mechanisms, secondary sources, direct exposure routes, and potential receptors (Fig. 3). Guidance from DOE Technical Standard DOE-STD-1153-2002 (Module 2, Chapter 1, "The Graded Approach, Ecological Risk Assessment, and Guidance on Their Implementation in Evaluating Radiation Doses to Biota," particularly section 1.4.1.4 - "Conceptual Model," and Chapter 2, "Guidance on Sources, Receptors, and Routes of Exposure") was reviewed to assist in the preparation of the conceptual models.

The intersection of contaminated areas and habitats can be used to help define the areas over which concentrations can be averaged if the use of maximum radionuclide concentrations at any location does not pass the general screening phase of the graded approach methodology. In preparation for the case study biota dose evaluation, the NML site was categorized into 35 evaluation areas, defined by the isopleths of modeled air concentrations, and by land cover information that included vegetation type data (that provided an understanding of habitat types available for plants and animals). Guidance from DOE Technical Standard DOE-STD-1153-2002 (Module 2, Chapter 4, "Guidance for Defining the Evaluation Area," and Module 2, Chapter 3, "Guidance on Spatial and Temporal Averaging Regarding Application of Biota Dose Limits and Mean Radionuclide Concentrations") was used to assist in defining the evaluation areas. The delineation of these evaluation areas, mapped by radionuclide concentration isopleths and vegetation types, is shown in Fig. 4. Land cover information, and soil sampling locations, are also shown in Fig. 4.

Questions:

(1) Maximum concentrations of radionuclides detected in liquid effluents and available soil media are summarized in dataset #1. Using the available maximum media concentration data, conduct a terrestrial biota dose evaluation for the NML. Report the total sum of fractions, limiting media type, the radionuclide(s) that provide the greatest contribution to the total sum of fractions, and the limiting organism type for that radionuclide. Did the maximum data result in compliance with the DOE biota dose limits?

Dataset #1. Maximum Radionuclide Concentration Data Measured Across the Entire Site: Liquid Effluent & Soil Media

Nuclide	Water Bq/m^3 (pCi/L)	Soil Bq/kg (pCi/g)
Am-241		2.9711 (0.0803)
Cs-137		1073 (29)
Co-60		37.37 (1.01)
Pu-239		3.774 (0.102)
Ra-226	139.49 (3.77)	
Sr-90	298.96 (8.08)	313.39 (8.47)
U-233		19.869 (0.537)
U-234		19.869 (0.537)
U-235		1.0989 (0.0297)
U-238		21.534 (0.582)

(2) From inspection of the media concentrations across each of the 35 evaluation areas it was determined that area 6 exhibited the largest source (i.e., maximum concentration) of Cs-137 in soils from NML (see Fig. 5). Further, upon inspection of the frequency distribution for Cs-137 detected in soils, this maximum concentration represented a single occurrence at a level much higher than the remaining distribution of detected concentrations. Based on this determination, it was decided to remove area 6 from consideration and conduct another biota dose evaluation using maximum radionuclide concentrations with area 6 removed. Evaluation area 6 will be considered separately in a subsequent evaluation.

Conduct another biota dose evaluation, again using maximum concentrations for the entire NML, but with evaluation area 6 removed from consideration. Use the data in dataset #2 for your evaluation. Report the total sum of fractions, the limiting media type, the radionuclide that provides the greatest contribution to the total sum of fractions, and the limiting organism type identified for that radionuclide. Did the NML Site (not including area 6) meet the DOE biota dose limits?

Dataset #2. Maximum Radionuclide Concentration Data Measured Across the Entire Site: Liquid Effluent & Soil Media (Area 6 Removed)

Nuclide	Water Bq/m^3 (pCi/L)	Soil Bq/kg (pCi/g)
Am-241		2.9711 (0.0803)
Cs-137		341.88 (9.24)
Co-60		37.37 (1.01)
Pu-239		3.774 (0.102)
Ra-226	139.49 (3.77)	
Sr-90	298.96 (8.08)	313.39 (8.47)
U-233		19.869 (0.537)
U-234		19.869 (0.537)
U-235		1.0989 (0.0297)
U-238		21.534 (0.582)

(3) Evaluation area 6 was then considered separately. After consideration of the sampling data, it was determined to be technically appropriate to average the radionuclide concentrations for soil samples collected within area 6. Conduct another biota dose evaluation using average radionuclide concentrations in soil for area 6. Use dataset #3 for your evaluation. Report the total sum of fractions, the limiting media type, the radionuclide that provides the greatest contribution to the total sum of fractions, and the limiting organism type identified for that radionuclide. Did evaluation area 6 meet the DOE biota dose limits?

Dataset #3. Average Radionuclide Concentration Data for Area 6 Soil Media

Nuclide	Soil Bq/kg (pCi/g)
Am-241	1.258 (0.034)
Cs-137	407 (11)
Co-60	6.66 (0.18)
Pu-239	1.8315 (0.0495)
Ra-226	
Sr-90	135.79 (3.67)
U-233	1.8389 (0.0497)
U-234	1.8389 (0.0497)
U-235	1.0249 (0.0277)
U-238	19.203 (0.519)

Answers:

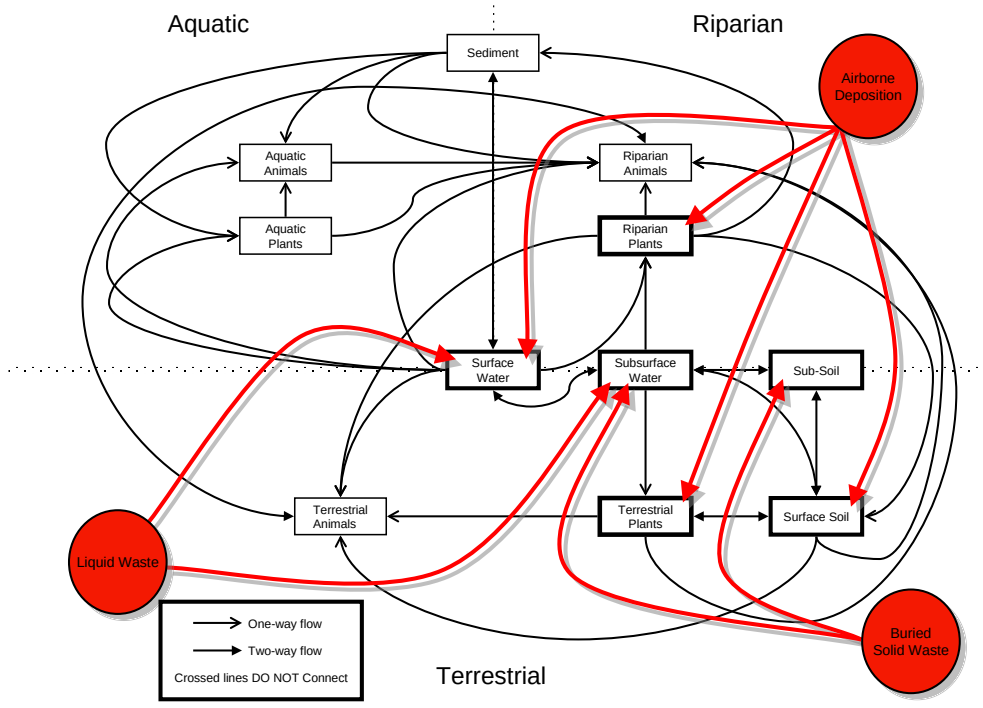
(1) Total sum of fractions = 1.78. Soil is the limiting media type. Cs-137 appears to be a major contributor to the total potential dose. A terrestrial animal is indicated as the limiting organism type for Cs-137. The site did not pass the screening process at level 1, the general screening phase of the DOE graded approach methodology.

(2) Total sum of fractions = 8.24E-1. Soil is the limiting media type. Cs-137 appears to be a major contributor to the total potential dose. A terrestrial animal is indicated as the limiting organism type for Cs-137. The site (all areas but evaluation area 6) passed the screening process at level 1, the general screening phase of the DOE graded approach methodology. Biota protection at DOE dose limits is demonstrated.

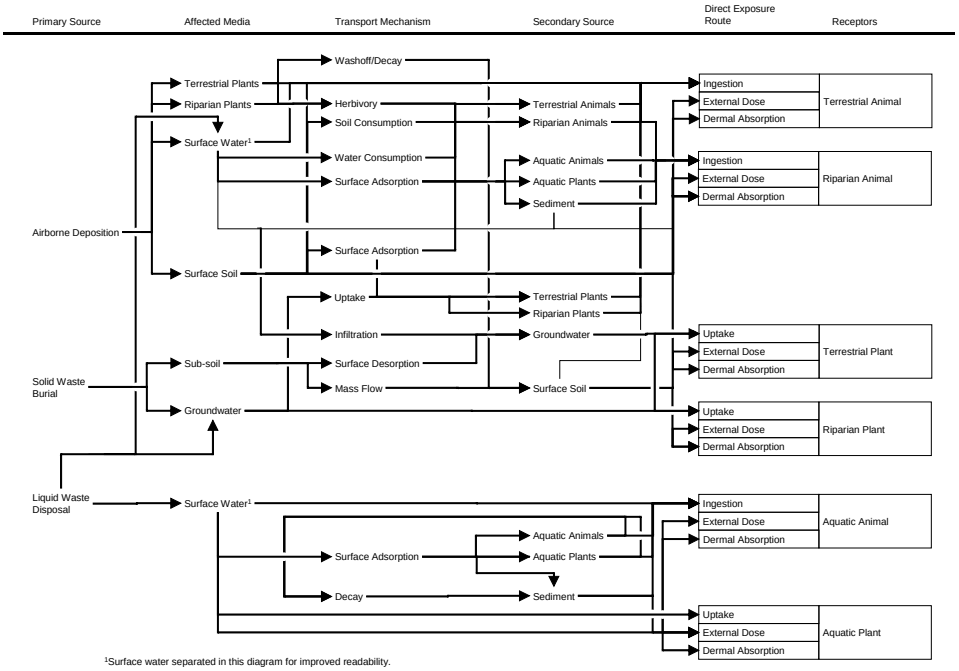
(3) Total sum of fractions = 6.93E-1. Soil is the limiting media type. Cs-137 appears to be a major contributor to the total potential dose. A terrestrial animal is indicated as the limiting organism type for Cs-137. Evaluation area 6 passed the screening process at level 2, the site-specific screening phase of the DOE graded approach methodology. Biota protection at DOE dose limits is demonstrated.

Prob. 2 (Fig. 1): NML Land Cover

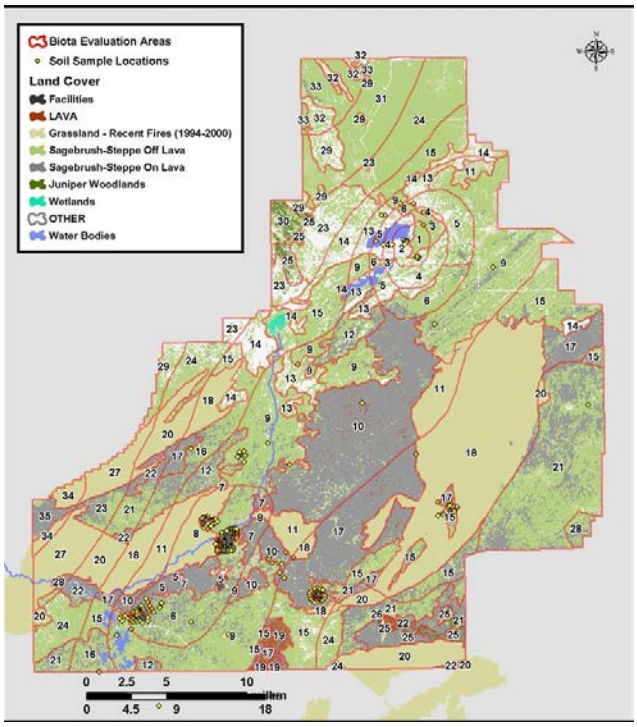
Prob. 2 (Fig. 2): Conceptual Model



Prob. 2 (Fig. 3): CM - Pathways

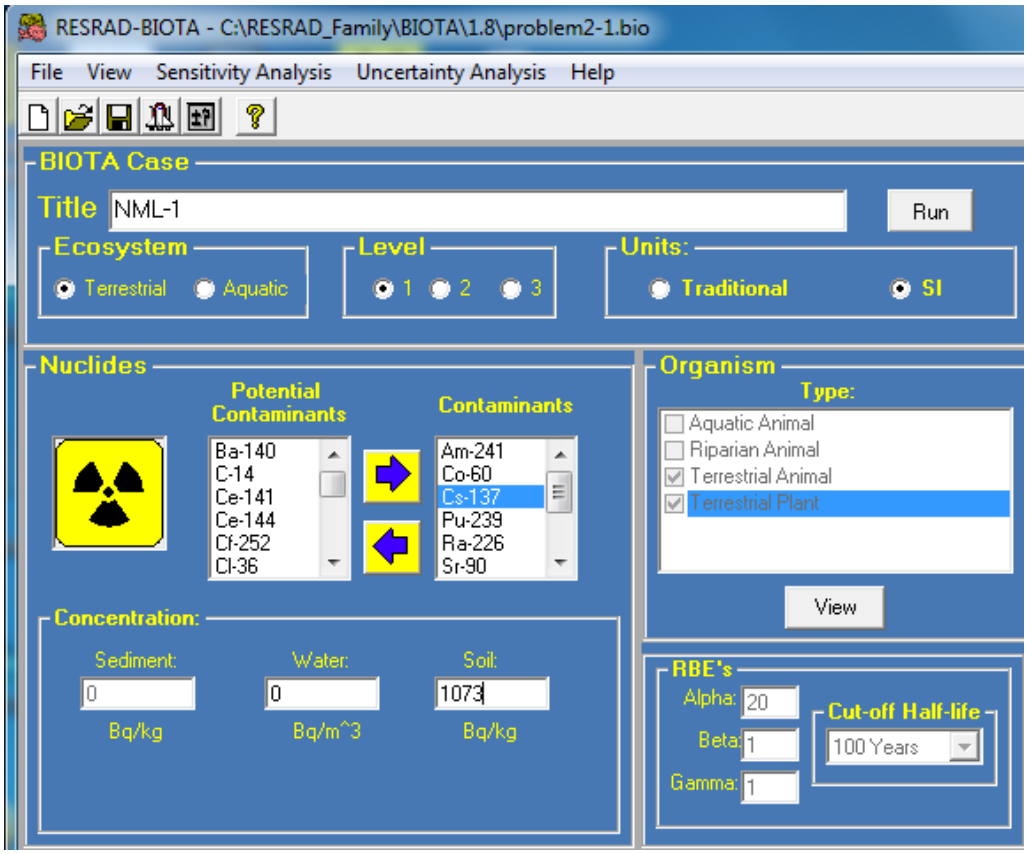


Prob. 2 (Fig. 4): Evaluation Areas

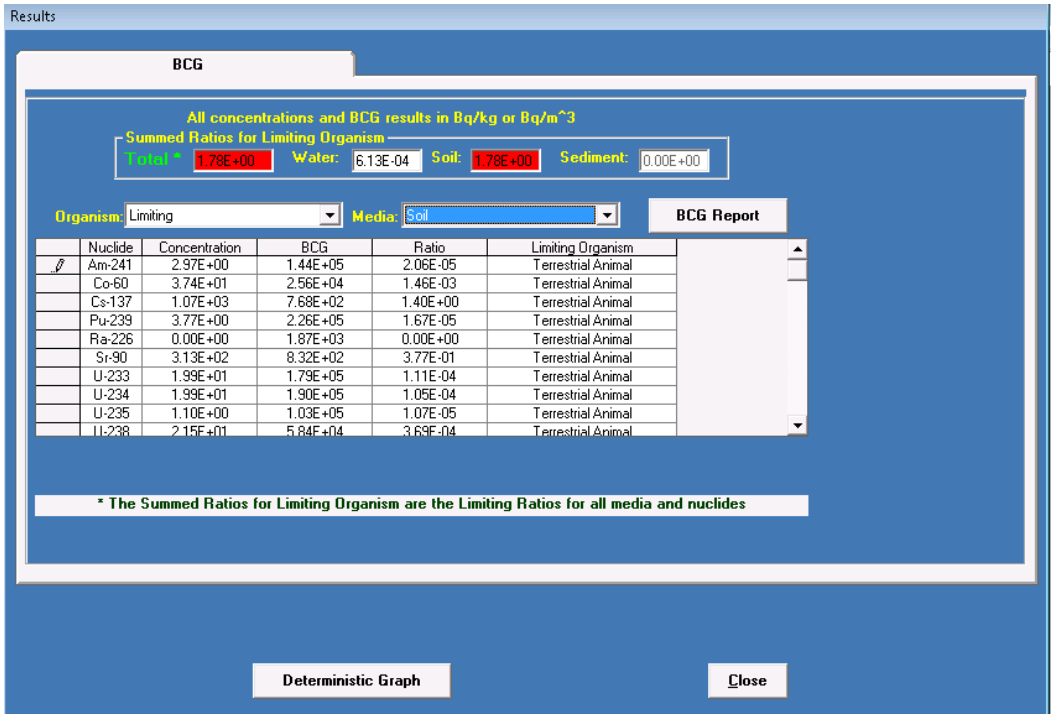


- Evaluation areas defined by the isopleths of air concentration and the land cover / vegetation types

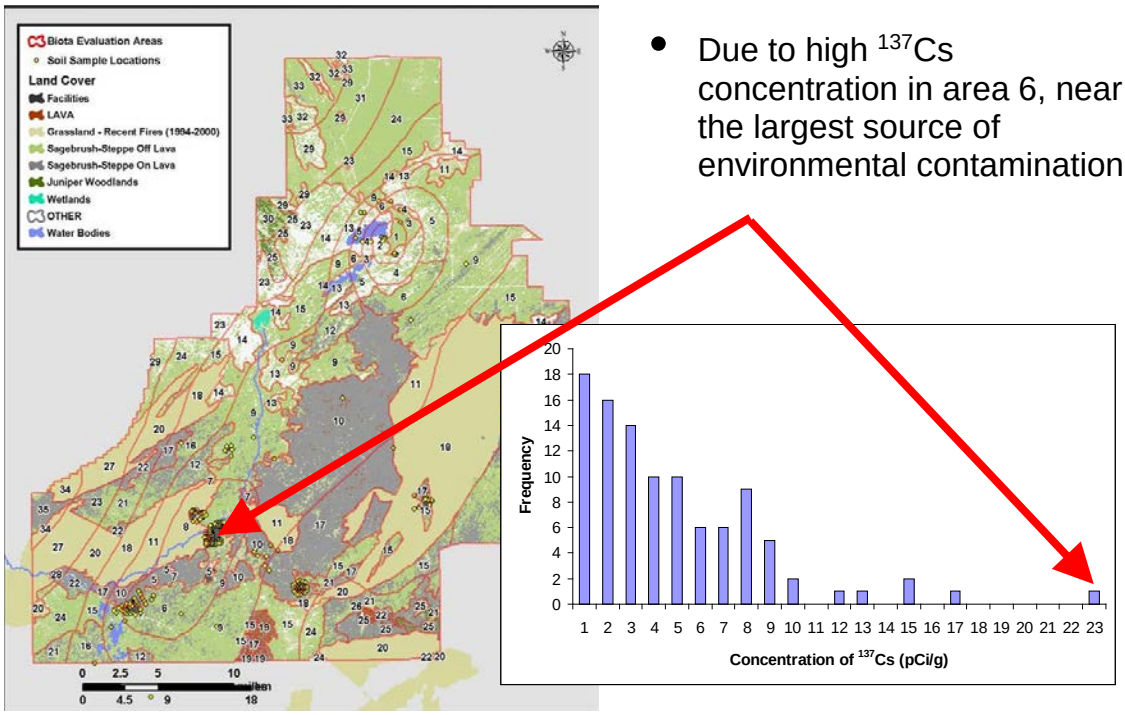
Prob. 2, Q. 1: Data Input Screen



Prob. 2, Q. 1: BCG Results

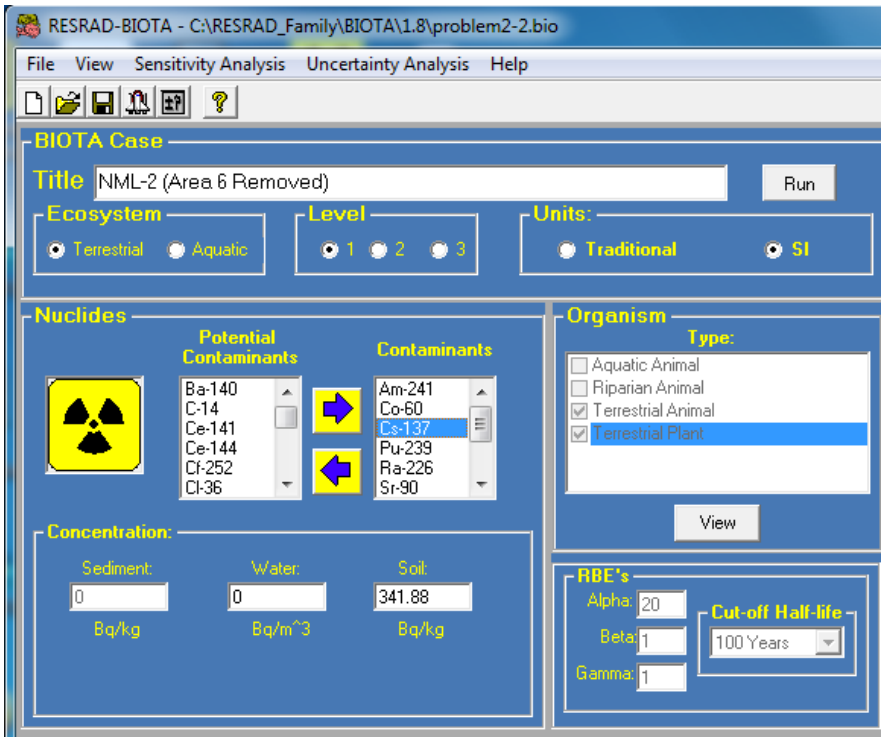


Prob. 2 (Fig. 5): Cs-137 in Area 6

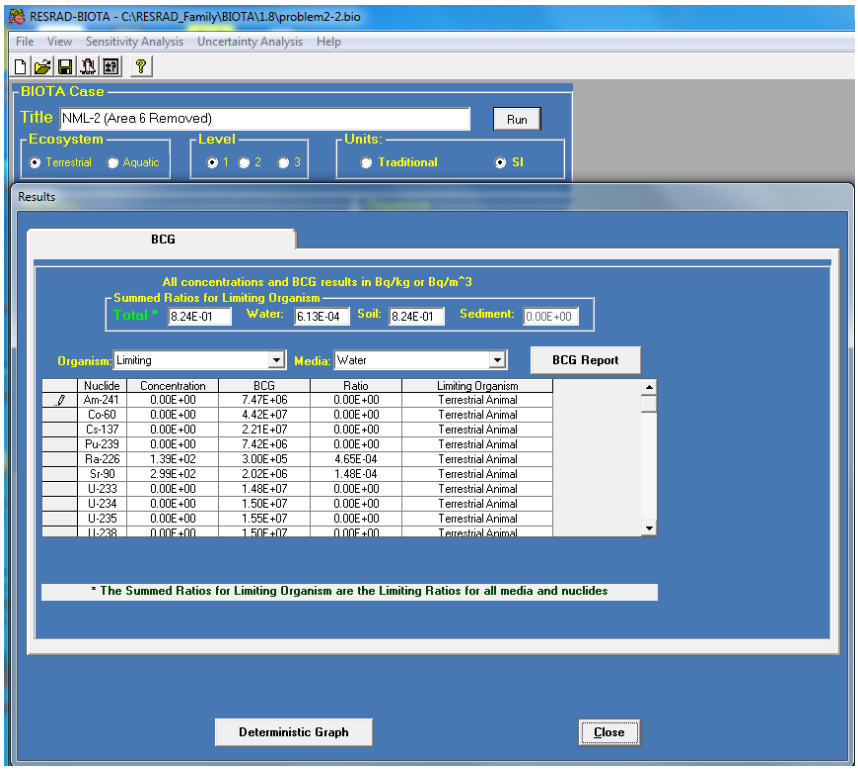


- Due to high ^{137}Cs concentration in area 6, near the largest source of environmental contamination

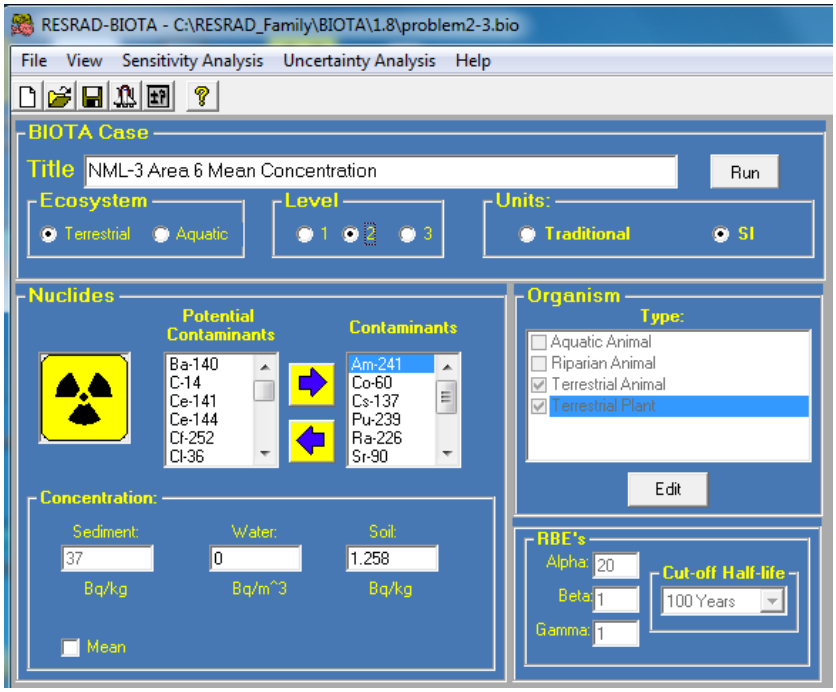
Prob. 2, Q. 2: Data Input Screen



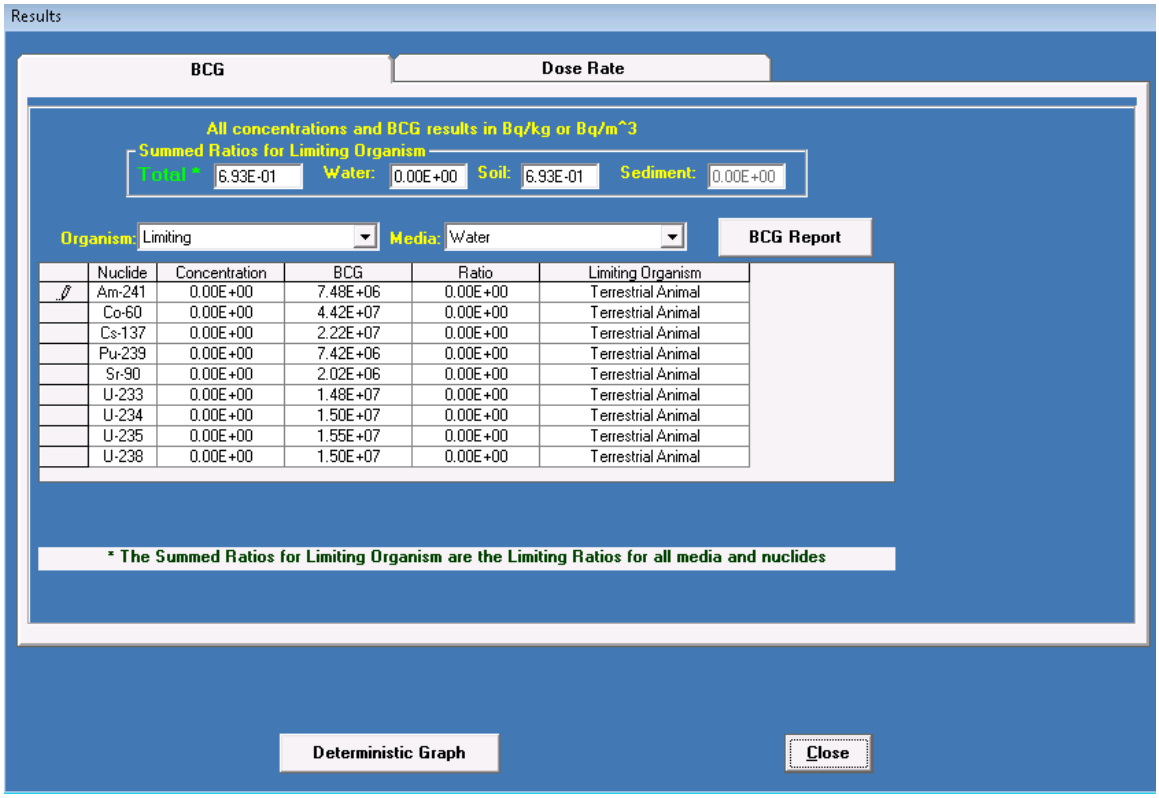
Prob. 2, Q. 2: BCG Results (Area 6 Removed)



Prob. 2, Q. 3: Data Input Screen (Area 6 Mean Soil Concentrations Only)



Prob. 2, Q. 3: BCG Results
(Area 6 Mean Soil Concentrations Only)



Hands-On Problem 3: Effect of Area Factor and Concentration Ratios in Site-Specific Analysis

The Little Forest Burial Ground (LFBG) site, located in New South Wales, Australia is conducting an evaluation to demonstrate protection of biota from the potential effects of ionizing radiation. From 1960 to 1968 radioactive waste from nearby reactor research facility was placed in a series of 79 shallow trenches. The LFBG is under active administrative control that includes environmental monitoring, maintenance, etc. The current site characterization identified cesium-137, cobalt-60, strontium-90, and americium-241 in surface soils. The data was collected in three different zones as described in Figure 2. Table 1 lists the measured concentrations.

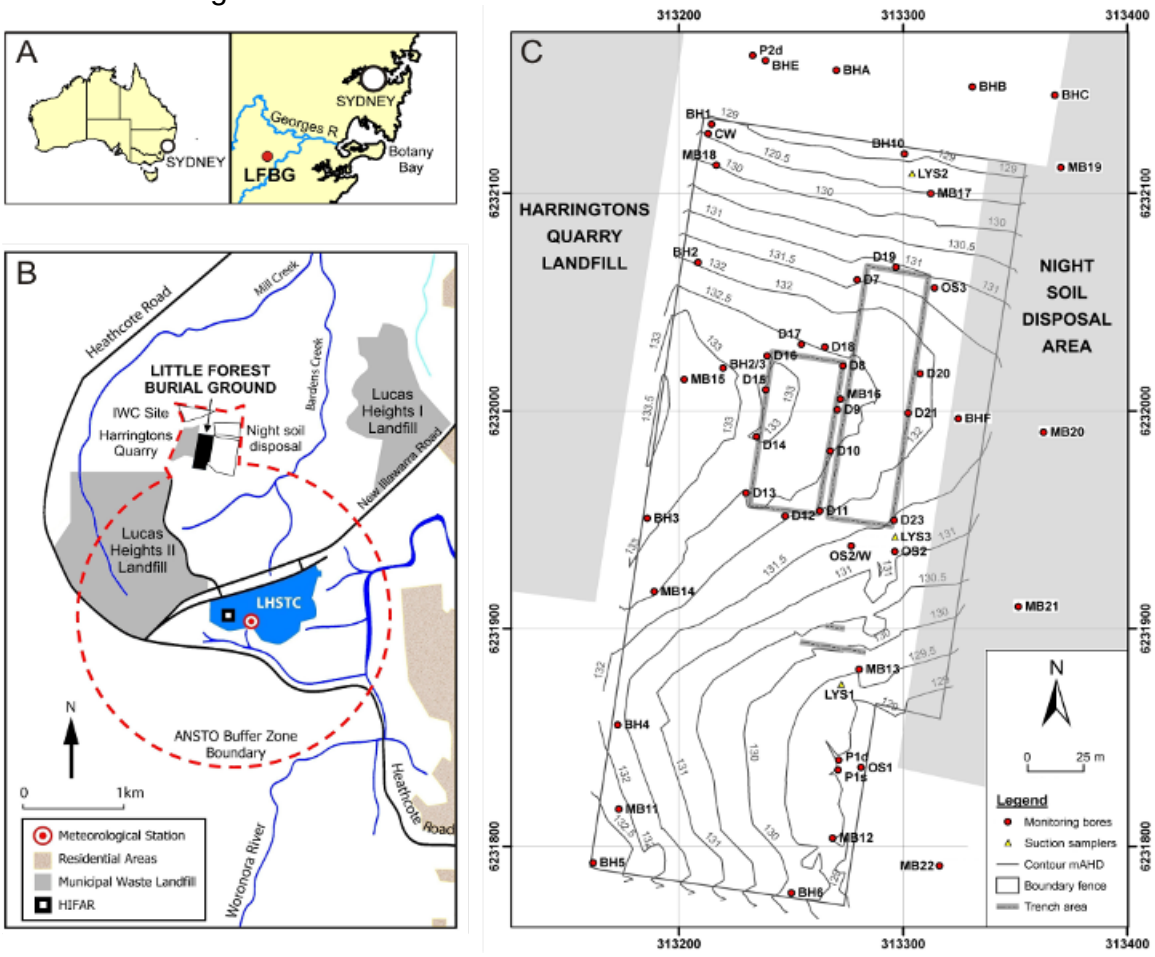


Figure 1 Location of Little Forest Burial Ground, New South Wales, Australia

The following four species, representative of site biota are to be analyzed:

- Acacia tree
- Grass
- Raven
- Red fox

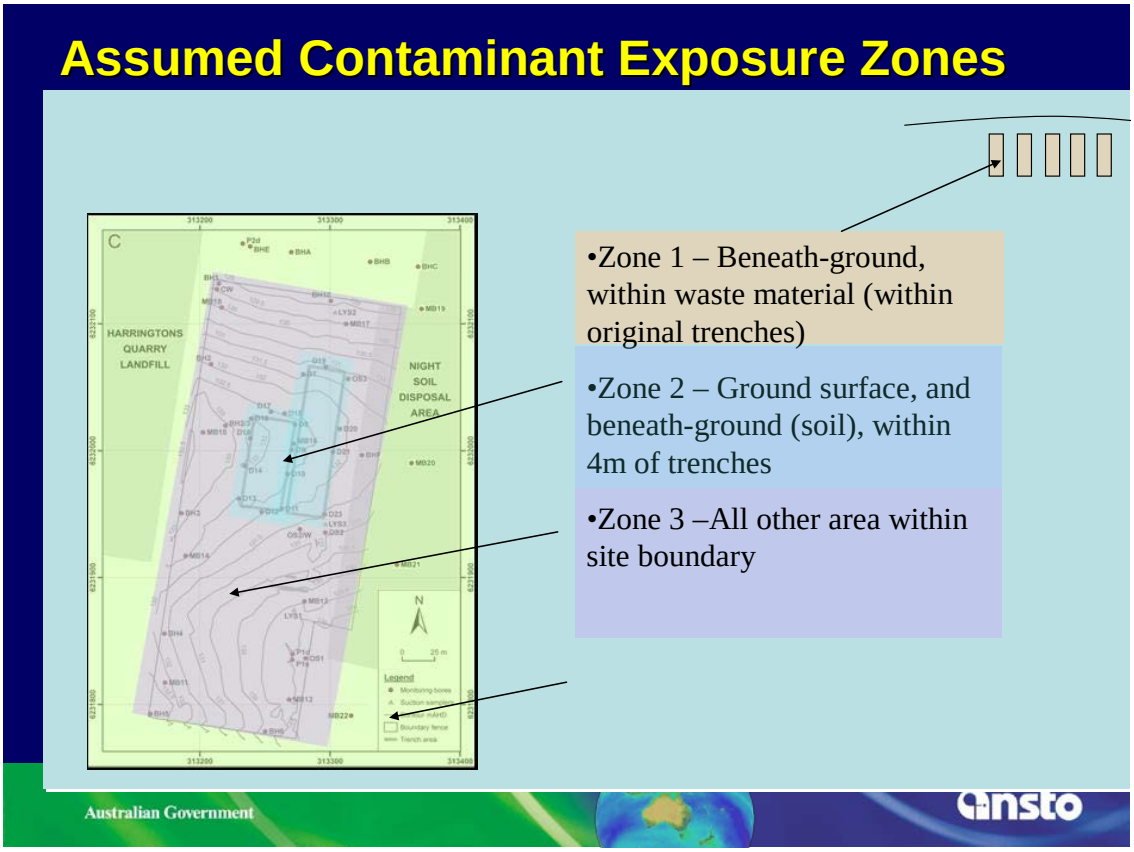


Figure 2 Contaminated Exposure Zones

Table 1 Average Radionuclide Concentrations in Three Zones

Area	Co-60	Sr-90	Cs-137	Am-241
	Bq/kg	Bq/kg	Bq/kg	Bq/kg
Zone 1				
Within waste trenches	2000	1000	470	710
Zone 2				
Soil <4m from trenches	2	28	3	4
Zone 3				
Soil >4m from trenches	1	4	2	0.01

Table 2 provides the time spent by these species in different zones.

Table 2 Time Spent by Species in Different Zones

Species	Zone 1	Zone 2	Zone 3	Outside
Acacia (tree)	100%			
Grass		100%		
Raven		30%		70%
Fox			30%	70%

Problem 3 – Question 1

Using data provided in Tables 1 and 2 and default RESRAD-BIOTA Biv values calculate total, internal and external doses received by each species at the site.

Problem 3 – Question 2

The International Atomic Energy Agency (IAEA) has recently published its new Technical Report Series (TRS) handbook on radionuclide transfer to wildlife (TRS 479). Repeat the evaluation, using the Biv values from TRS 479. Explain the differences in dose results compared to question (1). Table 3 provides the Biv values from TRS 479.

Table 3 Concentration Ratios (Bq/Kg per Bq/Kg) from TRS 479

Organism	Co-60	Sr-90	Cs-137	Am-241
Acacia (tree)	8.7E-03	4.9E-01	1.4E-01	2.7E-02
Grass	4.2E-03	1.8E+00	1.8E+00	1.0E-01
Raven	NA	4.8E-01	6.7E-01	3.2E-02
Fox	3.0E-01	1.8E+00	3.2E+00	3.0E-02

Answers:

Problem 3 – Question 1

Doses are estimated at RESRAD-BIOTA level 3 by entering the soil concentration in different zones. Two types of terrestrial species (terrestrial plant and terrestrial animal) can be evaluated in a single run. Acacia tree is located in zone 1. Grass and Raven occupy zone 2, and fox occupies zone 3. Three separate run will be done. Table 4 summarizes the dose results.

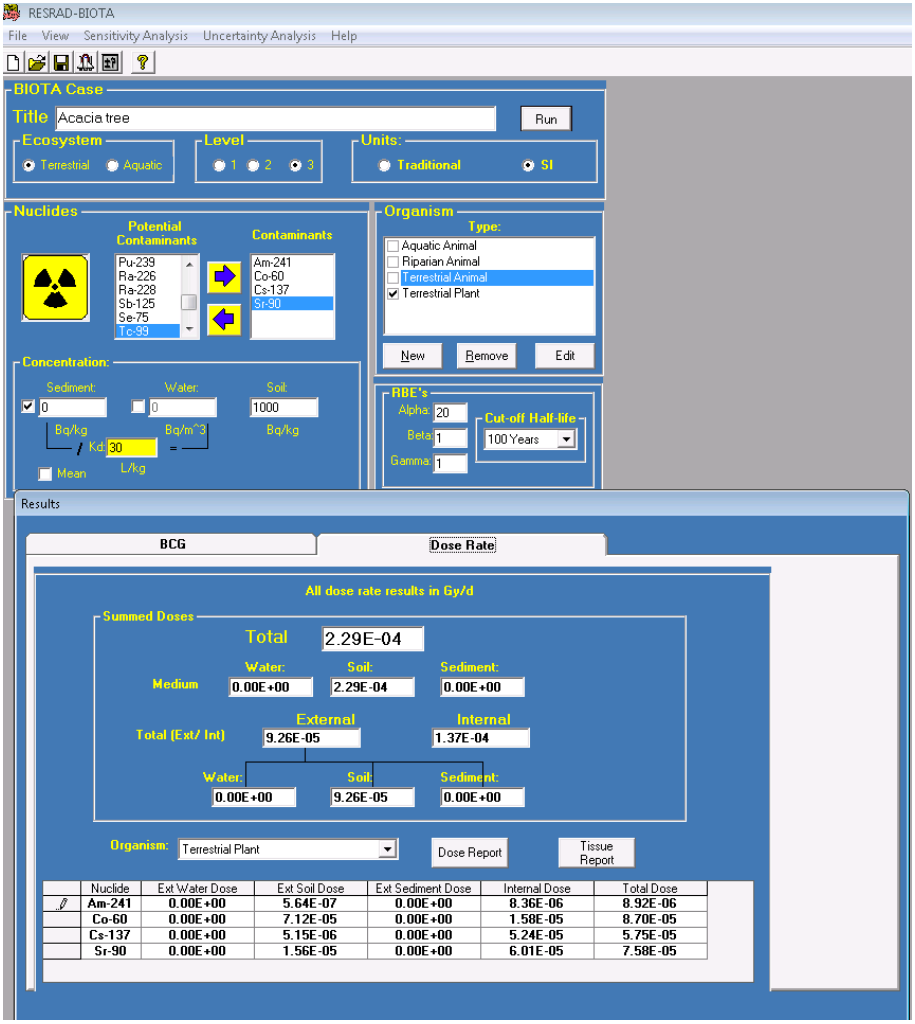
Table 4 Dose Results (Gy/d) with RESRAD-BIOTA Default Biv Values

Species	External	Internal	Total
Acacia (tree)	9.26E-5	1.37E-04	2.29E-04
Grass	5.45E-07	2.08E-06	2.63E-06
Raven	1.64E-07	1.11E-05	1.13E-05
Fox	3.60E-08	2.20E-06	2.23E-06

Dose estimation for Acacia

Enter soil concentration in zone 1.

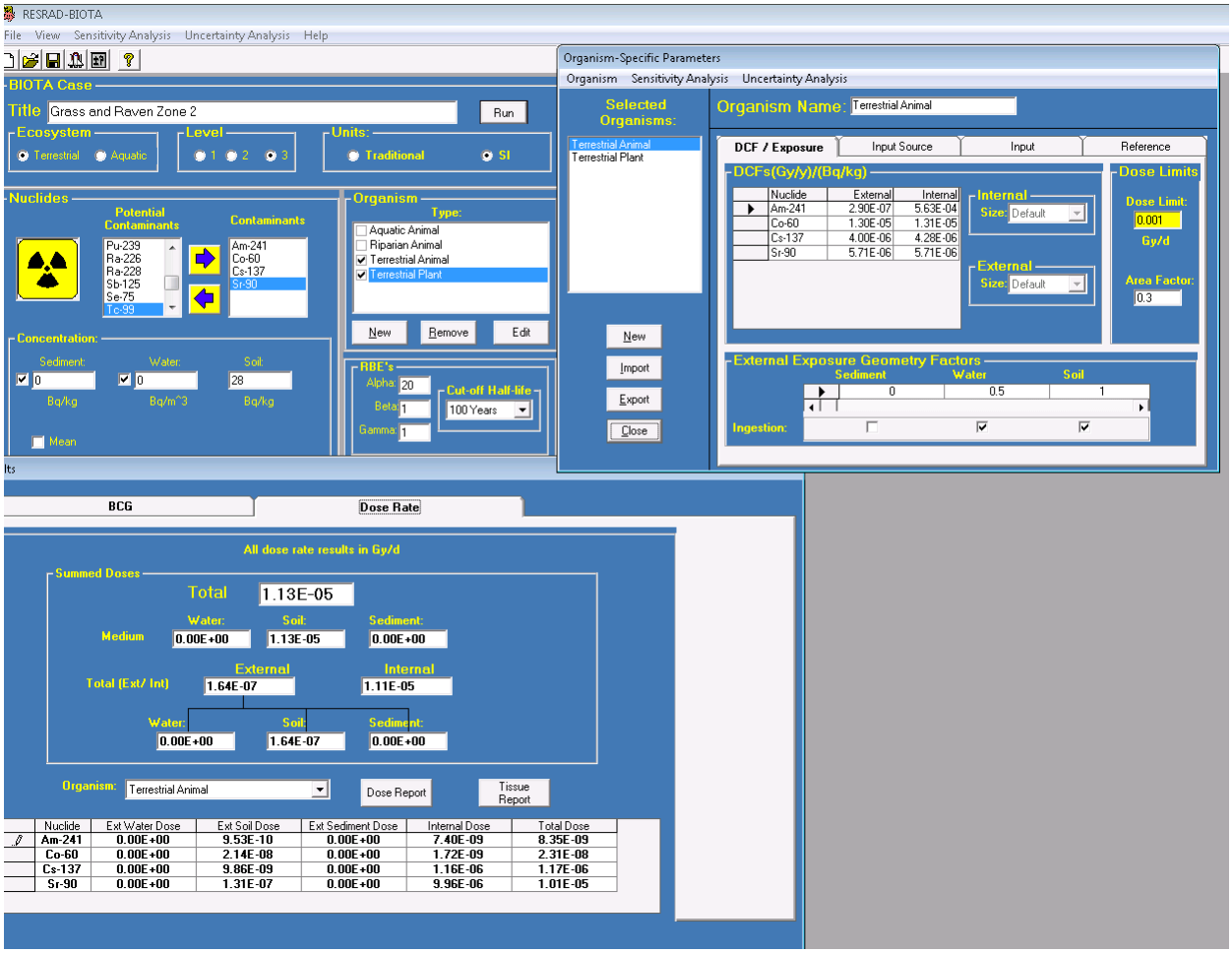
Data input and dose results for Acacia



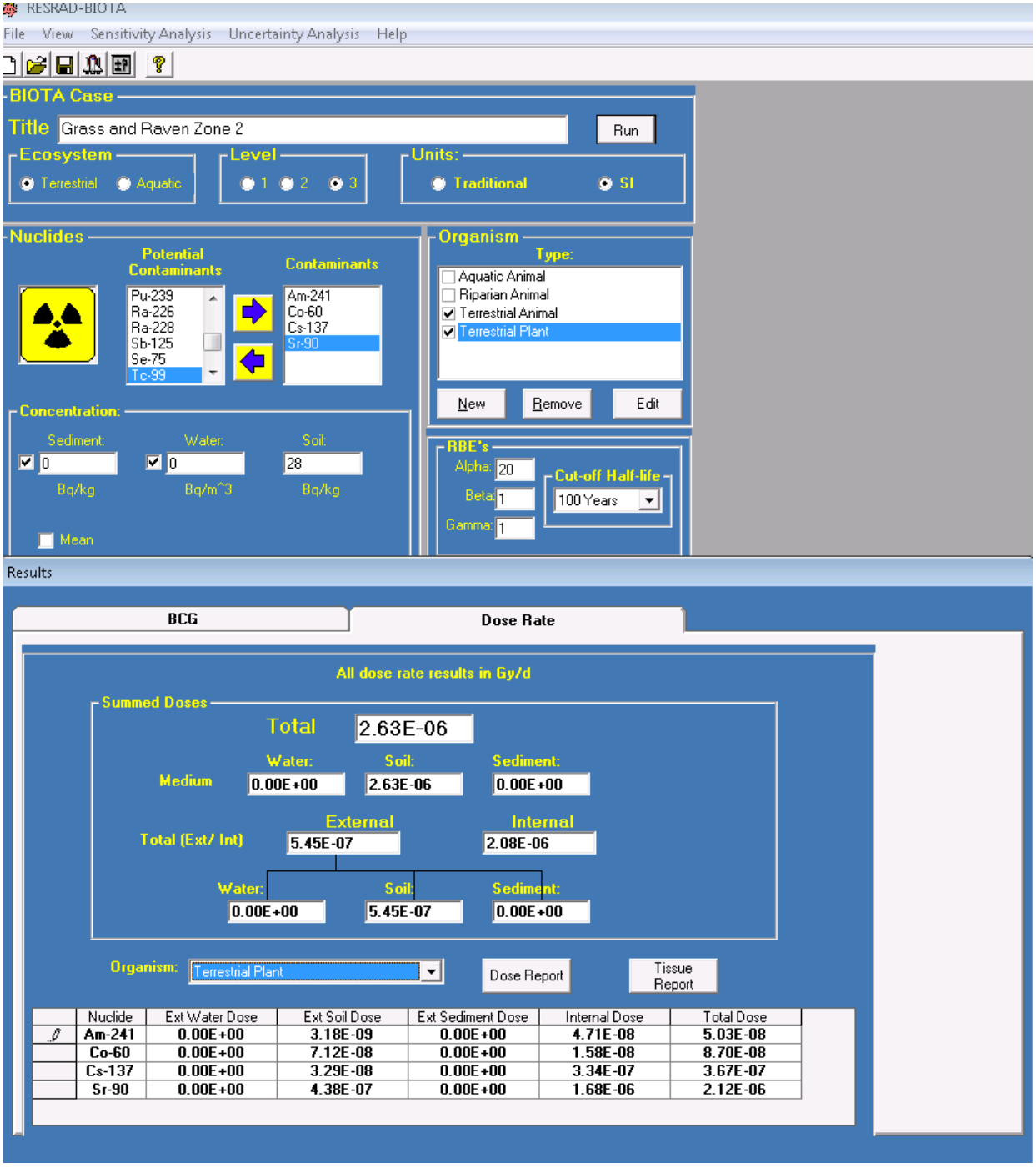
Dose estimation for Grass and Raven

Enter soil concentration in zone 2. Raven spends 30% time in zone 2 and is away from contamination 70% time. Change area factor for terrestrial animal.

Data Input and Dose Results for Raven



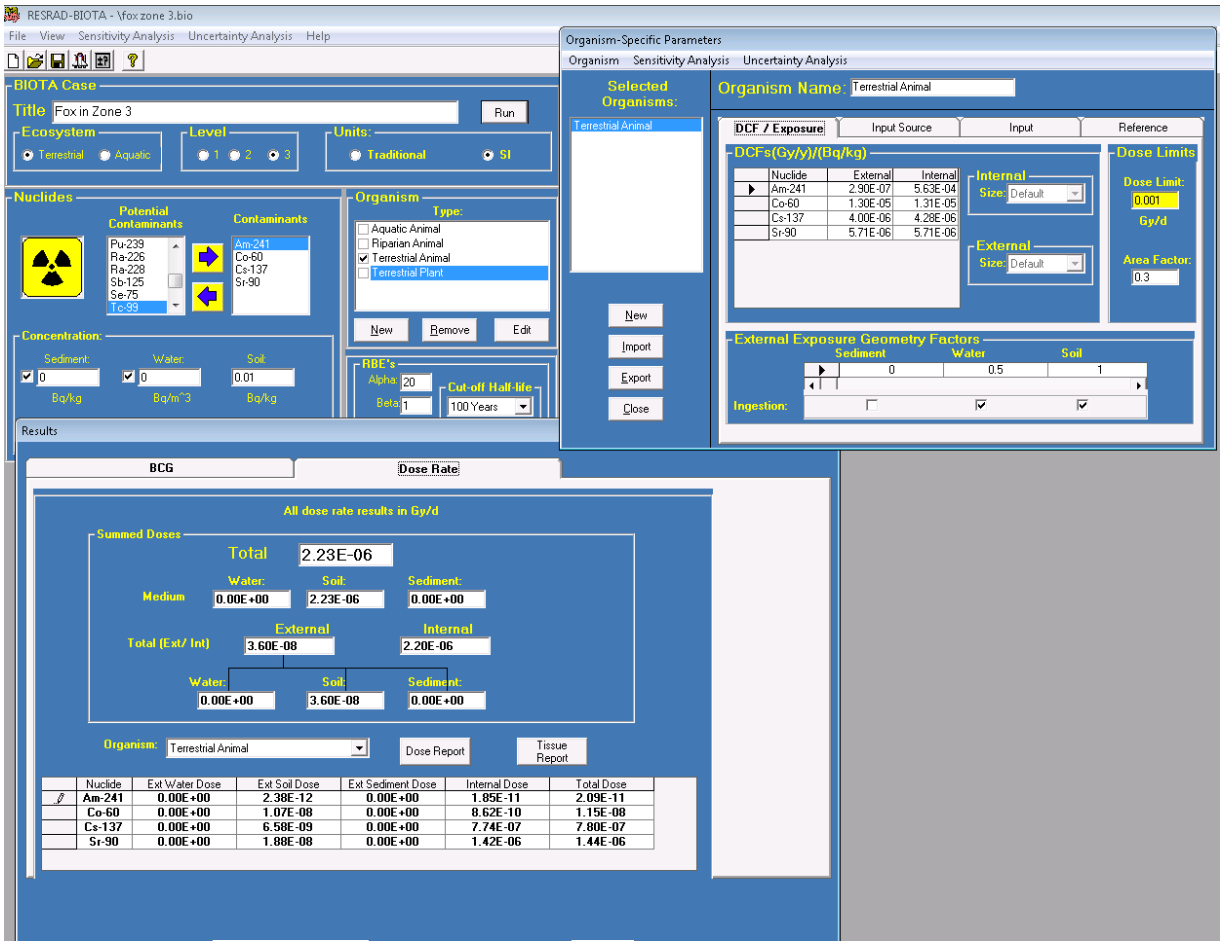
Data Input and Dose Results for Grass



Dose Estimation for Fox in Zone 3

Enter soil concentration in zone 3. Fox spends 30% time in zone 3 and is away from contamination 70% time. Change area factor for terrestrial animal.

Data Input and Dose Results for Fox



Problem 3 – Question 2

Now change Biv values to match the CR values in Table 3.

Doses are estimated at RESRAD-BIOTA level 3 by entering the soil concentration in different zones. Two types of terrestrial species (terrestrial plant and terrestrial animal) can be evaluated in a single run. Acacia tree is located in zone 1. Grass and Raven occupy zone 2, and fox occupies zone 3. Three separate run will be done. Table 5 summarizes the dose results.

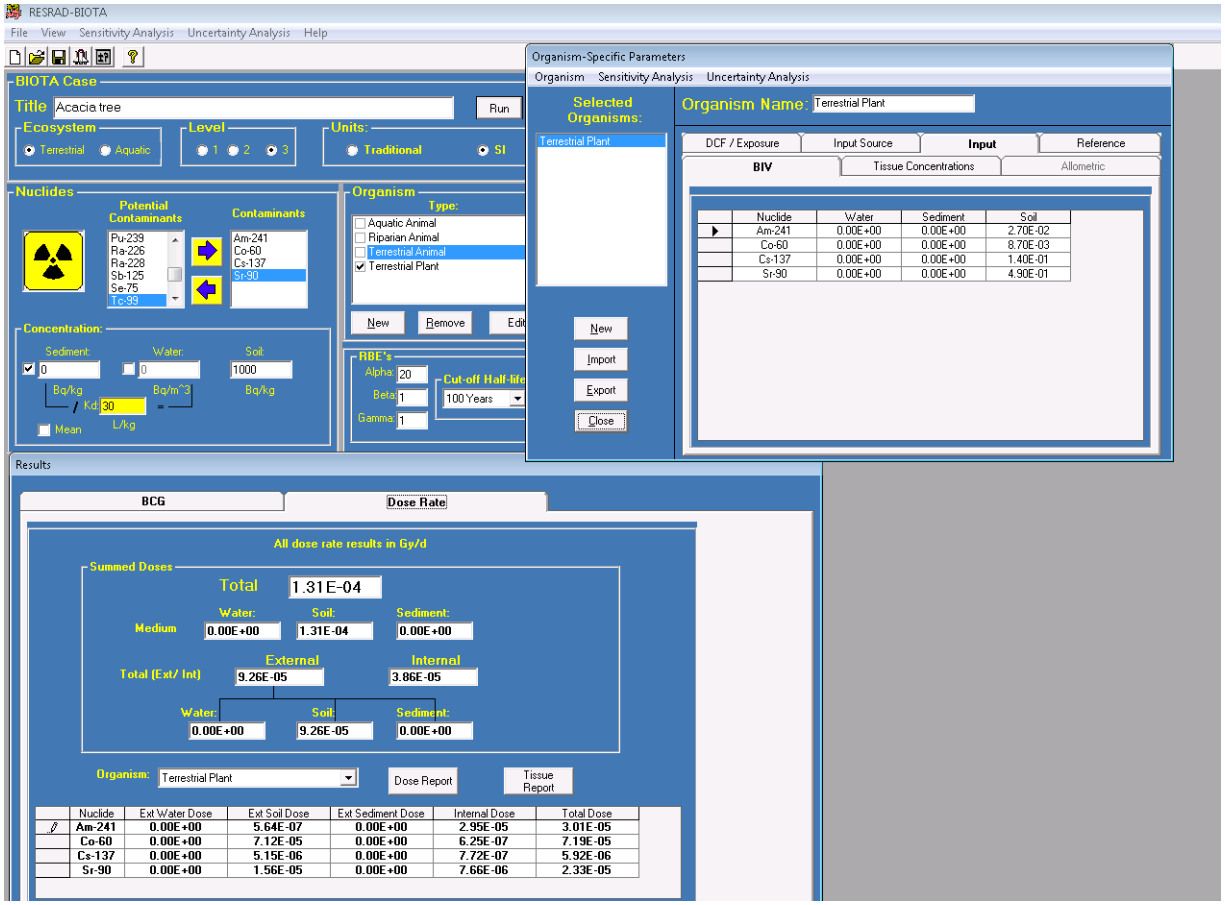
Table 5 Dose Results (Gy/d) with TRS 479 CR Values

Species	External	Internal	Total
Acacia (tree)	9.26E-05	3.86E-05	1.31E-04
Grass	5.45E-07	1.47E-06	2.01E-06
Raven	1.64E-07	1.31E-07	2.95E-07
Fox	3.60E-08	5.97E-08	9.57E-08

Dose Estimation for Acacia

Enter soil concentration in zone 1.

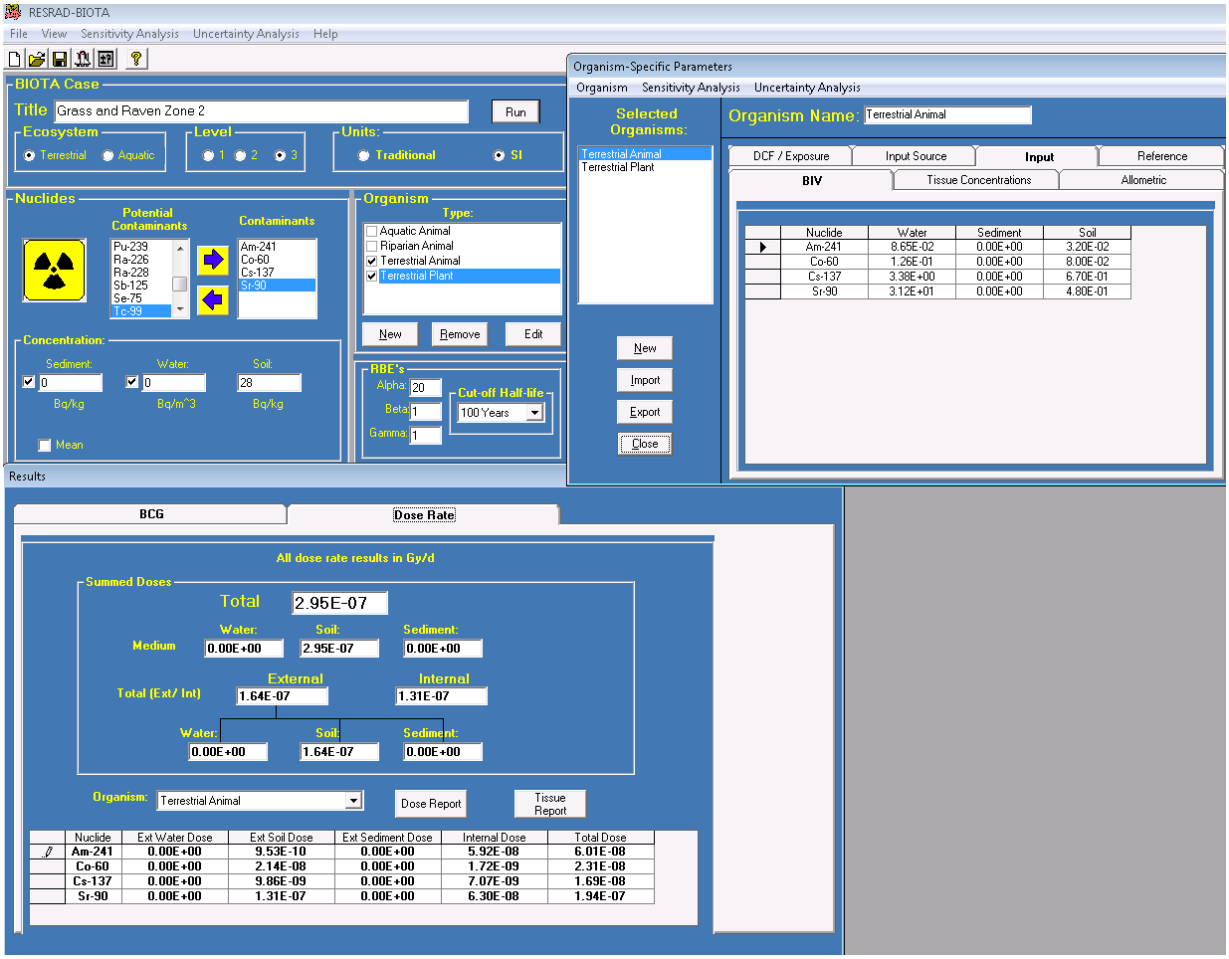
Data input and dose results for Acacia with TRS 479 CR values



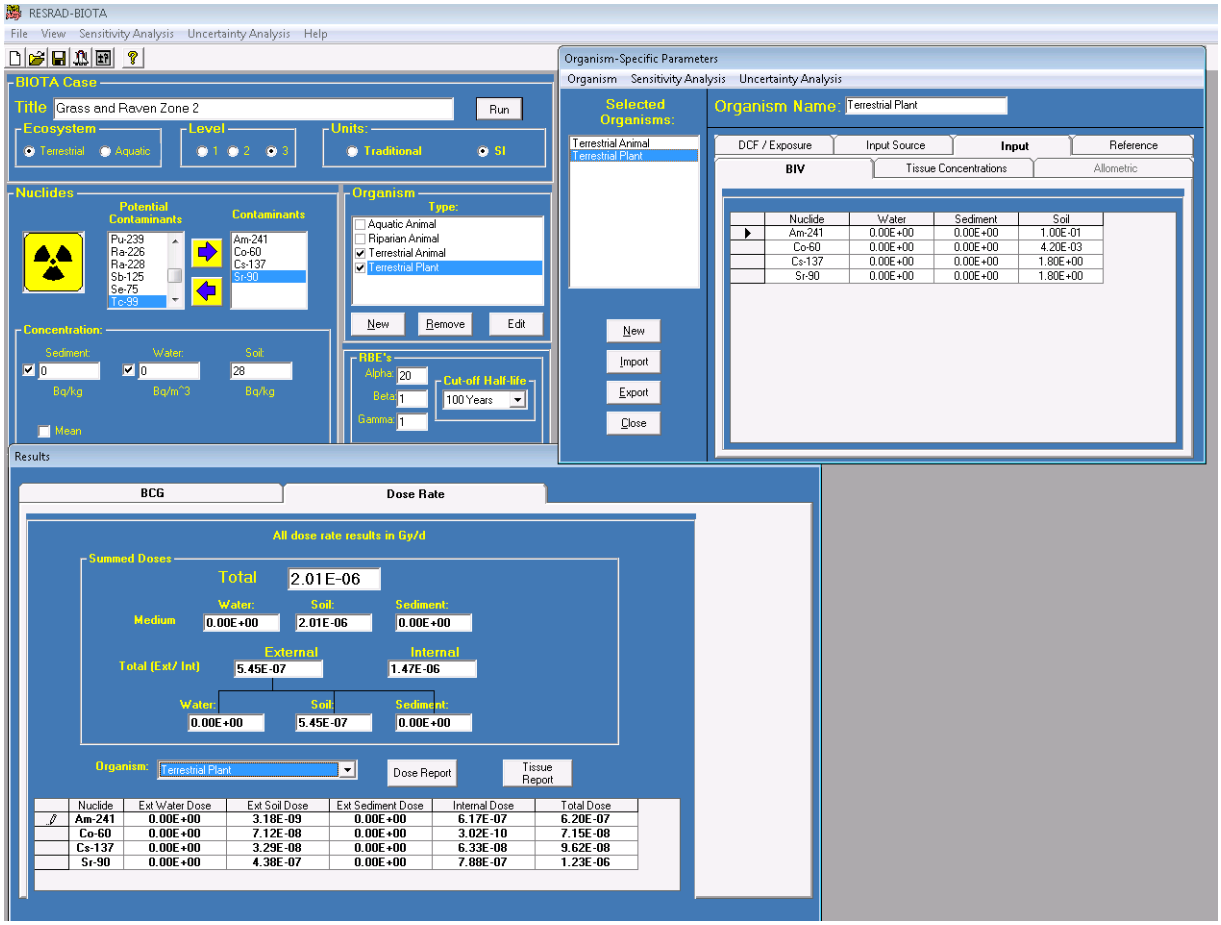
Dose Estimation for Grass and Raven

Enter soil concentration in zone 2. Raven spends 30% time in zone 2 and is away from contamination 70% time. Change area factor for terrestrial animal.

Dose Results for Raven with TRS 479 CR Values



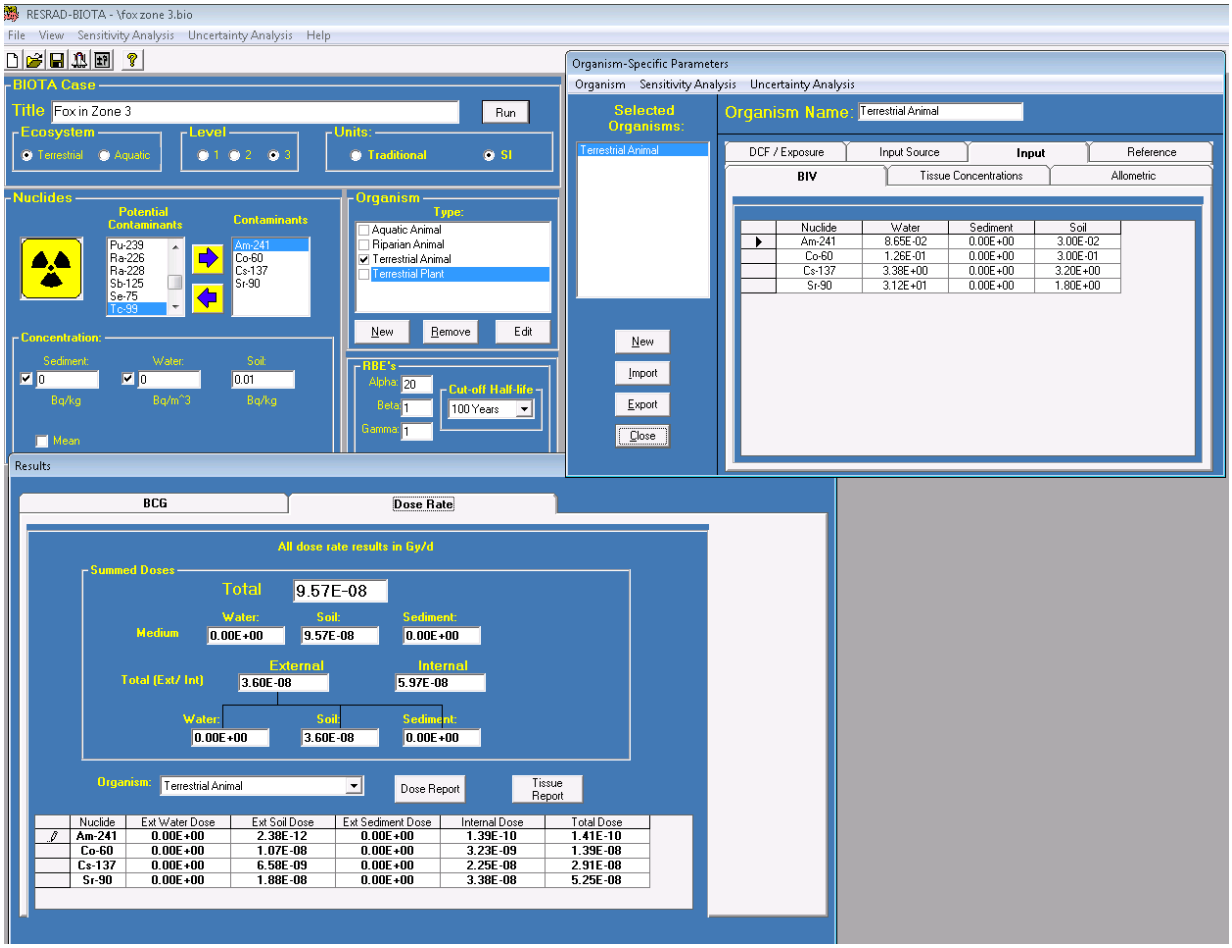
Dose Results for Grass with TRS 479 CR Values



Dose Estimation for Fox in Zone 3

Enter soil concentration in zone 3. Fox spends 30% time in zone 3 and is away from contamination 70% time. Change area factor for terrestrial animal.

Data Input and Dose Results for Fox Using TRS 479 CR Values



By using the species specific CR values from TRS 479 the internal dose is much lower compared to using default Biv values in RESRAD-BIOTA**.**

Hands-on Problem 4: Sensitivity Analysis

Background

Use sensitivity analysis to find the important parameters at level 3 for terrestrial animal. The terrestrial environment has Co-60 and Am-241 with equal concentrations in water (3.7E+04 Bq/m^3 [1000 pCi/L]) and soil (37 Bq/kg [1 pCi/g]).

Problems:

(a) Add sensitivity analysis for all 4 concentrations in Level 3. Run RESRAD-BIOTA.

(b) What parameter is the sum dose most sensitive to? Look at the interactive table for different sensitivity parameters in the “Sensitivity” tab for "Dose" Result Type.

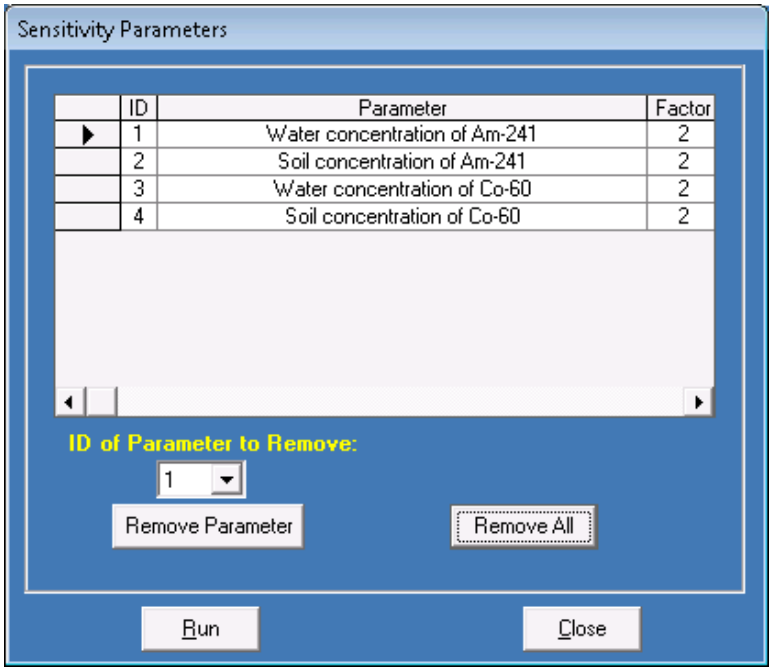
(c) Look at the “Detailed Sensitivity Report” for "Dose" Result Type and "Deterministic Graph" to determine which parameter is more sensitive to soil dose and what parameter is more sensitive to water dose?

(d) Select "Conc/BCG" Result Type. Why sensitivity is zero?

(e) Now remove the concentration sensitivities and add the four non-zero Biv parameters for sensitivity analysis for terrestrial animal.

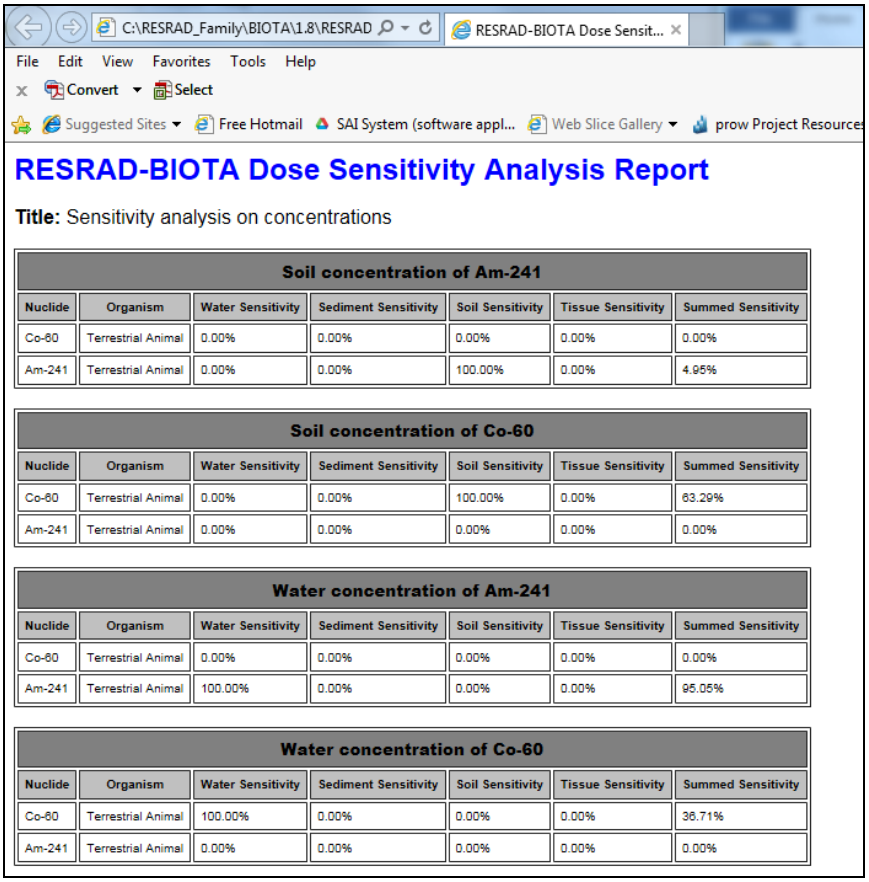
(f) What parameter is the dose most sensitive to? (Look at the "Detailed Sensitivity Report".)

Question 4a. Input parameters for sensitivity analysis



Question 4b. The Sum Dose is most sensitive to the water concentration of Am-241.

Question 4c. The soil dose is more sensitive to Co-60 soil concentration and the water dose is more sensitive to Am-241 water concentration.



C:\RESRAD_Family\BIOTA\1.8\RESRAD

RESRAD-BIOTA Dose Sensit...

File Edit View Favorites Tools Help

Convert Select

Suggested Sites Free Hotmail SAI System (software appl... Web Slice Gallery prow Project Resources

RESRAD-BIOTA Dose Sensitivity Analysis Report

Title: Sensitivity analysis on concentrations

Soil concentration of Am-241

Nuclide	Organism	Water Sensitivity	Sediment Sensitivity	Soil Sensitivity	Tissue Sensitivity	Summed Sensitivity
Co-60	Terrestrial Animal	0.00%	0.00%	0.00%	0.00%	0.00%
Am-241	Terrestrial Animal	0.00%	0.00%	100.00%	0.00%	4.95%

Soil concentration of Co-60

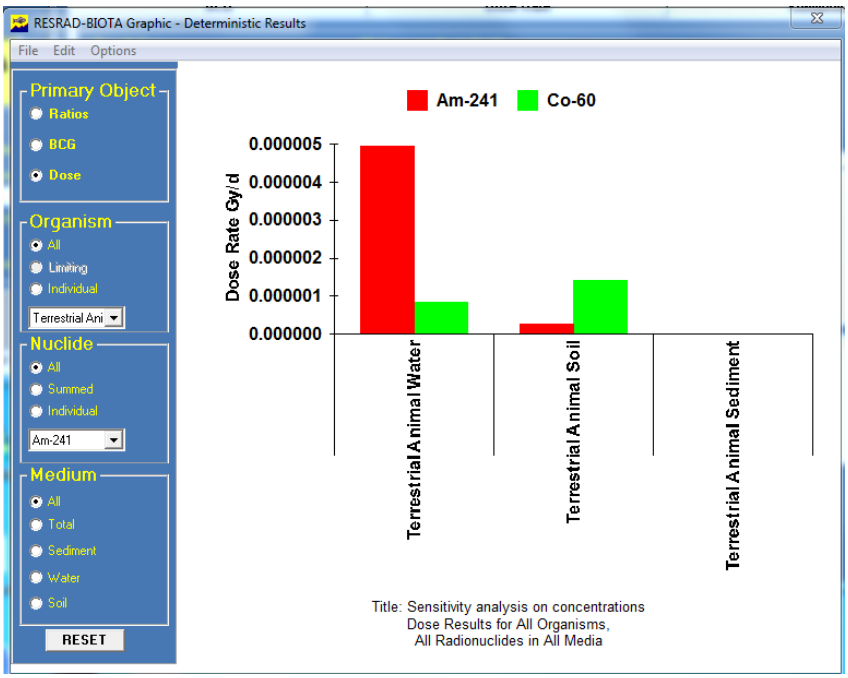
Nuclide	Organism	Water Sensitivity	Sediment Sensitivity	Soil Sensitivity	Tissue Sensitivity	Summed Sensitivity
Co-60	Terrestrial Animal	0.00%	0.00%	100.00%	0.00%	63.29%
Am-241	Terrestrial Animal	0.00%	0.00%	0.00%	0.00%	0.00%

Water concentration of Am-241

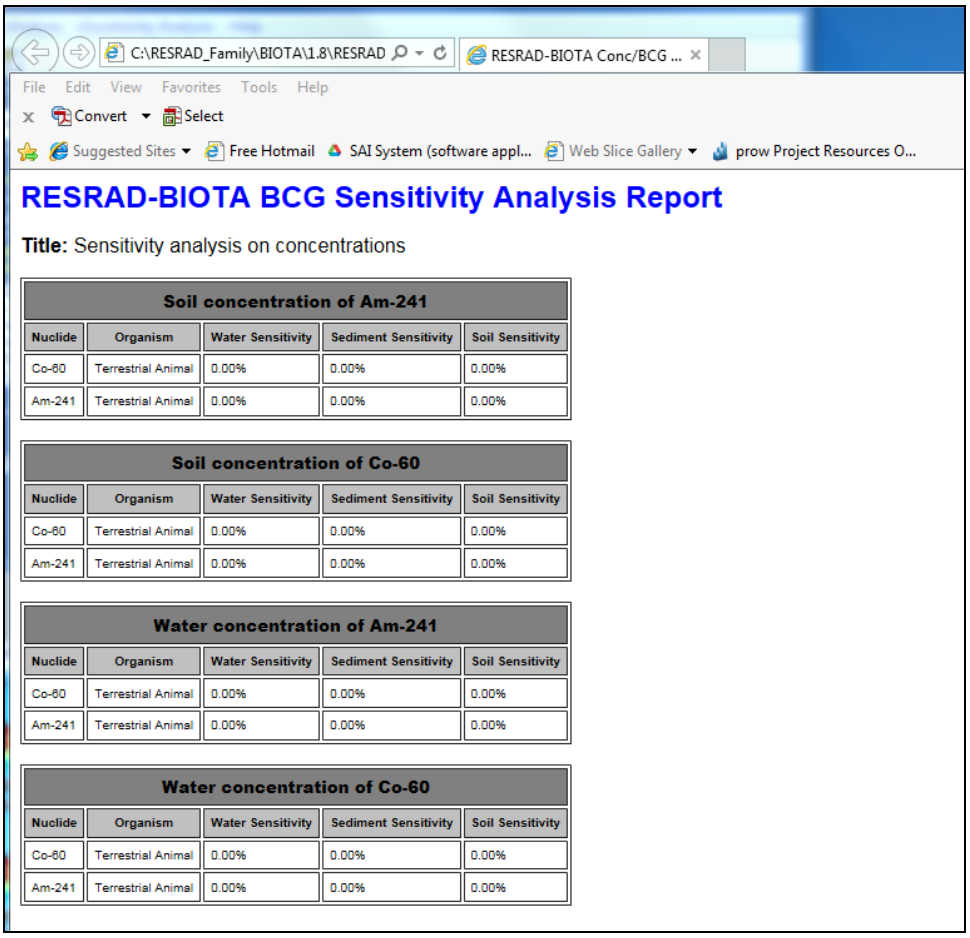
Nuclide	Organism	Water Sensitivity	Sediment Sensitivity	Soil Sensitivity	Tissue Sensitivity	Summed Sensitivity
Co-60	Terrestrial Animal	0.00%	0.00%	0.00%	0.00%	0.00%
Am-241	Terrestrial Animal	100.00%	0.00%	0.00%	0.00%	95.05%

Water concentration of Co-60

Nuclide	Organism	Water Sensitivity	Sediment Sensitivity	Soil Sensitivity	Tissue Sensitivity	Summed Sensitivity
Co-60	Terrestrial Animal	100.00%	0.00%	0.00%	0.00%	36.71%
Am-241	Terrestrial Animal	0.00%	0.00%	0.00%	0.00%	0.00%



Question 4d. The BCG's are independent of medium concentrations.



C:\RESRAD_Family\BIOTA\1.8\RESRAD | RESRAD-BIOTA Conc/BCG ...

File Edit View Favorites Tools Help

Convert Select

Suggested Sites | Free Hotmail | SAI System (software appl... | Web Slice Gallery | prow Project Resources O...

RESRAD-BIOTA BCG Sensitivity Analysis Report

Title: Sensitivity analysis on concentrations

Soil concentration of Am-241

Nuclide	Organism	Water Sensitivity	Sediment Sensitivity	Soil Sensitivity
Co-60	Terrestrial Animal	0.00%	0.00%	0.00%
Am-241	Terrestrial Animal	0.00%	0.00%	0.00%

Soil concentration of Co-60

Nuclide	Organism	Water Sensitivity	Sediment Sensitivity	Soil Sensitivity
Co-60	Terrestrial Animal	0.00%	0.00%	0.00%
Am-241	Terrestrial Animal	0.00%	0.00%	0.00%

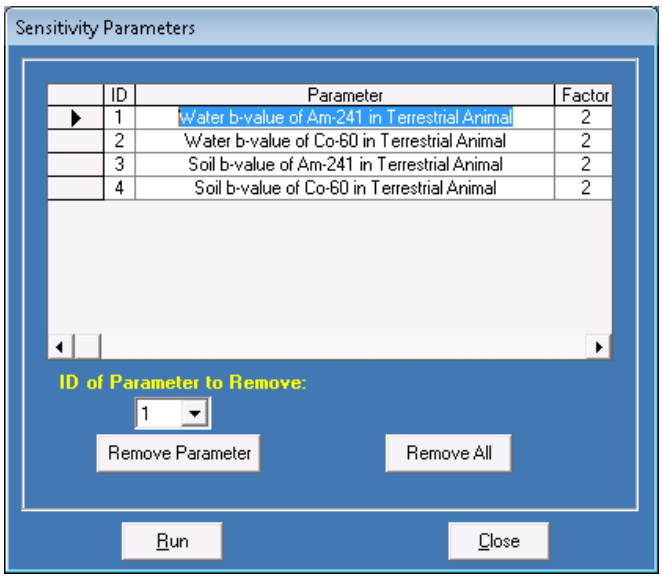
Water concentration of Am-241

Nuclide	Organism	Water Sensitivity	Sediment Sensitivity	Soil Sensitivity
Co-60	Terrestrial Animal	0.00%	0.00%	0.00%
Am-241	Terrestrial Animal	0.00%	0.00%	0.00%

Water concentration of Co-60

Nuclide	Organism	Water Sensitivity	Sediment Sensitivity	Soil Sensitivity
Co-60	Terrestrial Animal	0.00%	0.00%	0.00%
Am-241	Terrestrial Animal	0.00%	0.00%	0.00%

Question 4e: Input parameters for sensitivity analysis



Question 4f: The sum dose for Terrestrial Animal is most sensitive to the Am-241 water Biv.

RESRAD-BIOTA Dose Sensitivity Analysis Report

Title: Question 4 - Sensitivity Analysis

Soil b-value of Am-241 in Terrestrial Animal						
Nuclide	Organism	Water Sensitivity	Sediment Sensitivity	Soil Sensitivity	Tissue Sensitivity	Summed Sensitivity
Co-60	Terrestrial Animal	0.00%	0.00%	0.00%	0.00%	0.00%
Am-241	Terrestrial Animal	0.00%	0.00%	88.58%	0.00%	4.38%

Soil b-value of Co-60 in Terrestrial Animal						
Nuclide	Organism	Water Sensitivity	Sediment Sensitivity	Soil Sensitivity	Tissue Sensitivity	Summed Sensitivity
Co-60	Terrestrial Animal	0.00%	0.00%	7.46%	0.00%	4.72%
Am-241	Terrestrial Animal	0.00%	0.00%	0.00%	0.00%	0.00%

Water b-value of Am-241 in Terrestrial Animal						
Nuclide	Organism	Water Sensitivity	Sediment Sensitivity	Soil Sensitivity	Tissue Sensitivity	Summed Sensitivity
Co-60	Terrestrial Animal	0.00%	0.00%	0.00%	0.00%	0.00%
Am-241	Terrestrial Animal	99.70%	0.00%	0.00%	0.00%	94.77%

Water b-value of Co-60 in Terrestrial Animal						
Nuclide	Organism	Water Sensitivity	Sediment Sensitivity	Soil Sensitivity	Tissue Sensitivity	Summed Sensitivity
Co-60	Terrestrial Animal	20.22%	0.00%	0.00%	0.00%	7.42%
Am-241	Terrestrial Animal	0.00%	0.00%	0.00%	0.00%	0.00%

Hands-on Problem 5: Hanford Case Study – Aquatic Environment

Background

The 300 Area of the Hanford Site was used to produce nuclear fuel elements for the Hanford reactors. Metallic uranium was extruded into pipe-like cylinders and encapsulated with aluminum or zirconium cladding to produce nuclear fuel rods. Process wastes contained uranium and other heavy metals. These wastes were discharged as liquids into subsurface areas adjacent to the Columbia River shoreline. Subsequent surveys revealed that contamination from the waste sites entered the aquatic environment via ground water migration and emergence as seeps along the riverbank. Environmental samples were taken during low river stage to facilitate locating and collecting riverbank spring water samples. The following table lists the sampling results –

Radio-nuclide	Water Minimum Detection Limit (Bq/m^3)	Water (Bq/m^3)	Sediment Minimum Detection Limit (Bq/kg)	Sediment (Bq/kg)
Sr-90	2.22	7.5E+00	1.9	9.6E-01
Cs-137	370		1.1	8.5E+00
U-234	2.22	2.0E+03	0.75	1.0E+02
U-235	2.22	8.3E+01	0.75	3.8E+00
U-238	2.22	1.8E+03	0.75	9.1E+01

Problems:

(a) Based on the sampling results, run RESRAD-BIOTA for Level 1 analysis (see Fig. 1). Water concentration for Cs-137 is not available, what value should be used for the analysis? Also the measured sediment concentration for Sr-90 is lower than the detection limit, should the measured concentration be used for the analysis? Determine the Cs-137 and Sr-90 concentrations and enter them to RESRAD-BIOTA. Can you duplicate the Level 1 General Screening results as shown in Fig. 2? What is the water concentration for Cs-137 according to Fig.2 and how is it determined? Display the graphical output (See Fig. 3). Note the sum of fractions and the limiting organisms.

(b) Select Level 2 in RESRAD-BIOTA (Site-specific screening phase). Select and input site-specific bioaccumulation coefficients (Biv parameters) for uranium in water for aquatic animal, using a value of 11. Rerun the program. See Fig. 4 for results. How does the limiting organism change?

(c) Select Level 3 Analysis in RESRAD-BIOTA (Site-specific analysis phase). In the box labeled “Organism Type” select the “new” button. This will launch the Organism Wizard. Walk through the Wizard, entering the following information when prompted:

a. Name for organism: clam
b. Select geometry for organism: use the slider bar to move through the 8 organism sizes. Review the example receptors provided for each of the geometries. Select geometry 2.
c. Enter a weight for the organism. Select the default mass of 0.001 kg
d. Select a model for the internal ingestion parameters. Select the generic aquatic animal
e. Enter comments about the organism.
f. Run the Level 3 analysis. Examine dose and BCG output. See Fig. 5, 6, 7,8 for results

Figure 1. This is what the image should look like for Level 1 analysis:

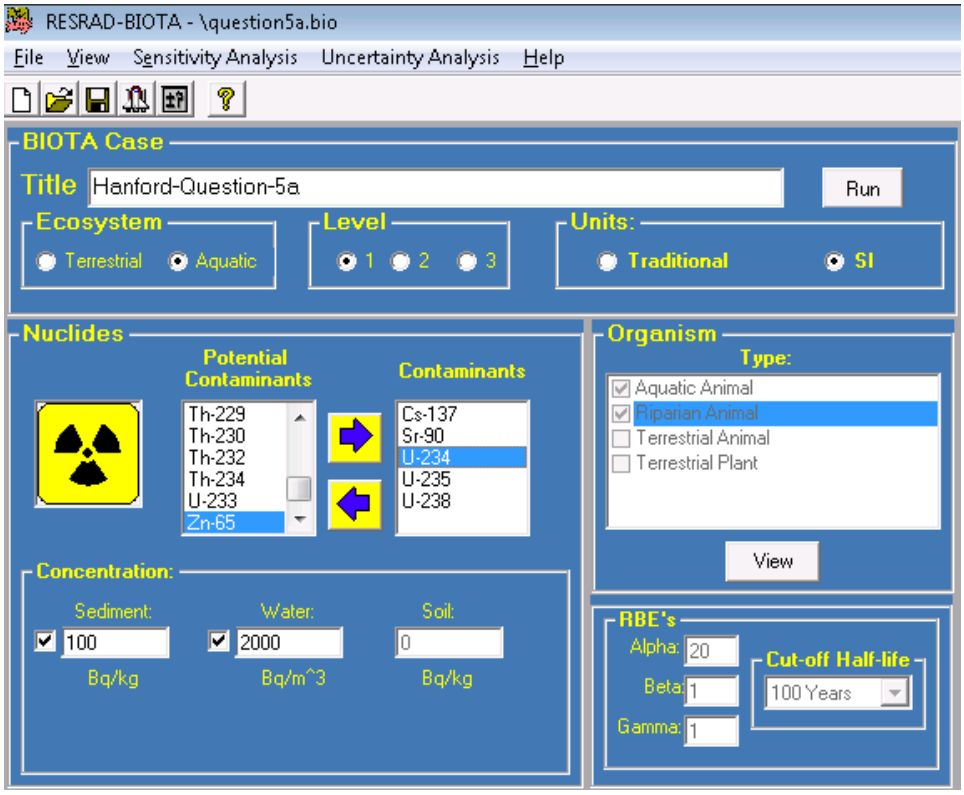


Figure 2. This is what the output should look like for Level 1 analysis:

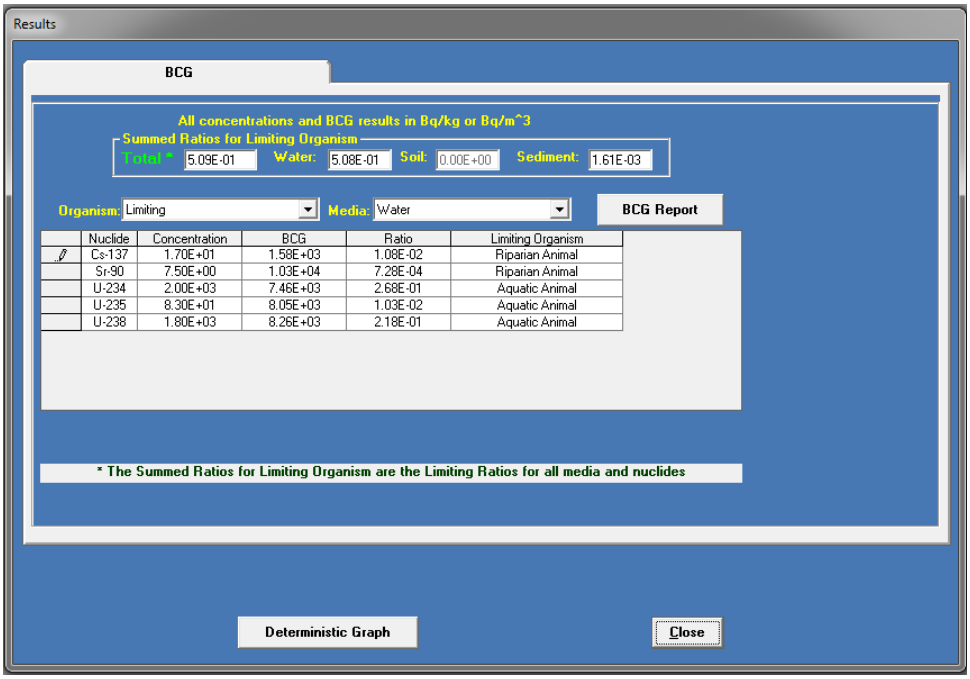


Figure 3. This is the graphical output from Level 1 analysis

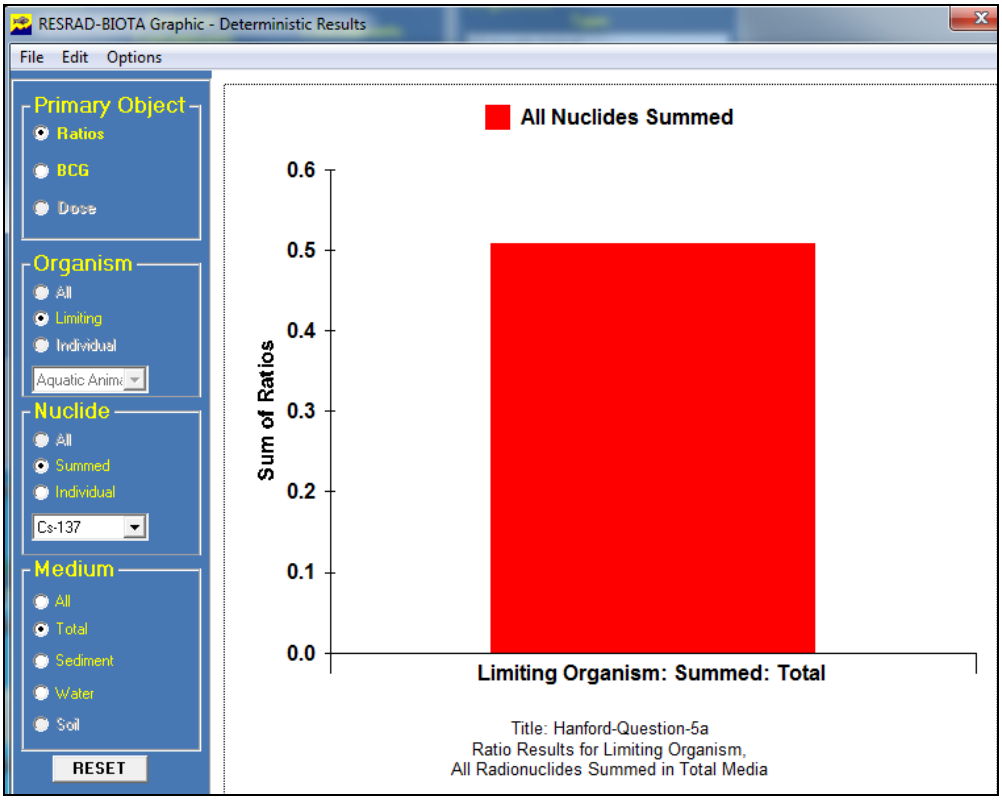


Figure 4. Level 2 results after changing U Biv values

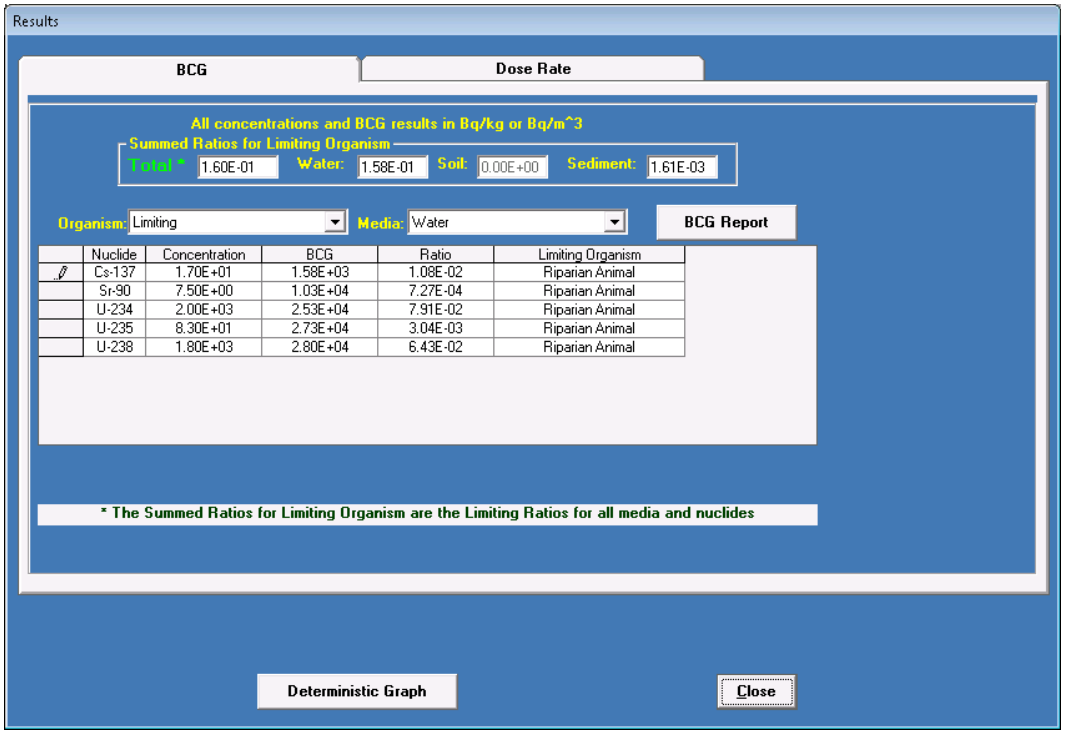


Figure 5. Level 3 results after running Organism Wizard

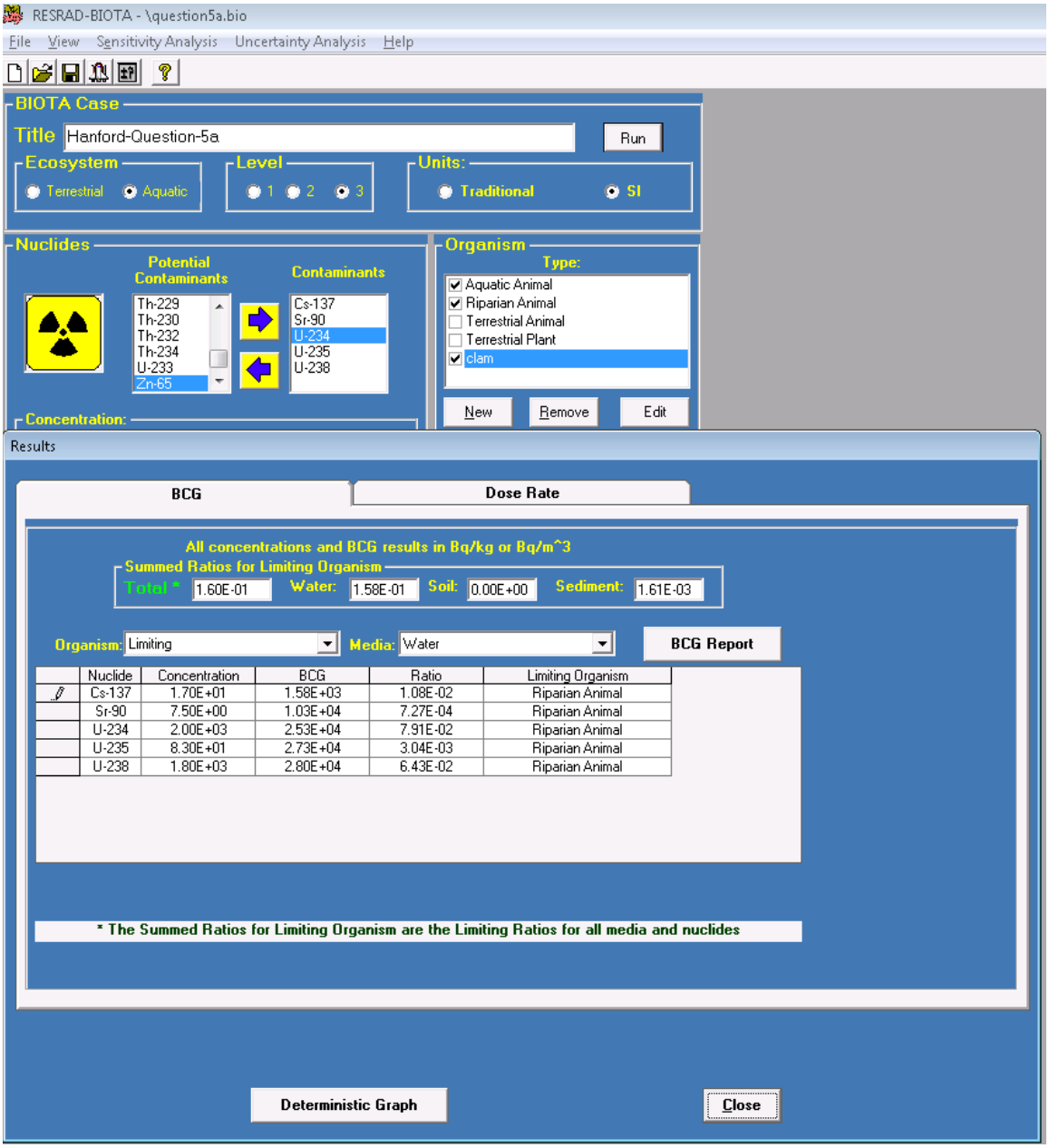


Figure 6. Graphical output from Level 3 screening.

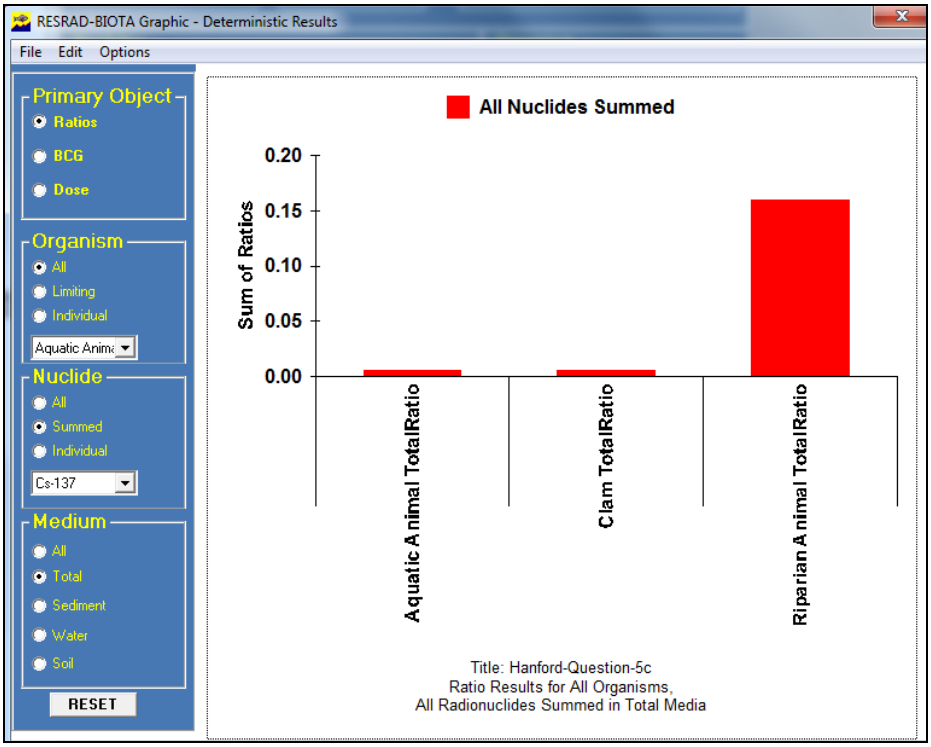


Figure 7. Nuclide contribution to limit

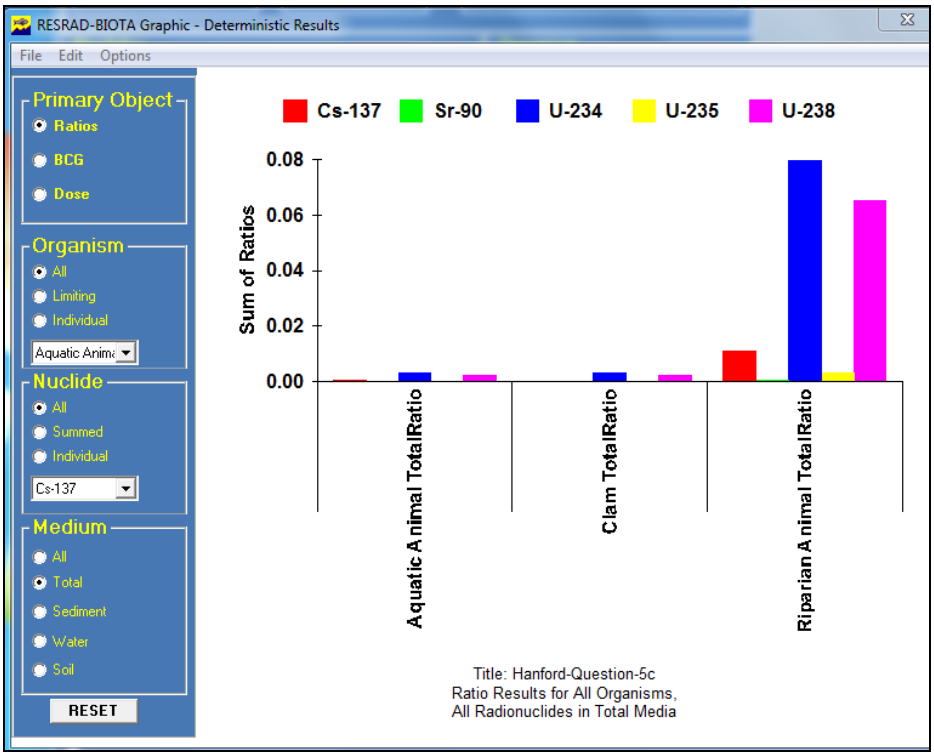


Figure 8 – Dose Output

Dose Report for Level 3 in Gy/d

Title: Hanford-Question-5c

Aquatic Animal												
Nuclide	External				Internal				Total			
	ext_Wtr	ext_Soil	ext_Sed	ext_Sum	int_Wtr	int_Soil	int_Sed	int_Sum	tot_Wtr	tot_Soil	tot_Sed	tot_Sum
Cs-137	9.32E-11	0.00E+00	4.66E-08	4.67E-08	4.39E-06	0.00E+00	0.00E+00	4.39E-06	4.39E-06	0.00E+00	4.66E-08	4.43E-06
Sr-90	5.87E-11	0.00E+00	1.76E-09	1.82E-09	3.75E-08	0.00E+00	0.00E+00	3.75E-08	3.76E-08	0.00E+00	1.76E-09	3.93E-08
U-234	1.78E-10	0.00E+00	8.92E-09	9.10E-09	2.94E-05	0.00E+00	0.00E+00	2.94E-05	2.94E-05	0.00E+00	8.92E-09	2.95E-05
U-235	2.05E-10	0.00E+00	9.37E-09	9.57E-09	1.13E-06	0.00E+00	0.00E+00	1.13E-06	1.13E-06	0.00E+00	9.37E-09	1.14E-06
U-238	1.13E-08	0.00E+00	5.73E-07	5.85E-07	2.39E-05	0.00E+00	0.00E+00	2.39E-05	2.40E-05	0.00E+00	5.73E-07	2.45E-05
Summed	1.19E-08	0.00E+00	6.40E-07	6.52E-07	5.89E-05	0.00E+00	0.00E+00	5.89E-05	5.90E-05	0.00E+00	6.40E-07	5.96E-05

Riparian Animal												
Nuclide	External				Internal				Total			
	ext_Wtr	ext_Soil	ext_Sed	ext_Sum	int_Wtr	int_Soil	int_Sed	int_Sum	tot_Wtr	tot_Soil	tot_Sed	tot_Sum
Cs-137	9.32E-11	0.00E+00	4.66E-08	4.67E-08	1.08E-05	0.00E+00	2.69E-08	1.08E-05	1.08E-05	0.00E+00	7.34E-08	1.08E-05
Sr-90	5.87E-11	0.00E+00	1.76E-09	1.82E-09	7.27E-07	0.00E+00	8.71E-09	7.36E-07	7.27E-07	0.00E+00	1.05E-08	7.38E-07
U-234	1.78E-10	0.00E+00	8.92E-09	9.10E-09	7.91E-05	0.00E+00	5.04E-07	7.96E-05	7.91E-05	0.00E+00	5.13E-07	7.96E-05
U-235	2.05E-10	0.00E+00	9.37E-09	9.57E-09	3.04E-06	0.00E+00	1.78E-08	3.06E-06	3.04E-06	0.00E+00	2.71E-08	3.07E-06
U-238	1.13E-08	0.00E+00	5.73E-07	5.85E-07	6.43E-05	0.00E+00	4.14E-07	6.47E-05	6.43E-05	0.00E+00	9.88E-07	6.53E-05
Summed	1.19E-08	0.00E+00	6.40E-07	6.52E-07	1.58E-04	0.00E+00	9.71E-07	1.59E-04	1.58E-04	0.00E+00	1.61E-06	1.60E-04

Clam												
Nuclide	External				Internal				Total			
	ext_Wtr	ext_Soil	ext_Sed	ext_Sum	int_Wtr	int_Soil	int_Sed	int_Sum	tot_Wtr	tot_Soil	tot_Sed	tot_Sum
Cs-137	6.78E-11	0.00E+00	3.39E-08	3.39E-08	1.21E-06	0.00E+00	0.00E+00	1.21E-06	1.21E-06	0.00E+00	3.39E-08	1.24E-06
Sr-90	1.52E-11	0.00E+00	4.57E-10	4.72E-10	2.77E-08	0.00E+00	0.00E+00	2.77E-08	2.77E-08	0.00E+00	4.57E-10	2.82E-08
U-234	1.22E-11	0.00E+00	6.10E-10	6.22E-10	2.94E-05	0.00E+00	0.00E+00	2.94E-05	2.94E-05	0.00E+00	6.10E-10	2.94E-05
U-235	1.05E-10	0.00E+00	4.83E-09	4.93E-09	1.12E-06	0.00E+00	0.00E+00	1.12E-06	1.12E-06	0.00E+00	4.83E-09	1.12E-06
U-238	3.01E-09	0.00E+00	1.52E-07	1.55E-07	2.35E-05	0.00E+00	0.00E+00	2.35E-05	2.35E-05	0.00E+00	1.52E-07	2.36E-05
Summed	3.21E-09	0.00E+00	1.92E-07	1.95E-07	5.53E-05	0.00E+00	0.00E+00	5.53E-05	5.53E-05	0.00E+00	1.92E-07	5.54E-05

> If the Tissue-Concentration option is selected (i.e., a tissue concentration was entered rather than a BIV value or allometric parameters in the organism 'input source' and 'input' tabs), then the internal dose to the organism from the radionuclide is calculated based on this concentration.

- This dose is not attributed to any media, i.e. it is listed in the dose table under the heading 'Int_Sum'.

- The external dose from each medium, calculated based on the user input media concentrations, are listed in the dose table under the headings for each medium (Water, Soil, or Sediment).

- The total external dose, ext_sum, is added into the total internal dose, int_sum (Tissue Concentration) to get the total dose which is reported under the heading 'tot_Sum'.

> If the tissue concentration input option is not used, then the calculated internal and external doses based on media concentrations are reported.

Hands-on Problem 6: Import/Export Features

Background

You want to share the setup for the clam organism made in problem 5. Then a new case can be constructed with the new organism. Perform some analysis and save the file

Problems:

(a) Open case for problem 5.

(b) Go to level 3. Select clam. Select “Export”. Save as “clam.org”

(c) Close Biota. Launch the code again. Go to level 3. Select “Import” and browse to where clam.org is saved. Open the file.

(d) Make some changes in the case and clam.org. Save the file as mod_clam.bio.

(e) What files should be sent if you want a colleague to reproduce your results? Is there enough documentation to know what was done?

Hands-on Problem 7: Allometric Approach and Food Chain Features

Background

In this problem, you are tasked to perform an ecological risk assessment for a hypothetical site where Am-241, Cs-137, and Sr-90 contamination is detected in soil and surface water.

A variety of animal species feed or inhabit within this site, including mammals and birds. After a thorough study, representative species for different trophic levels were identified and the food chain relationships between the species and the environment were established, as illustrated by Figure 1. According to the food chain relationships, vegetation and insects are the foundation food sources and they were sampled routinely as the contaminated environmental media. Table 1 lists the maximum concentrations measured through the samplings. Table 2 provides specific dietary compositions for the representative species.

Perform a Level 3 site-specific assessment for a terrestrial ecosystem. Utilize the organism wizard to create new species in the order of low to high trophic level. Select the allometric input option to obtain tissue concentrations in lower level organisms, and then derive the corresponding Biv's (which are the ratios between the calculated tissue concentrations to the respective environmental medium concentrations) for use in the subsequent evaluation of higher-level organisms.

Table 1. Maximum Radionuclide Concentration Measured

Nuclide	Water (Bq/m^3 [pCi/L])	Soil (Bq/kg [pCi/g])	Plant (Bq/kg [pCi/g])	Insects (Bq/kg [pCi/g])
Am-241	370 (10)	37 (1)	0.296 (0.008)	12.95 (0.35)
Cs-137	740 (20)	185 (5)	7.4 (0.2)	64.75 (1.75)
Sr-90	555 (15)	129.5 (3.5)	38.85 (1.05)	45.325 (1.225)

Table2: Terrestrial Organisms Data from EPA's Wildlife Exposure Factor Handbook

Species	Body Weight	Dietary Composition	Soil Ingestion Rate	Water Ingestion Rate
Kangaroo rat	0.0411 kg	insect: 4%, vegetation: 96%	2% of food ingestion rate	5.3 mL/d
Kit fox	2 kg	mammals (kangaroo rat): 66%, birds (mourning dove): 10%, insects: 24%	2.8% of food ingestion rate	0.1839 L/d
Mourning dove	0.125 kg	vegetation: 97%, insect: 3%	10.4% of food ingestion rate	13.6 mL/d

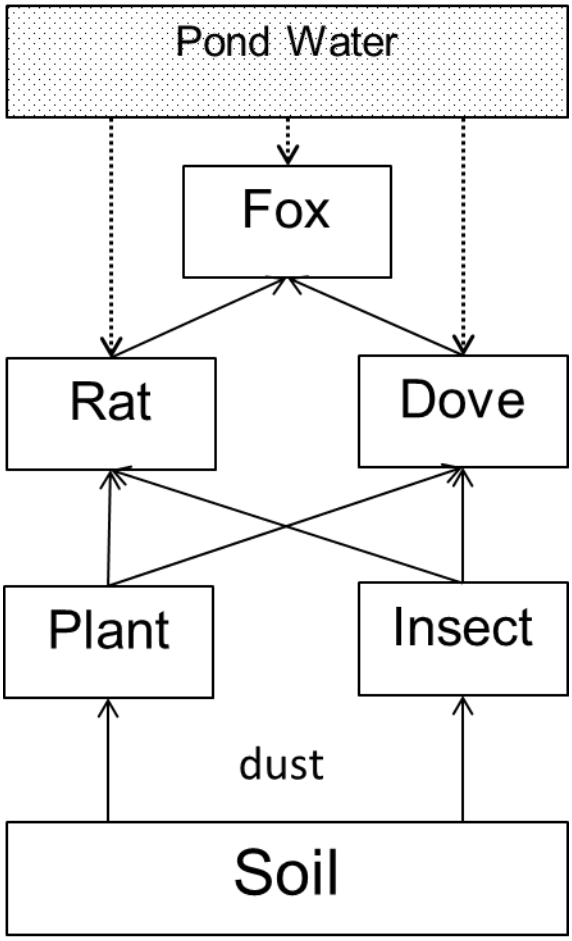


Figure 1: Conceptual Model (Food Chain) for the Representative Species

Questions:

(1) What are the maximum tissue concentrations in Kangaroo rats, Mourning doves, and Kit Foxes? Assume 100% of the air inhaled and food ingested are contaminated.

(2) Calculate the internal doses for these three organisms using the tissue concentrations obtained in part 1.

(3) Calculate the total annual doses received by these three organisms.

Answers:

(1) Approach: The contamination in soil could be dispersed into the air through the resuspension of soil particles. Use the default values to consider the exposures through the inhalation pathway.

Calculate the soil Biv's for plants and insects using the given concentrations. Then evaluate the exposures of Kangaroo rats and Mourning doves with the plant and insect Biv's by using the allometric input option.

The calculated tissue concentrations of Kangaroo rats and Mourning doves can be used to derive the corresponding soil and water Biv's, which then can be used in the next round of calculation to evaluate the exposures of Kit foxes.

Table 3 Plant and Insect Biv Calculations Using the Given Measured Concentrations

Nuclide	Water (Bq/m^3 [pCi/L])	Soil (Bq/kg [pCi/g])	Plant (Bq/kg [pCi/g])	Insects (Bq/kg [pCi/g])	Plant Biv for soil	Insect Biv for soil
Am-241	370 (10)	37 (1)	0.296 (0.008)	12.95 (0.35)	8.00E-03	3.50E-01
Cs-137	740 (20)	185 (5)	7.4 (0.2)	64.75 (1.75)	4.00E-02	3.50E-01
Sr-90	555 (15)	129.5 (3.5)	38.85 (1.05)	45.33 (1.23)	3.00E-01	3.50E-01

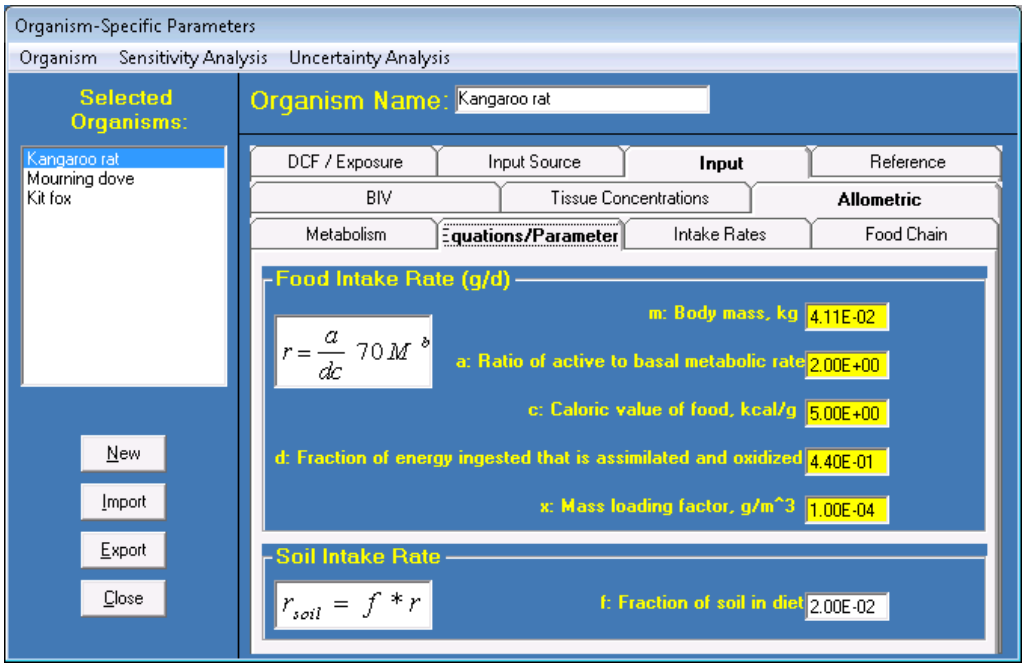
Choose Terrestrial ecosystem and Level 3 for the analysis. In the first analysis, create two new organisms - Kangaroo rat and Mourning dove, using the "Organism" wizard and the body weights and dietary compositions given in Table 2. In the second analysis, add another organism – Kit fox, and enter the Biv's for Kangaroo rat and Mourning dove obtained from the first analysis.

All of the three organisms are terrestrial animals. Choose conservative internal and external DCFs based on the sizes, i.e. body weights, provided in Table 2.

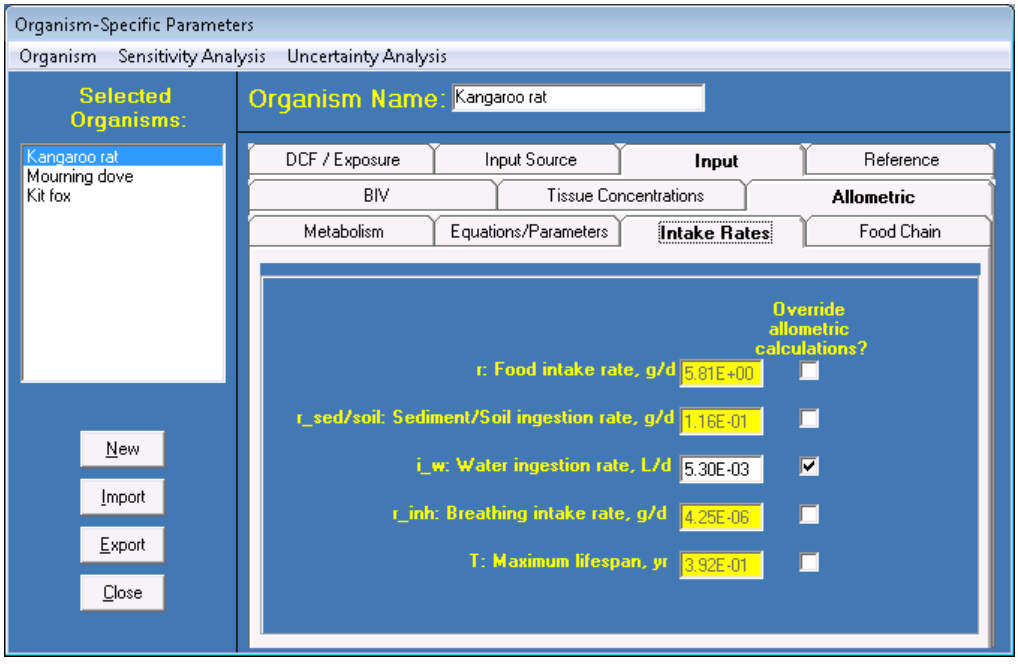
Tissue Concentration Calculations for Kangaroo rat

Change input parameters as shown in the following four screens -

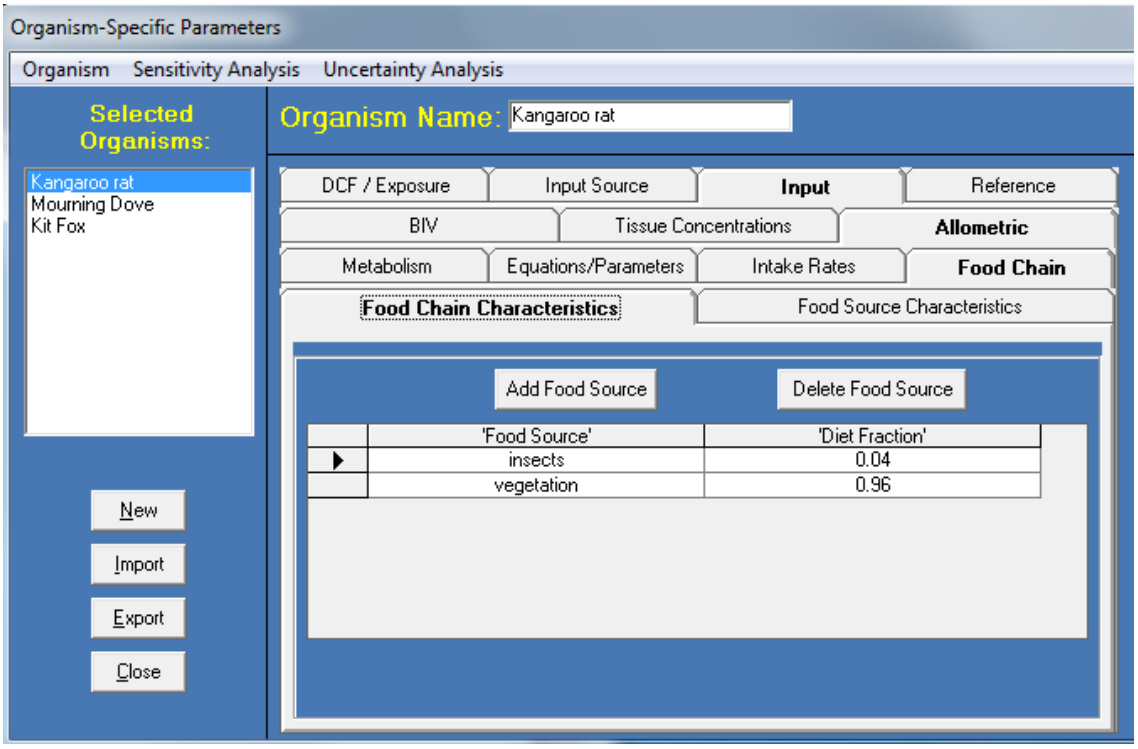
Fraction of soil in diet from Table 2 –



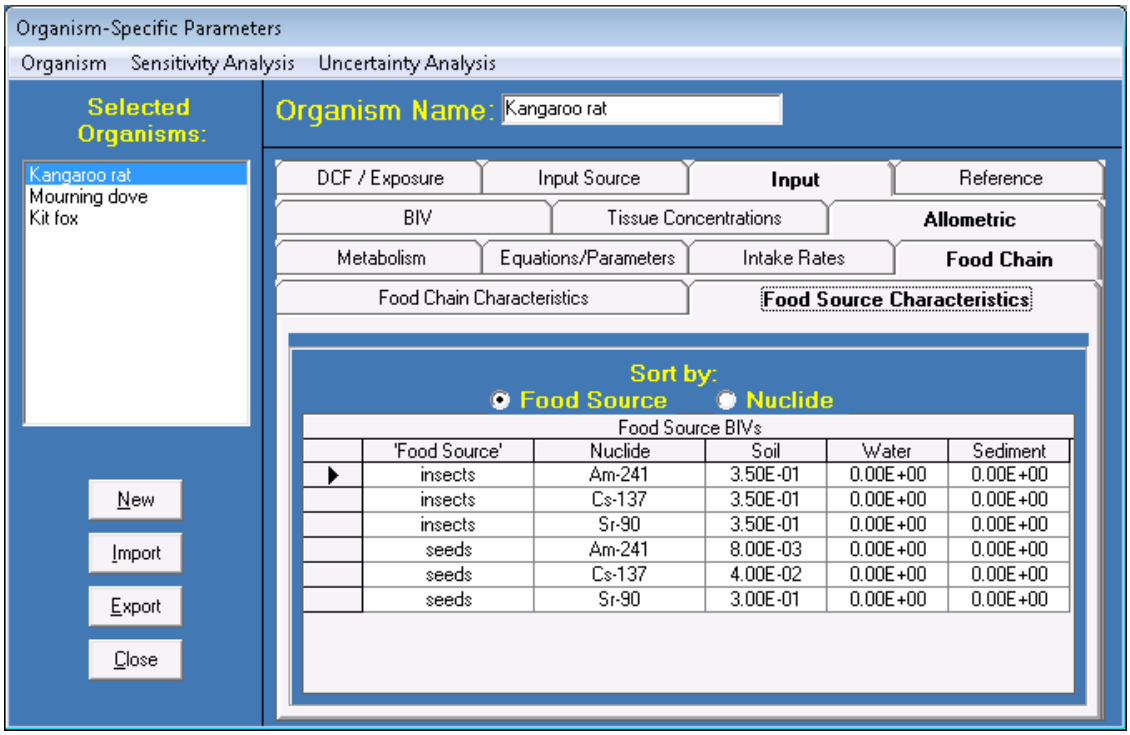
Water ingestion rate from Table 2 –



Diet fractions from Table 2 –



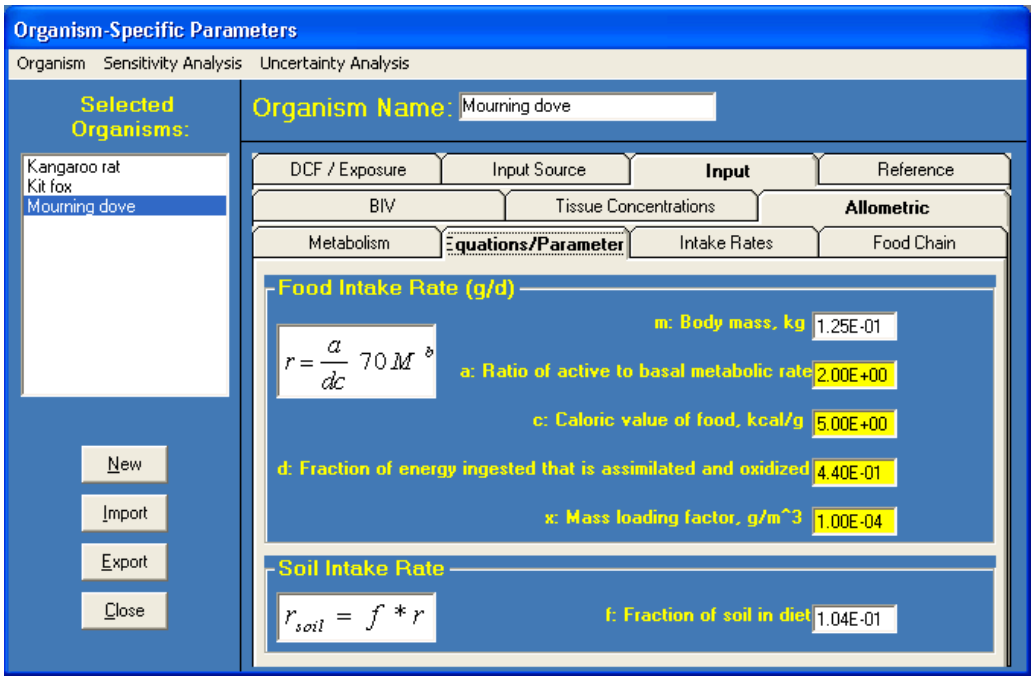
Food source Biv's from Table 3 –



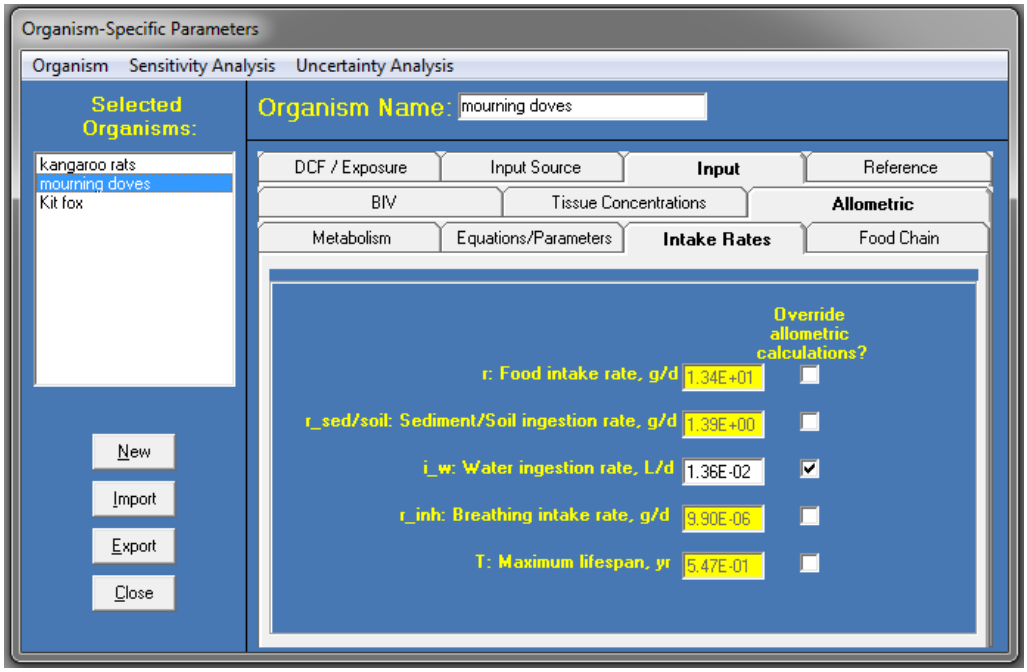
Tissue Concentration Calculations for Mourning Dove

Change parameter values as shown in the following four screens -

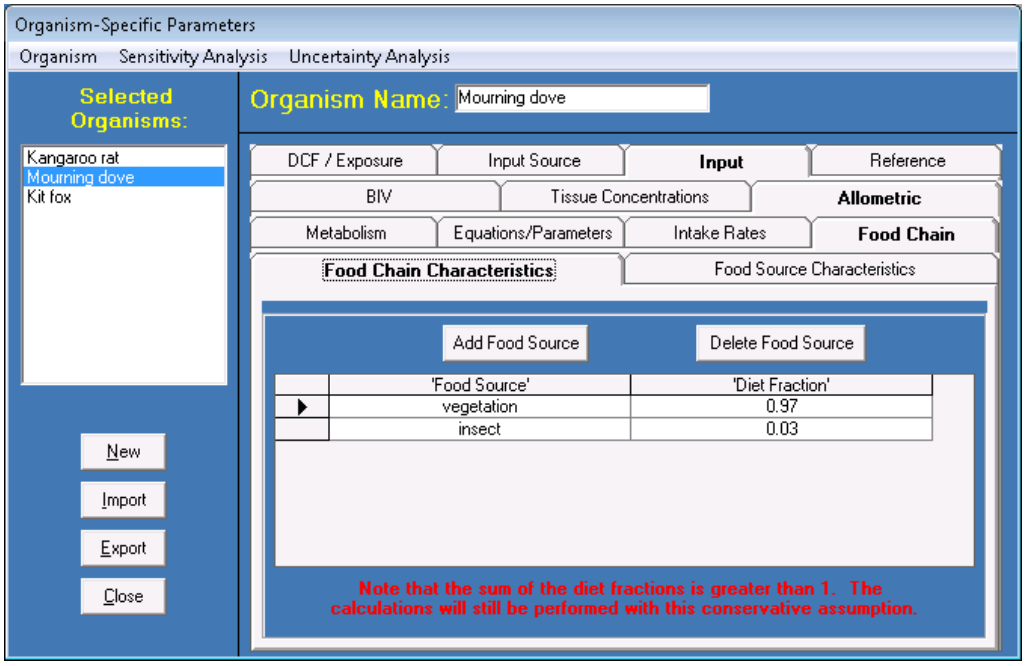
Fraction of soil in diet from Table 2 –



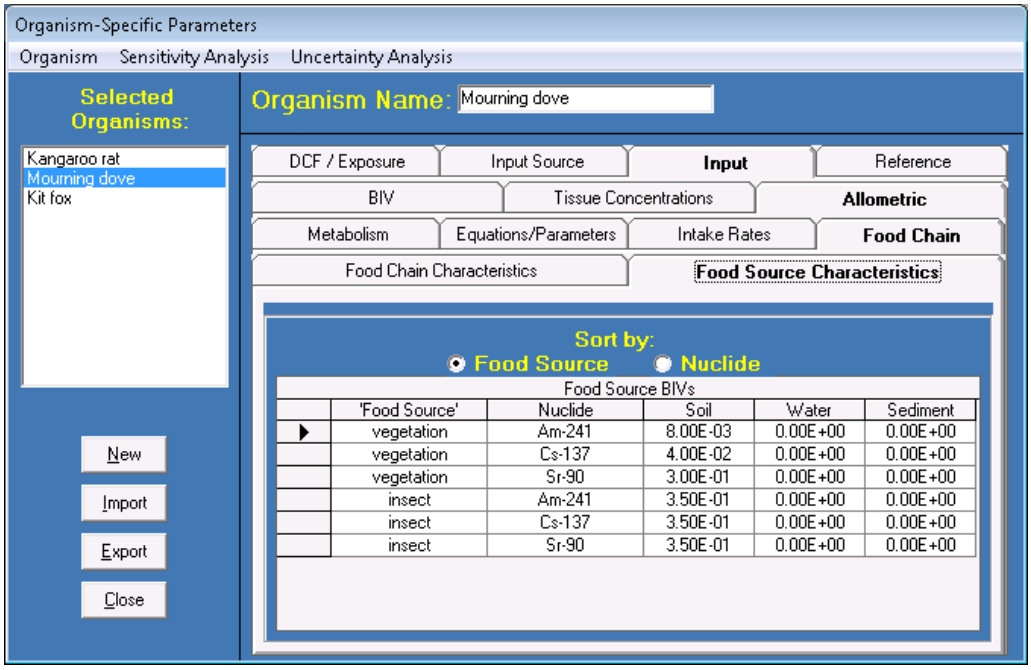
Water ingestion rate from Table 2 –



Diet fractions from Table 2 –



Food source Bivs from Table 3 –



Run the RESRAD-BIOTA and find tissue concentrations for Kangaroo rat and Mourning dove.

Tissue concentrations from the Tissue Report –

Tissue Concentration Report for Level 3 in Bq/kg

Title: Problem 7

Kangaroo rat				
Nuclide	**water**	**Soil**	**sediment**	**Total(Tissue Conc)**
Am-241	1.11E-03	5.11E-03	0.00E+00	6.23E-03
Cs-137	1.17E+00	2.33E+01	0.00E+00	2.45E+01
Sr-90	2.58E+00	2.12E+02	0.00E+00	2.15E+02

Mourning dove				
Nuclide	**water**	**Soil**	**sediment**	**Total(Tissue Conc)**
Am-241	2.52E-03	2.71E-02	0.00E+00	2.96E-02
Cs-137	1.45E+00	4.88E+01	0.00E+00	5.02E+01
Sr-90	3.37E+00	2.80E+02	0.00E+00	2.83E+02

Now calculate Biv values for Kangaroo rat and Mourning dove. The calculated Biv's can be used in the next RESRAD-BIOTA run to obtain tissue concentrations of Kit fox.

Table 4. Water and Soil Biv Calculations for Kangaroo Rat and Mourning Dove Using the Given Soil and Water Concentrations

Kangaroo rat tissue conc. (Bq/kg) from different media (see tissue concentration report)					Media Conc.		Kangaroo rat Biv for Different Media	
Nuclide	water	Soil	sediment	Total	Water (Bq/m^3)	Soil (Bq/kg)	Water [(Bq/kg) per (Bq/L)]	Soil [(Bq/kg) per Bq/kg]
Am-241	1.11E-03	5.11E-03	0.00E+00	6.23E-03	370	37	3.01E-03	1.38E-04
Cs-137	1.17E+00	2.33E+01	0.00E+00	2.45E+01	740	185	1.59E+00	1.26E-01
Sr-90	2.58E+00	2.12E+02	0.00E+00	2.15E+02	555	129.5	4.65E+00	1.64E+00

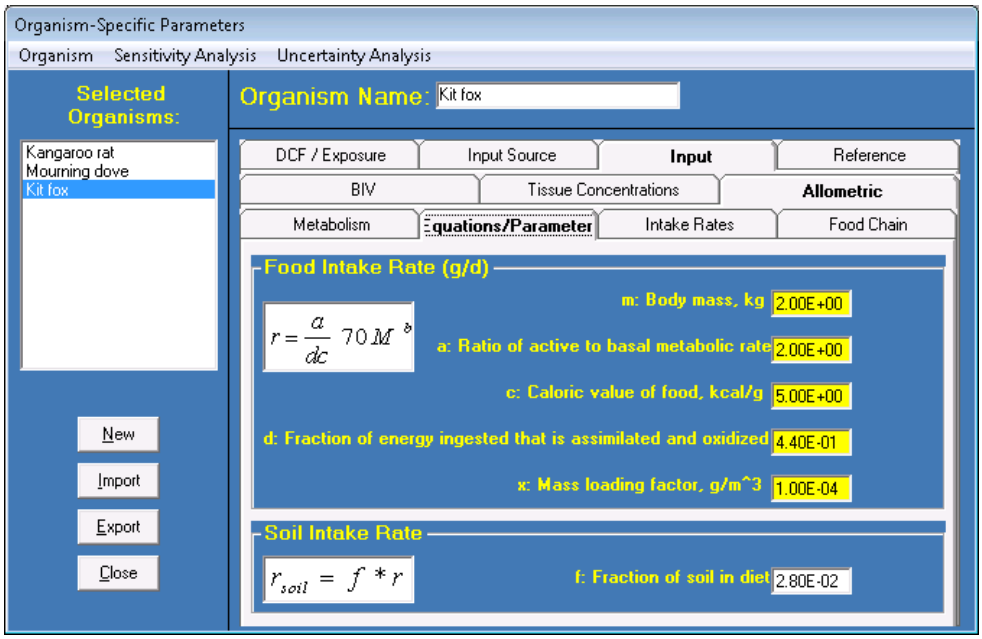
Mourning dove tissue conc. (Bq/kg) from different media (see tissue concentration report)					Media Conc.		Mourning dove Biv for Different Media	
Nuclide	water	Soil	sediment	Total	Water (Bq/m^3)	Soil (Bq/kg)	Water [(Bq/kg) per (Bq/L)]	Soil [(Bq/kg) per Bq/kg]
Am-241	2.52E-03	2.71E-02	0.00E+00	2.96E-02	370 (10)	37 (1)	6.80E-03	7.32E-04
Cs-137	1.45E+00	4.88E+01	0.00E+00	5.02E+01	740 (20)	185 (5)	1.96E+00	2.64E-01
Sr-90	3.37E+00	2.80E+02	0.00E+00	2.83E+02	555 (15)	129.5 (3.5)	6.07E+00	2.16E+00

(Note: Convert water conc. from Bq/m^3 to Bq/L to obtain Biv's with the correct unit)

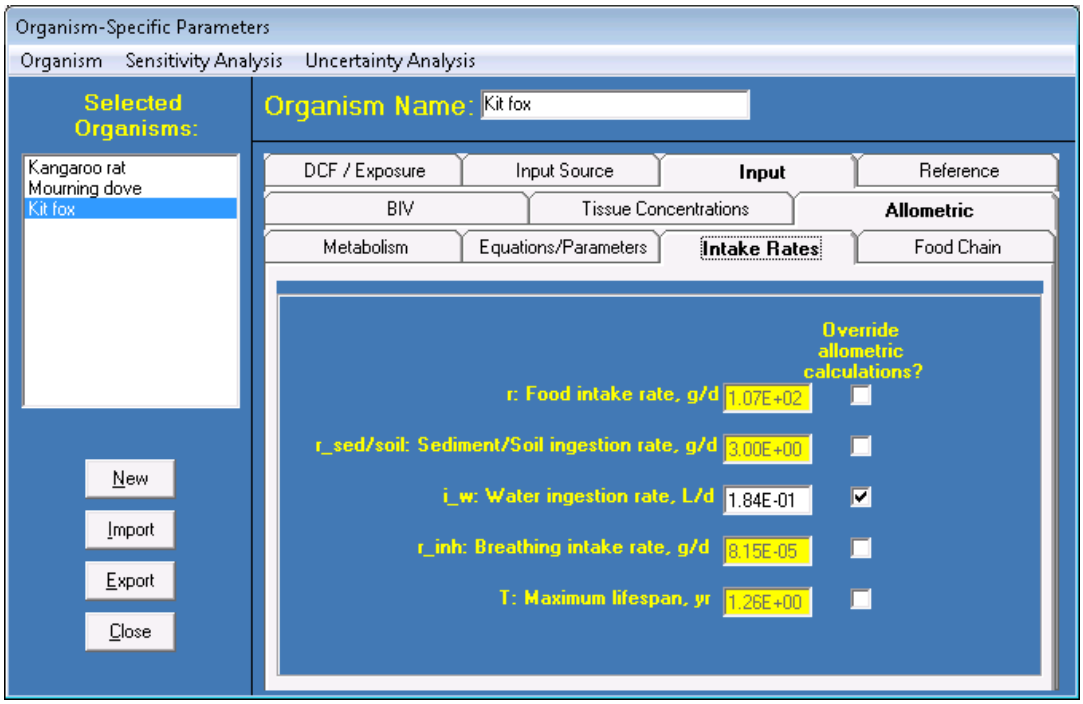
Tissue Concentration Calculations for Kit Fox

Change parameter values as shown in the following four screens –

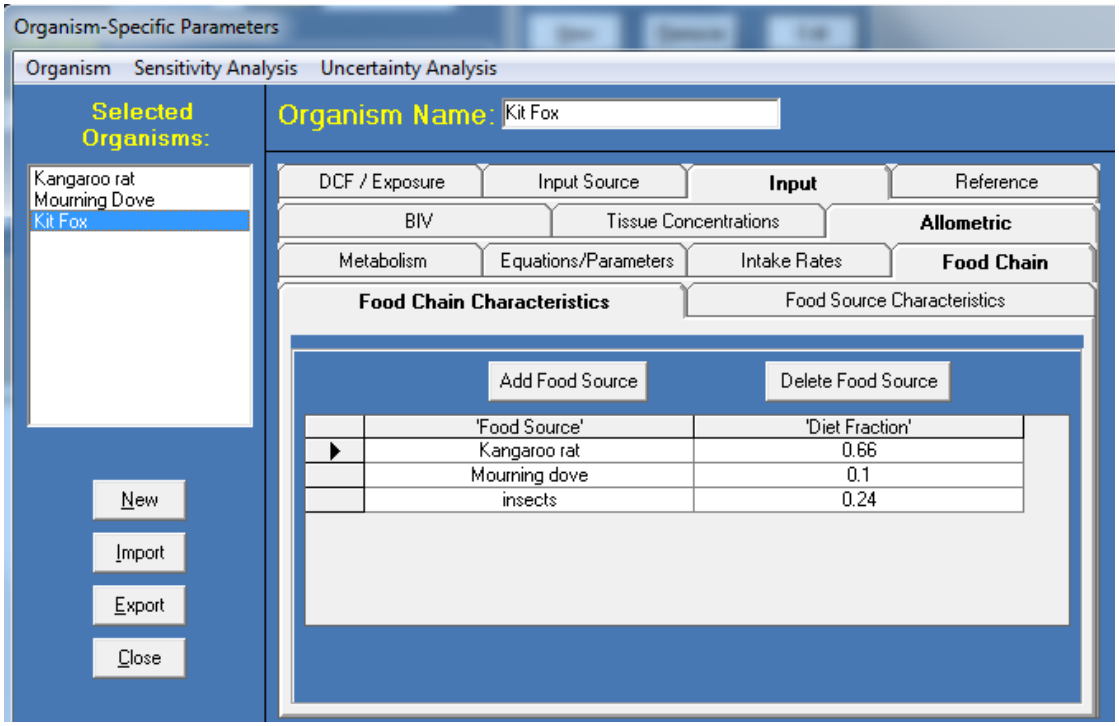
Fraction of soil in diet from Table 2



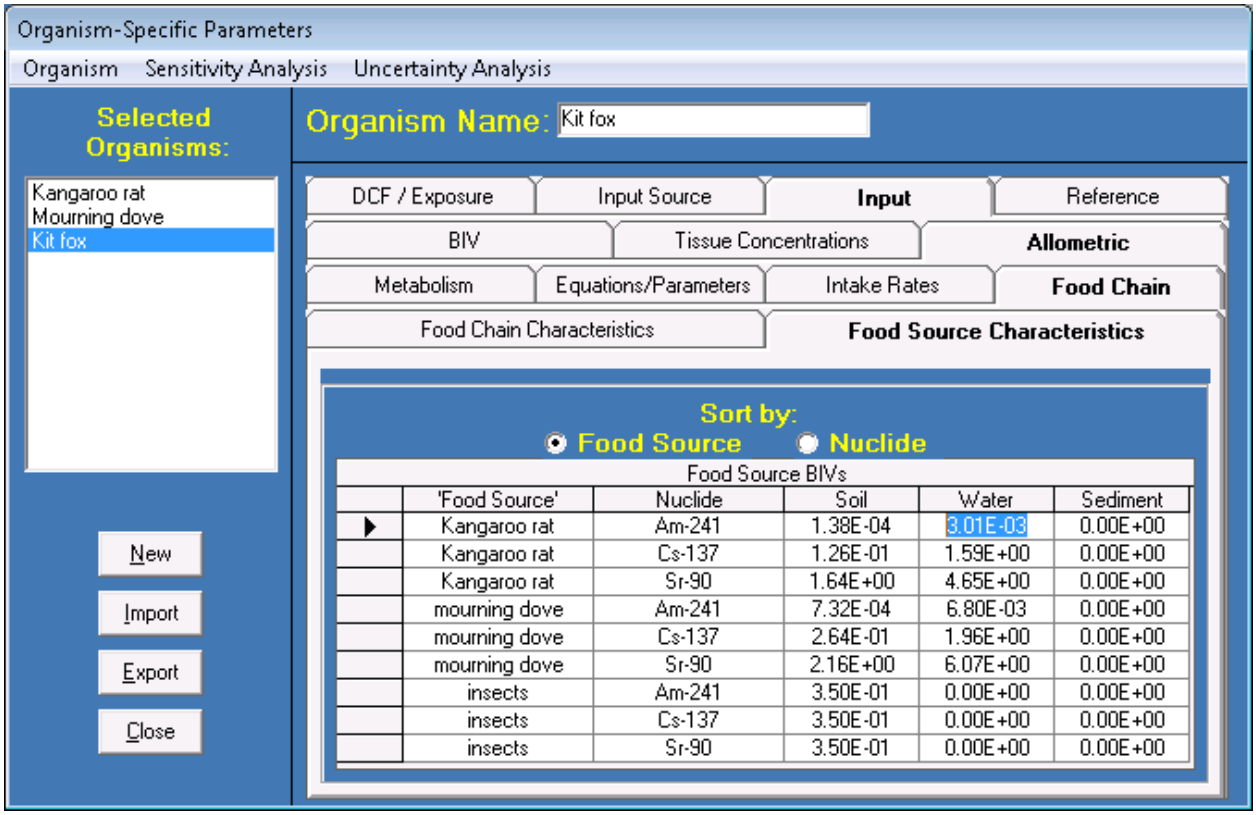
Water ingestion rate from Table 2



Diet fractions from Table 2



Food source Bivs from Table 3 and Table 4



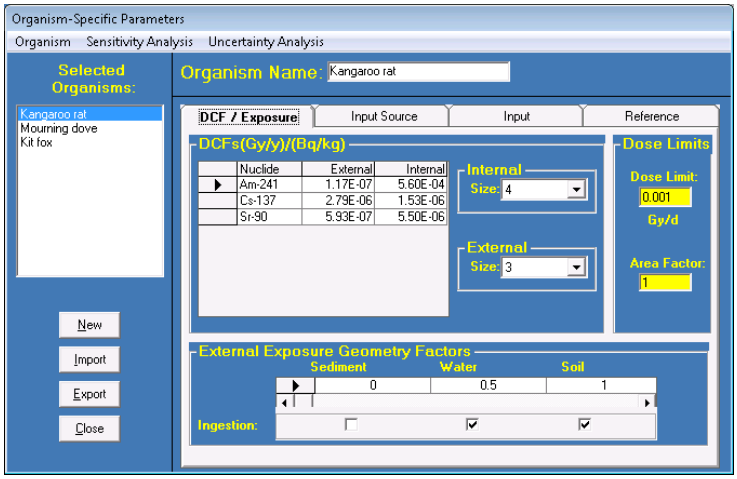
Run RESRAD-BIOTA and get the tissue concentrations for Kit fox from the Tissue Report (results are shown below) –

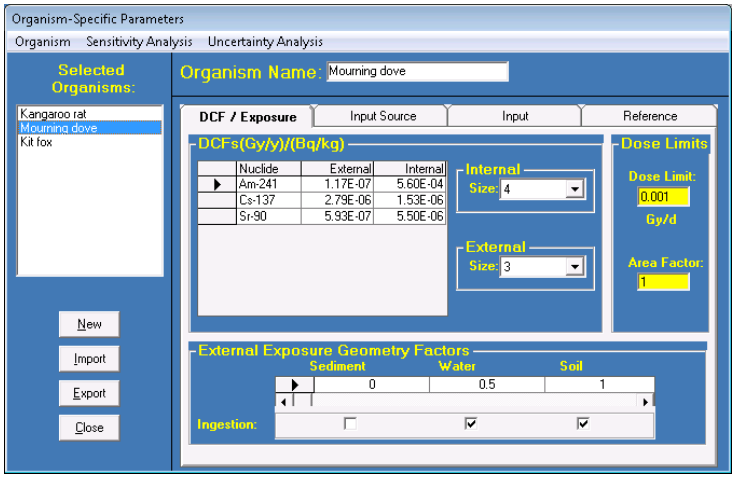
Tissue Concentration Report for Level 3 in Bq/kg

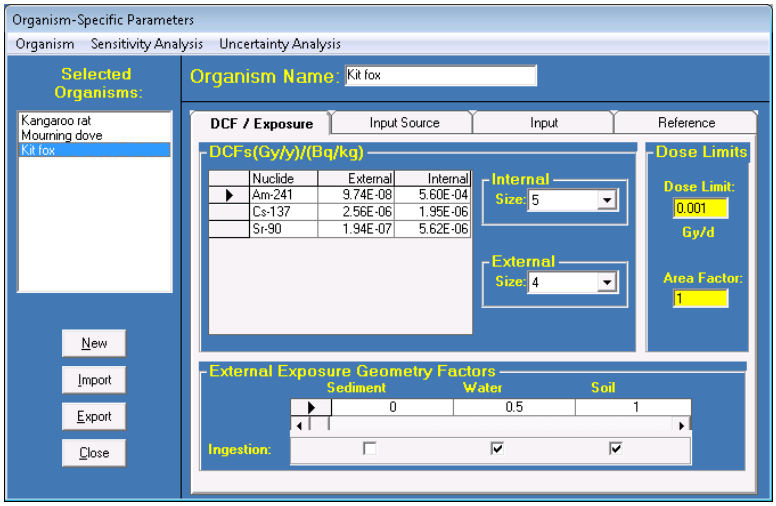
Title: Problem 7

Kit fox				
Nuclide	**water**	**Soil**	**sediment**	**Total(Tissue Conc)**
Am-241	1.06E-02	6.89E-02	0.00E+00	7.95E-02
Cs-137	3.68E+00	6.85E+01	0.00E+00	7.22E+01
Sr-90	1.78E+01	1.09E+03	0.00E+00	1.11E+03

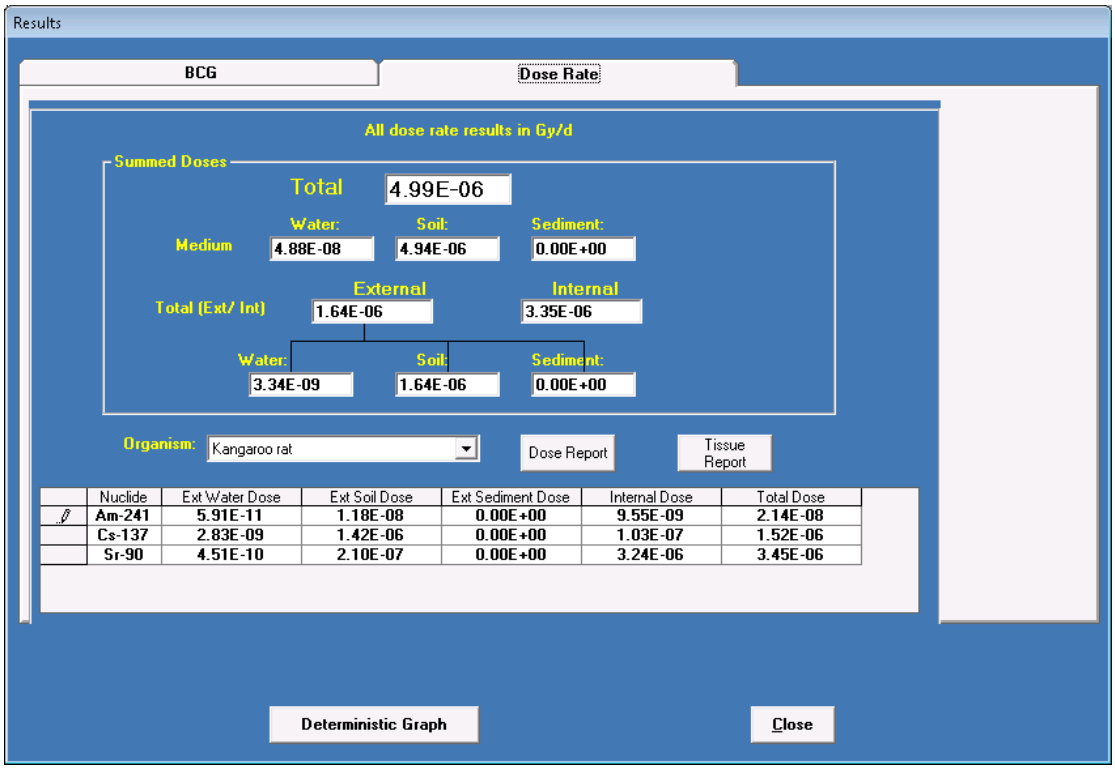
(2) Use conservative internal DCFs for internal dose calculations
(see the following three screens for conservative internal DCFs size selection) –

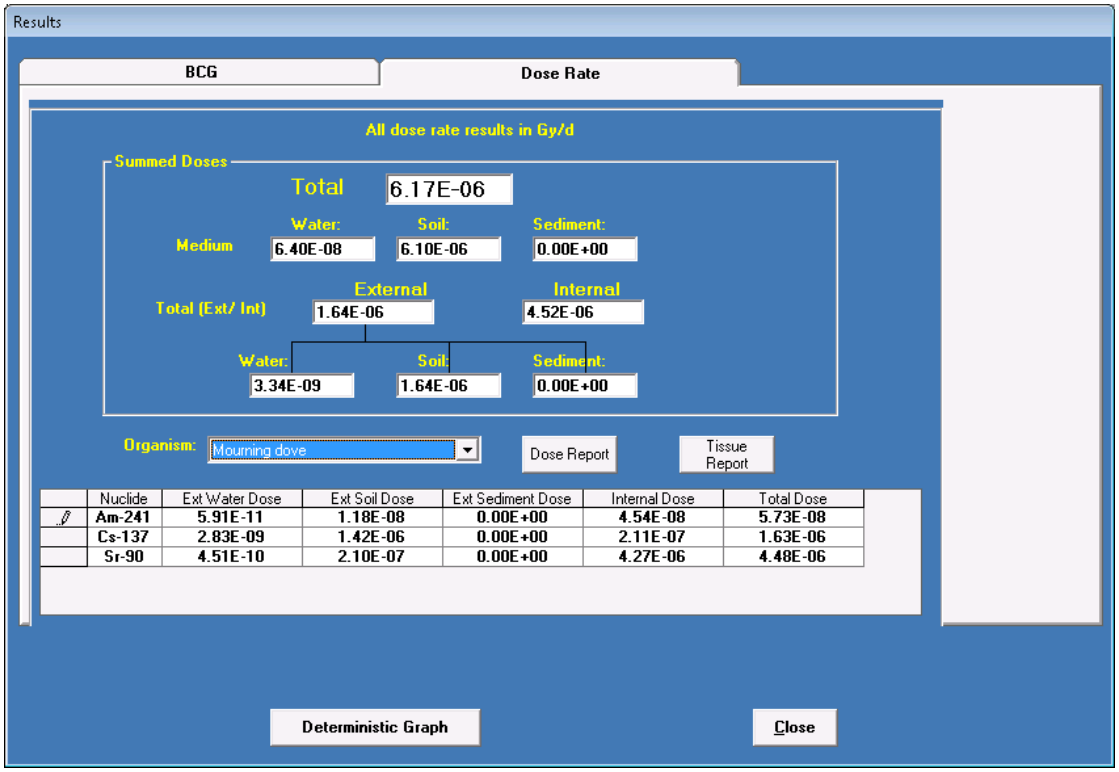


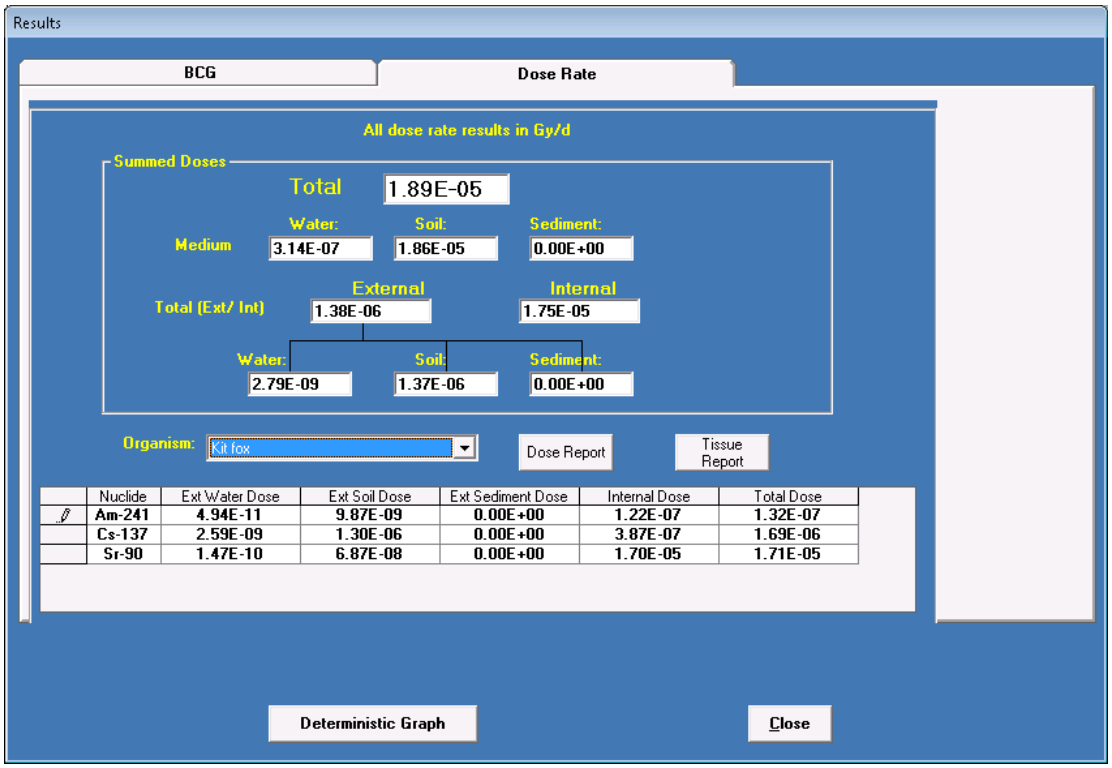




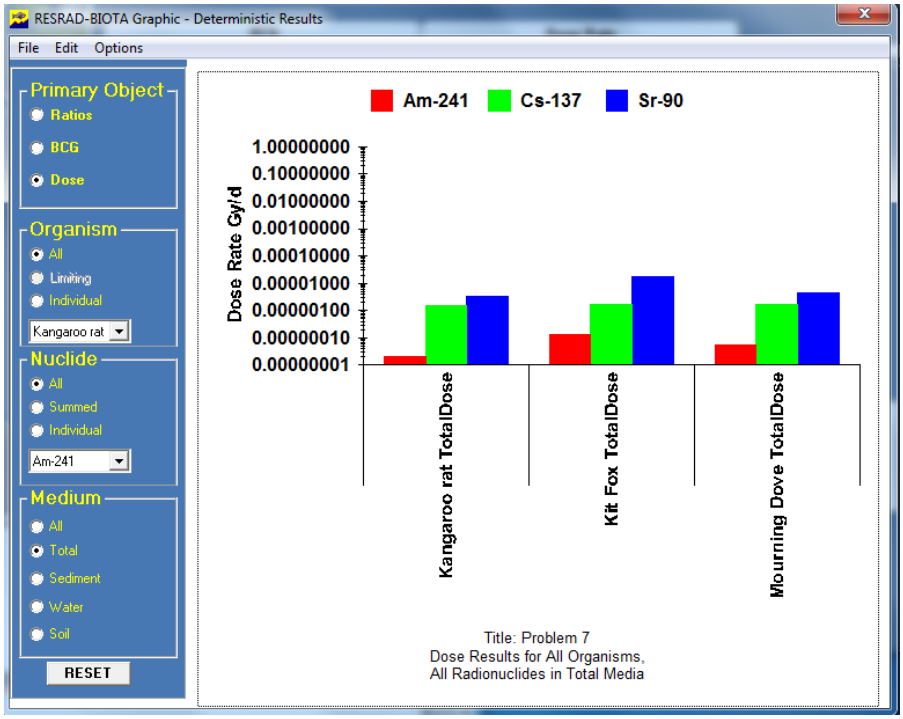
The following three screens show the calculated dose results –







(3) Use conservative external DCFs for external dose calculations and check the total dose rates in the deterministic graphics as well as in the dose report.



Dose Report for Level 3 in Gy/d

Title: Problem 7

Kangaroo rat												
Nuclide	External				Internal				Total			
	ext_Wtr	ext_Soil	ext_Sed	ext_Sum	int_Wtr	int_Soil	int_Sed	int_Sum	tot_Wtr	tot_Soil	tot_Sed	tot_Sum
Am-241	5.91E-11	1.18E-08	0.00E+00	1.19E-08	1.71E-09	7.84E-09	0.00E+00	9.55E-09	1.77E-09	1.97E-08	0.00E+00	2.14E-08
Cs-137	2.83E-09	1.42E-06	0.00E+00	1.42E-06	4.94E-09	9.79E-08	0.00E+00	1.03E-07	7.77E-09	1.51E-06	0.00E+00	1.52E-06
Sr-90	4.51E-10	2.10E-07	0.00E+00	2.11E-07	3.88E-08	3.20E-06	0.00E+00	3.24E-06	3.93E-08	3.41E-06	0.00E+00	3.45E-06
Summed	3.34E-09	1.64E-06	0.00E+00	1.64E-06	4.55E-08	3.30E-06	0.00E+00	3.35E-06	4.88E-08	4.94E-06	0.00E+00	4.99E-06

Mourning dove												
Nuclide	External				Internal				Total			
	ext_Wtr	ext_Soil	ext_Sed	ext_Sum	int_Wtr	int_Soil	int_Sed	int_Sum	tot_Wtr	tot_Soil	tot_Sed	tot_Sum
Am-241	5.91E-11	1.18E-08	0.00E+00	1.19E-08	3.86E-09	4.15E-08	0.00E+00	4.54E-08	3.92E-09	5.33E-08	0.00E+00	5.73E-08
Cs-137	2.83E-09	1.42E-06	0.00E+00	1.42E-06	6.09E-09	2.05E-07	0.00E+00	2.11E-07	8.92E-09	1.62E-06	0.00E+00	1.63E-06
Sr-90	4.51E-10	2.10E-07	0.00E+00	2.11E-07	5.07E-08	4.22E-06	0.00E+00	4.27E-06	5.12E-08	4.43E-06	0.00E+00	4.48E-06
Summed	3.34E-09	1.64E-06	0.00E+00	1.64E-06	6.07E-08	4.46E-06	0.00E+00	4.52E-06	6.40E-08	6.10E-06	0.00E+00	6.17E-06

Kit fox												
Nuclide	External				Internal				Total			
	ext_Wtr	ext_Soil	ext_Sed	ext_Sum	int_Wtr	int_Soil	int_Sed	int_Sum	tot_Wtr	tot_Soil	tot_Sed	tot_Sum
Am-241	4.94E-11	9.87E-09	0.00E+00	9.92E-09	1.63E-08	1.06E-07	0.00E+00	1.22E-07	1.63E-08	1.16E-07	0.00E+00	1.32E-07
Cs-137	2.59E-09	1.30E-06	0.00E+00	1.30E-06	1.97E-08	3.67E-07	0.00E+00	3.87E-07	2.23E-08	1.66E-06	0.00E+00	1.69E-06
Sr-90	1.47E-10	6.87E-08	0.00E+00	6.89E-08	2.75E-07	1.67E-05	0.00E+00	1.70E-05	2.75E-07	1.68E-05	0.00E+00	1.71E-05
Summed	2.79E-09	1.37E-06	0.00E+00	1.38E-06	3.11E-07	1.72E-05	0.00E+00	1.75E-05	3.14E-07	1.86E-05	0.00E+00	1.89E-05

> If the Tissue-Concentration option is selected (i.e., a tissue concentration was entered rather than a BIV value or allometric parameters in the organism 'input source' and 'input' tabs), then the internal dose to the organism from the radionuclide is calculated based on this concentration.

- This dose is not attributed to any media, i.e. it is listed in the dose table under the heading 'Int_Sum'.

- The external dose from each medium, calculated based on the user input media concentrations, are listed in the dose table under the headings for each medium (Water, Soil, or Sediment).

- The total external dose, ext_sum, is added into the total internal dose, int_sum (Tissue Concentration) to get the total dose which is reported under the heading 'tot_Sum'.

> If the tissue concentration input option is not used, then the calculated internal and external doses based on media concentrations are reported.

Hands-on Problem 8: Uncertainty Analysis (Including Modifications of Exposure Geometry, Area Factor, and RBE)

Background –

A large lake is located near a uranium mining facility. Over the years, surface runoff from the facility has flowed to the lake and contaminated the water. Perform a probabilistic analysis using the RESRAD-BIOTA code to evaluate the potential impacts to the aquatic organisms living in the lake, including benthic fish, pelagic fish, and frogs.

As part of the environmental monitoring program, water and sediment samples from the lake are routinely collected for contamination analysis. Table 1 lists the radionuclide concentrations measured with the collected samples.

Use the following information for your analysis; if information on a parameter is not provided, use the default value – alpha RBE = 10, cutoff half-life = 180 days, number of observations =100, and sampling repetition = 3.

Table 1 Radionuclide Concentration in Water and Sediment Samples

Radionuclide	Mean water concentration (Bq/m^3)	Mean sediment concentrations (Bq/kg)
Pb-210	55	1.45E4
Po-210	35	1.38E4
Ra-226	95	2.85E3
Th-230		1.08E3
U-238	6450	1.75E5

Table 2 Distributions of Water Biv's for Fish

Element	Distribution	Lambda	Mean	Error Factor	Min	Max
Pb-210	Exponential	3.33E-03	300			
Po-210	Exponential	4.17E-03	240			
Ra-226	Bounded Lognormal		80	6.5	0.3	810
Th-230	Bounded Lognormal		110	4	15	560
Uranium	Bounded Lognormal		30	8.95	0.3	200

Table 3 Mass and Occupancy Factors

Species	Mass (g)	Occupancy		
		Away	Inside water	Sediment-water interface
Pelagic Fish	1200	0%	75%	25%
Benthic Fish	1191	0%	30%	70%
Frog	12	25%	25%	50%

Questions –

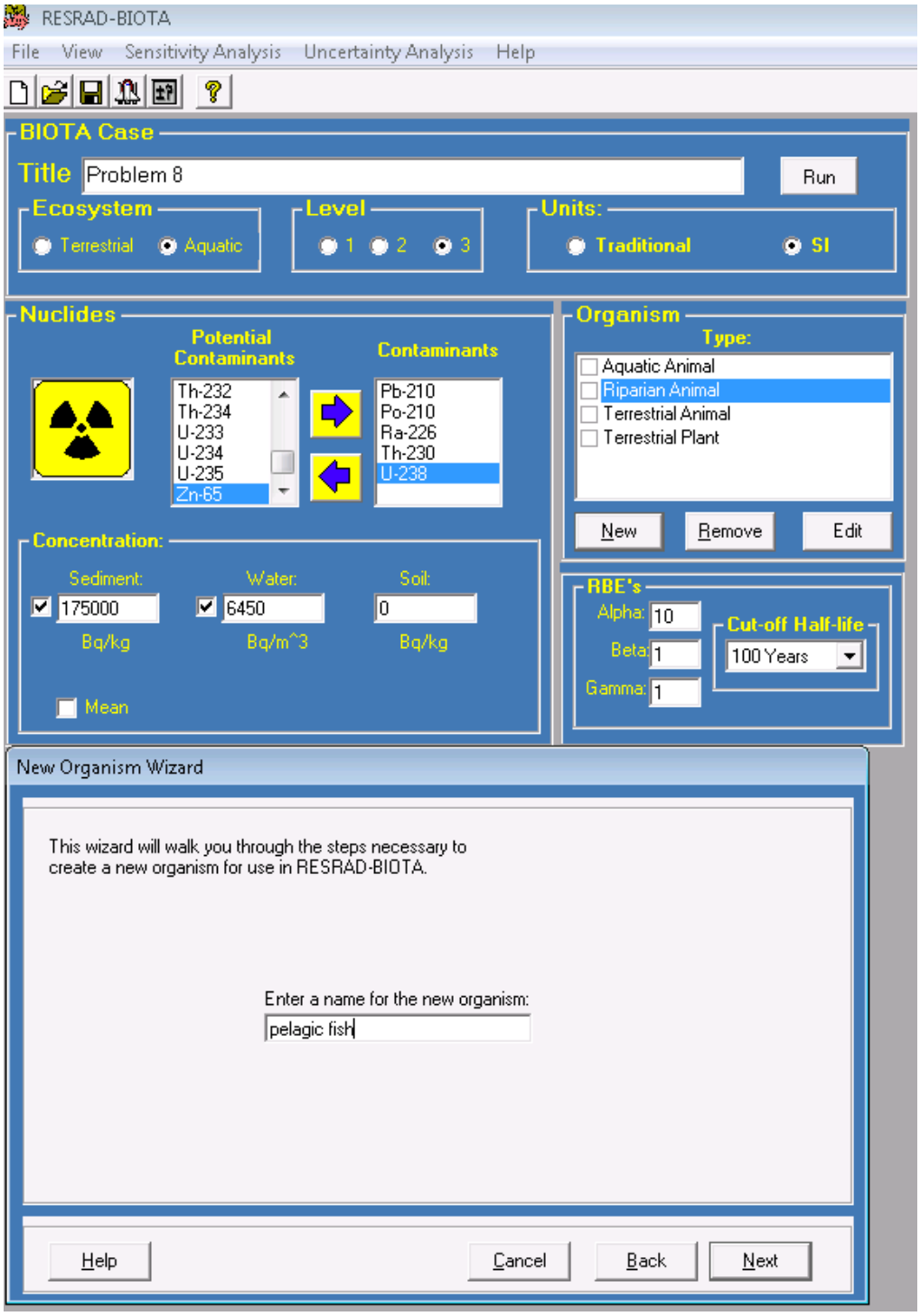
(1) Calculate the radiation doses for pelagic fish, benthic fish, and frog with a deterministic analysis.
(2) Calculate the mean, 75%, and 90% tissue concentrations for pelagic fish.
(3) Calculate 90% total water and sediment dose rates, respectively, for benthic fish.
(4) Calculate mean and 95% total dose for fish species. Explain the difference in dose rates.

Answers –

First set up the analysis with the following selections –
Title – Problem 8,
Ecosystem – Aquatic,
Level – 3,
Units – SI,
Cut-off Half-Life = 180 days, and
Alpha RBE = 10.

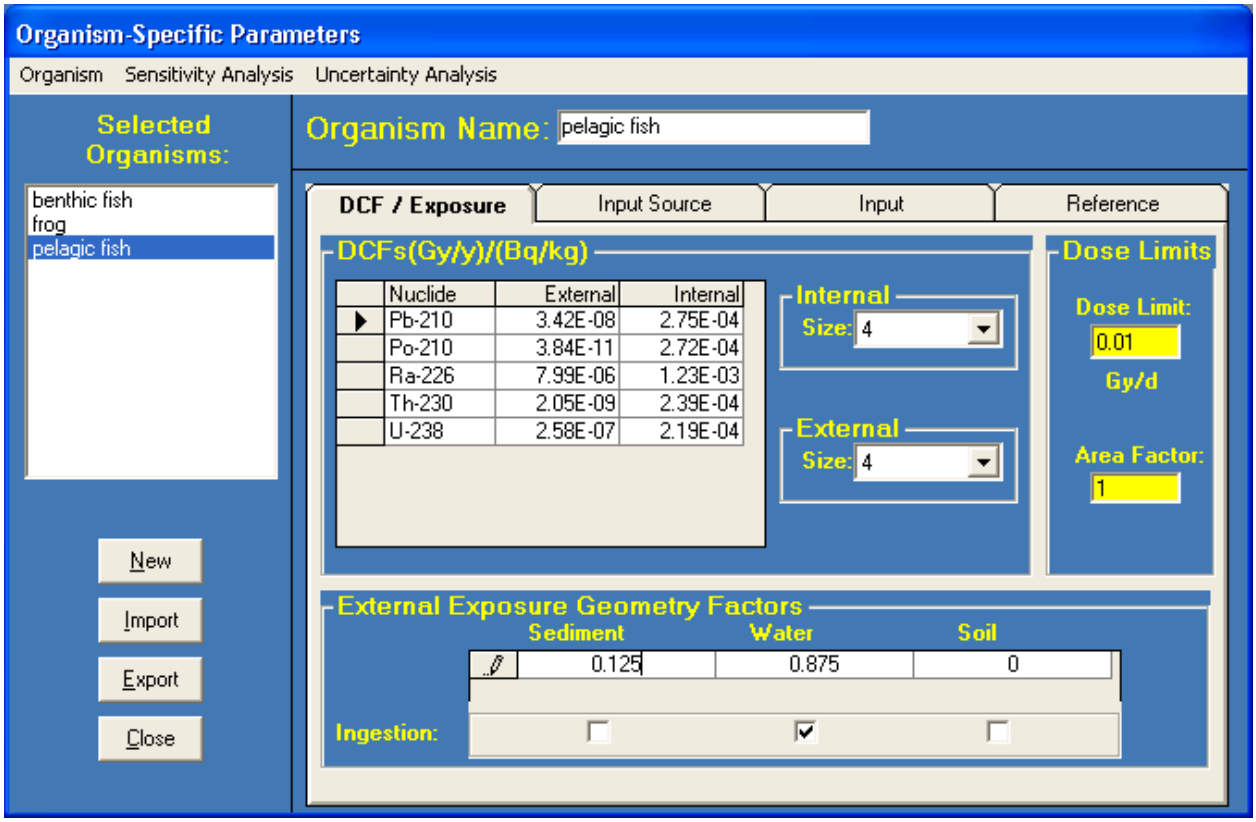
Select the 5 radionuclides of concern - Po210, Pb-210, Ra-226, Th-230, and U-238, and input the measured sediment and water concentrations from Table 1. For Th-230, measured water concentration is not provided; use the default Kd to estimate an equilibrium water concentration based on the measured sediment concentration. (Pay attention to the units!)

Create a new species "pelagic fish," using the organism wizard

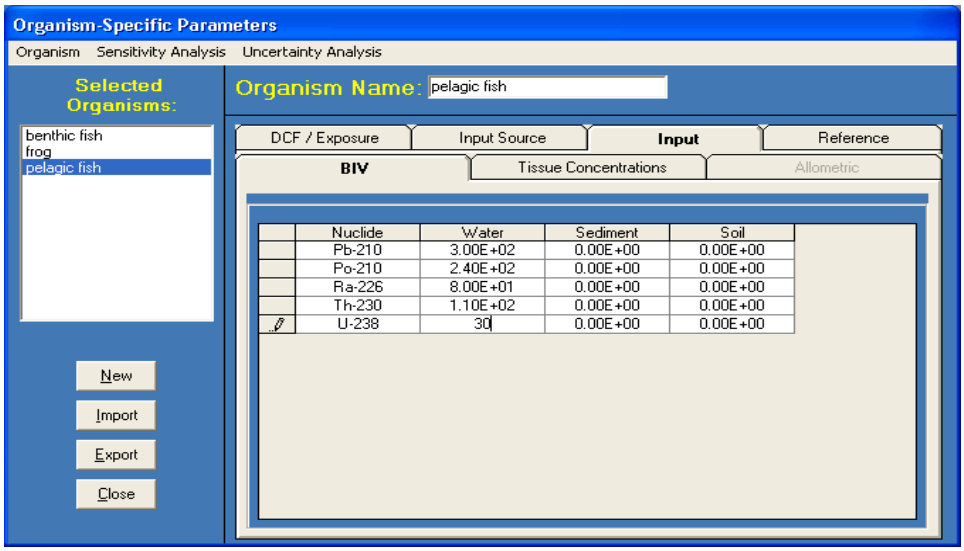


Select the appropriate geometry based on the mass of the organism as provided in Table 3. Select “Generic Aquatic Animal” to generate a template for input parameters. Change “External Exposure Geometry Factors” based on the occupancy factors provided in Table 3. The following screen shows the input values –

Input screen for external exposure geometry factors for pelagic fish -



Enter the mean Biv values from Table 2.

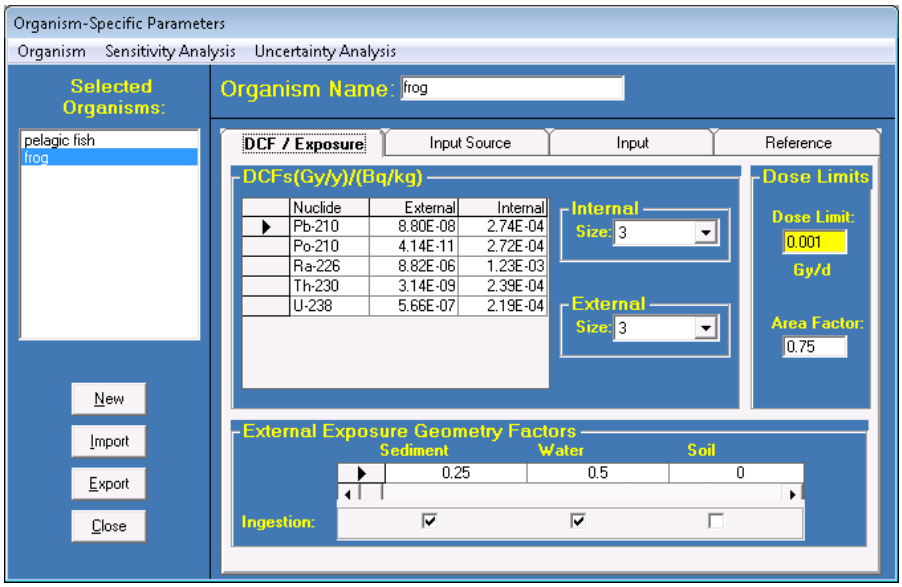


Create new species "frog" using the organism wizard

Select an appropriate geometry based on the mass of the organism as provided in Table 3. Choose “Generic riparian animal” to generate a template for input parameters.

Change “External Exposure Geometry Factors” and “Area Factor” based on the occupancy factors provided in Table 3. Use the RESRAD-BIOTA default Biv values for water and sediment. The following screen shows the input values –

Input screen for changing external exposure geometry factors for frog -

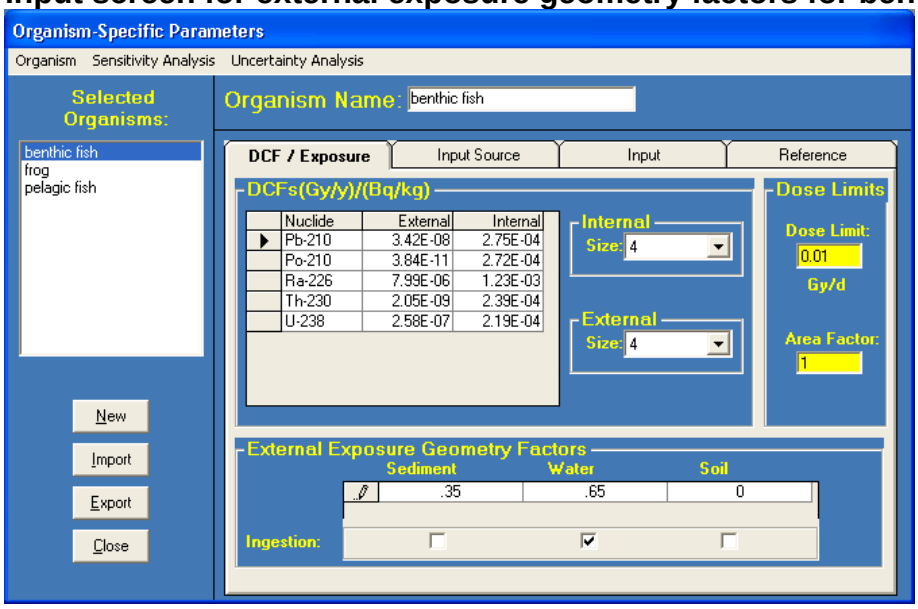


(What is the difference if “Generic aquatic animal” was selected to generate an input template?)

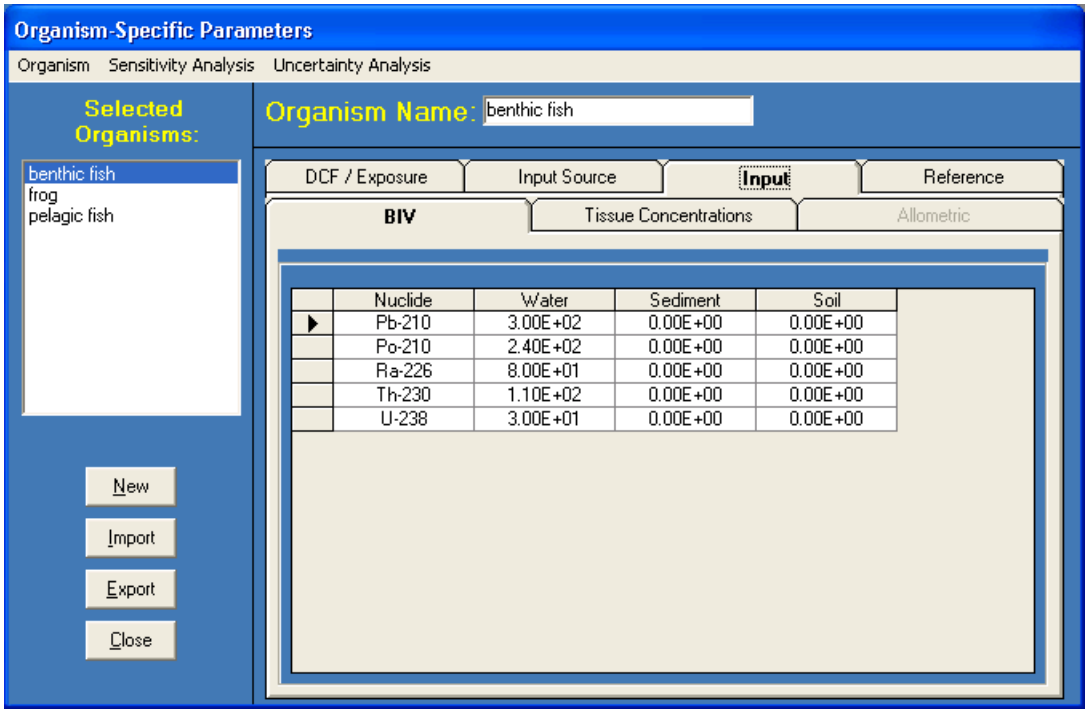
Create new species "benthic fish" using the organism wizard

Select an appropriate geometry based on the mass of the organism as provided in Table 3. Select “Generic Aquatic Animal” to generate a template for input parameters. Change “External Exposure Geometry Factors” based on the occupancy factors provided in Table 3.

Input screen for external exposure geometry factors for benthic fish -



Use the mean Biv values from Table 2.

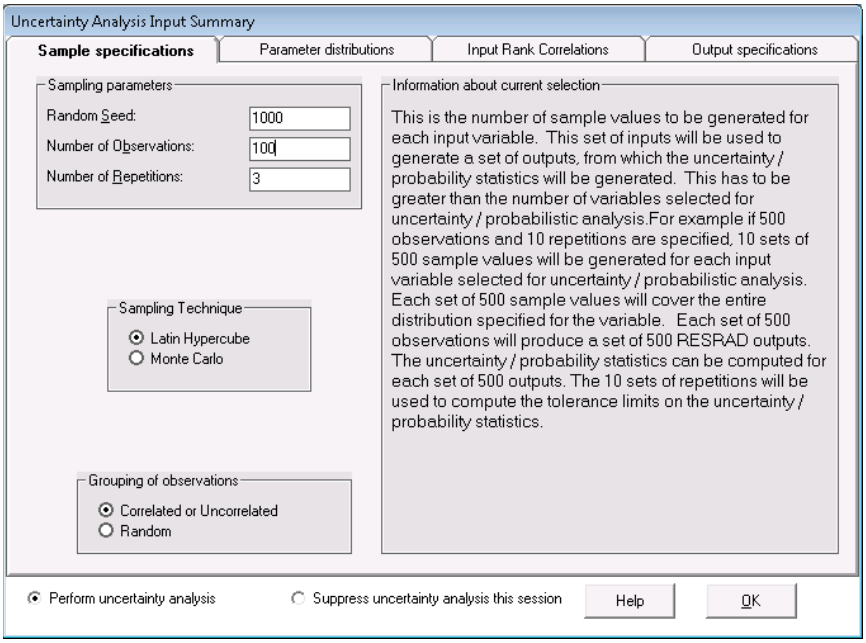


Run the RESRAD-BIOTA code. Obtain the dose rates for pelagic fish, frog, and benthic fish, respectively.

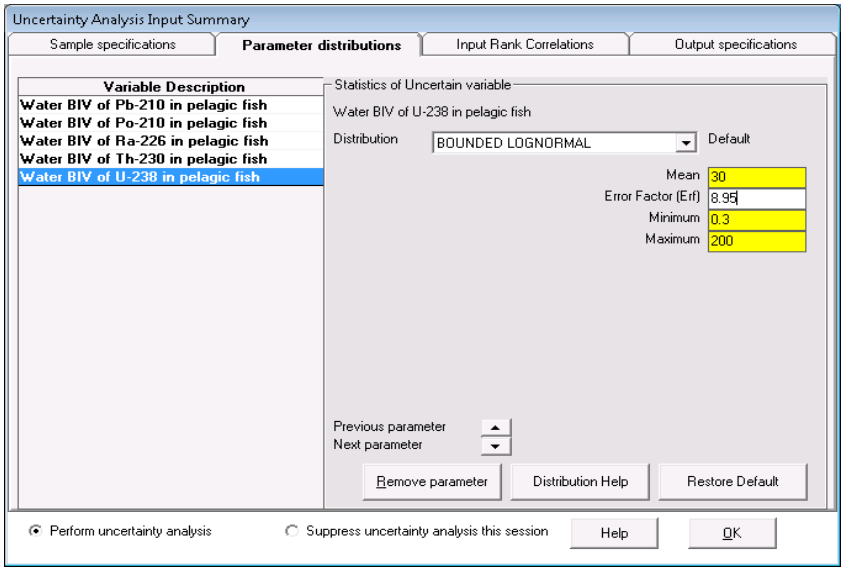
Total dose rate for benthic fish = 2.27E-4 Gy/d
Total dose rate for frog = 9.59E-4 Gy/d
Total dose rate for pelagic fish = 1.85E-4 Gy/d

(2) Select water Biv for each radionuclide for pelagic fish and press F8 or click "uncertainty analysis." Change the number of observations to100. Select the distribution function and enter the distribution parameters as provided in Table 2. The following two screens show the input parameter values –

Uncertainty analysis input summary screen - change number of observations –



Parameter distributions for water Biv values for pelagic fish –



Uncertainty Analysis Results - Pelagic fish tissue concentrations

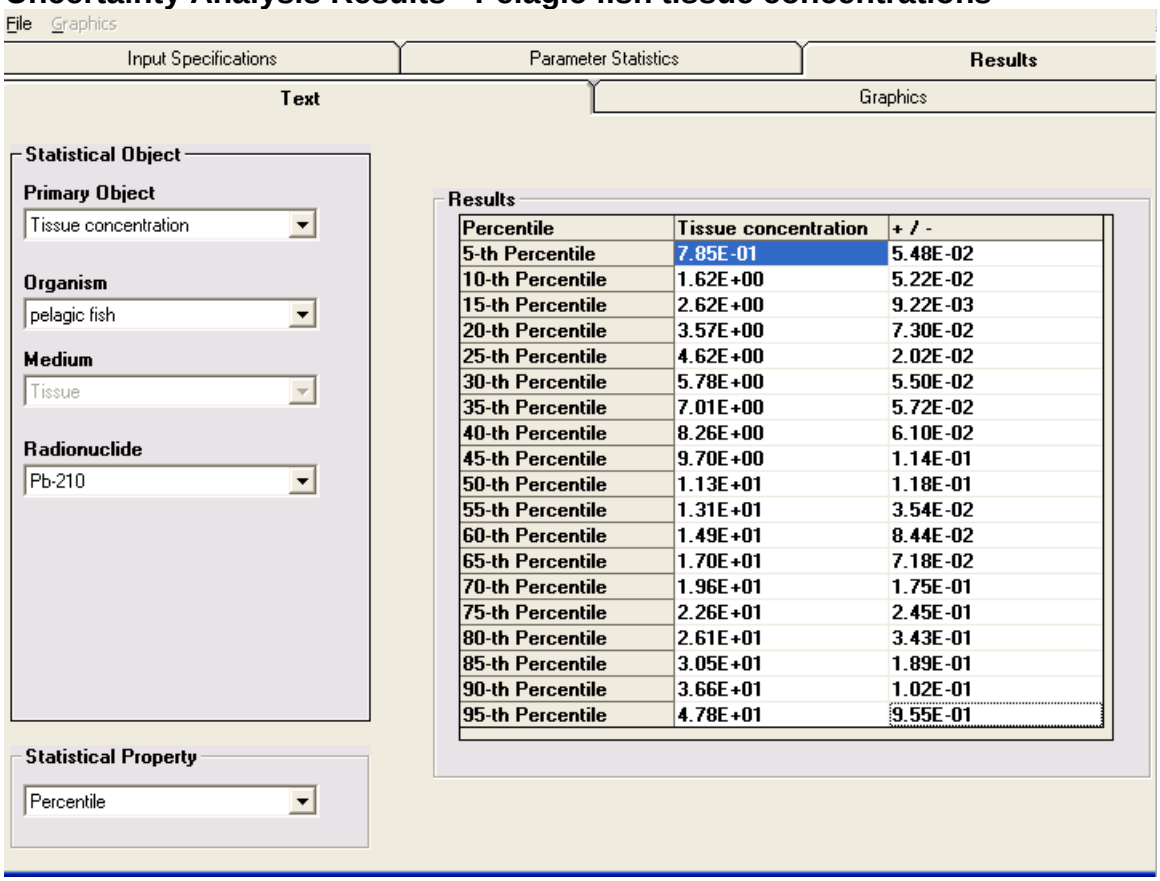


Table 4 provides the calculated mean, 75%, 90% tissue concentrations for pelagic fish.

Table 4 Predicted Tissue Concentrations (Bq/kg) at Different Percentiles in Pelagic Fish Species

Contaminant	Concentration (Bg/kg) at mean	Concentration (Bg/kg) at 75%	Concentration (Bg/kg) at 90%
Pb-210	16.4 ± 0.13	22.6 ± 0.25	36.6 ± 0.10
Po-210	8.37 ± 0.15	11.6 ± 0.11	18.9 ± 0.088
Ra-226	7.13 ± 0.15	8.33 ± 0.11	16.3 ± 0.43
Th-230	1.91 ± 0.015	2.41 ± 0.016	3.88 ± 0.020
U-238	153 ± 1.3	182 ± 1.6	378 ± 4.25

(3) Select water Biv for each contaminant for Benthic fish and press F8 or click "Uncertainty analysis." Select the distribution function and enter the distribution parameters as provided in Table 2. Run the RESRAD-BIOTA code. In the uncertainty analysis result screen, select "Dose" for the primary object, "water" for medium, and note the dose at 90th-percentile for each radionuclide.

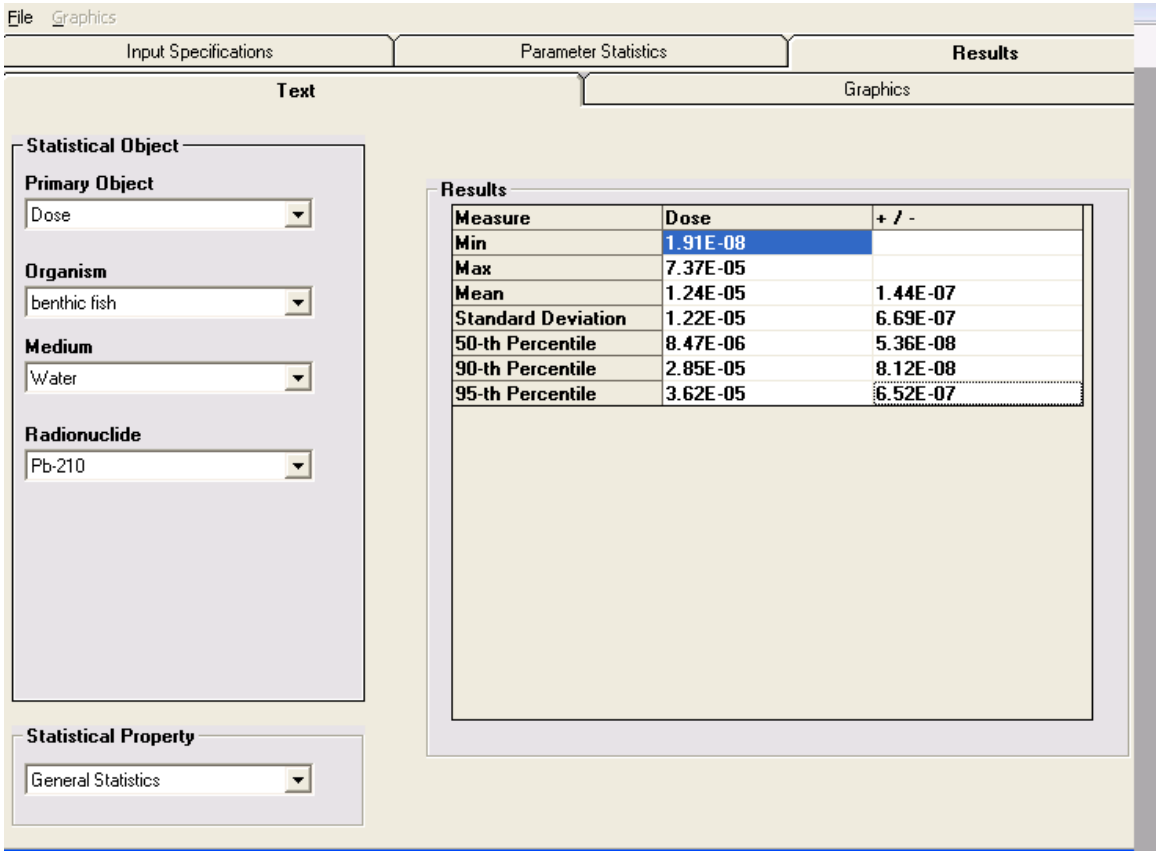


Table 5 list 90% water and sediment dose rates from the probabilistic analysis.

Table 5 Water and Sediment dose rates (Gy/d) at 90% for Benthic Fish

Results	Pb-210	Po-210	Ra-226	Th-230	U-238	Total
90% water dose rate	2.85E-5	1.42E-5	5.46E-5	2.55E-6	2.31E-4	2.73E-4
90% sediment dose rate	4.76E-7	5.08E-10	2.18E-5	2.12E-9	4.32E-5	6.56E-5

The calculated dose for the water medium shows some distribution; while the calculated dose for the sediment medium does not, i.e. the mean, 50%, 90%, and 95% values are the same. Why?

Tables 6 and 7 provide mean and 95% total dose rates for Benthic and Pelagic fish, respectively.

Table 6 Total Dose Rates (Gy/d) for Benthic Fish						
Results	Pb-210	Po-210	Ra-226	Th-230	U-238	Total
Mean	1.295E-5	6.27E-6	4.56E-5	1.26E-6	1.35E-4	2.02E-4
95%	3.67E-5	1.85E-5	1.03E-4	3.33E-6	3.71E-4	4.77E-4

Table 7 Total Dose Rates (Gy/d) for Pelagic Fish						
Percentile	Pb-210	Po-210	Ra-226	Th-230	U-238	Total
Mean	1.25E-5	6.25E-6	3.19E-5	1.25E-6	1.07E-4	1.59E-4
95%	3.61E-5	1.81E-5	8.67E-5	3.24E-6	3.57E-4	4.12E-4

The difference in the dose rates between benthic fish and pelagic fish is due to the difference in the external exposure geometry factors.