SNAP/RADTRAD Exercise 5:

Loss of Coolant Accident (LOCA)

Loss of Coolant Accident Overview

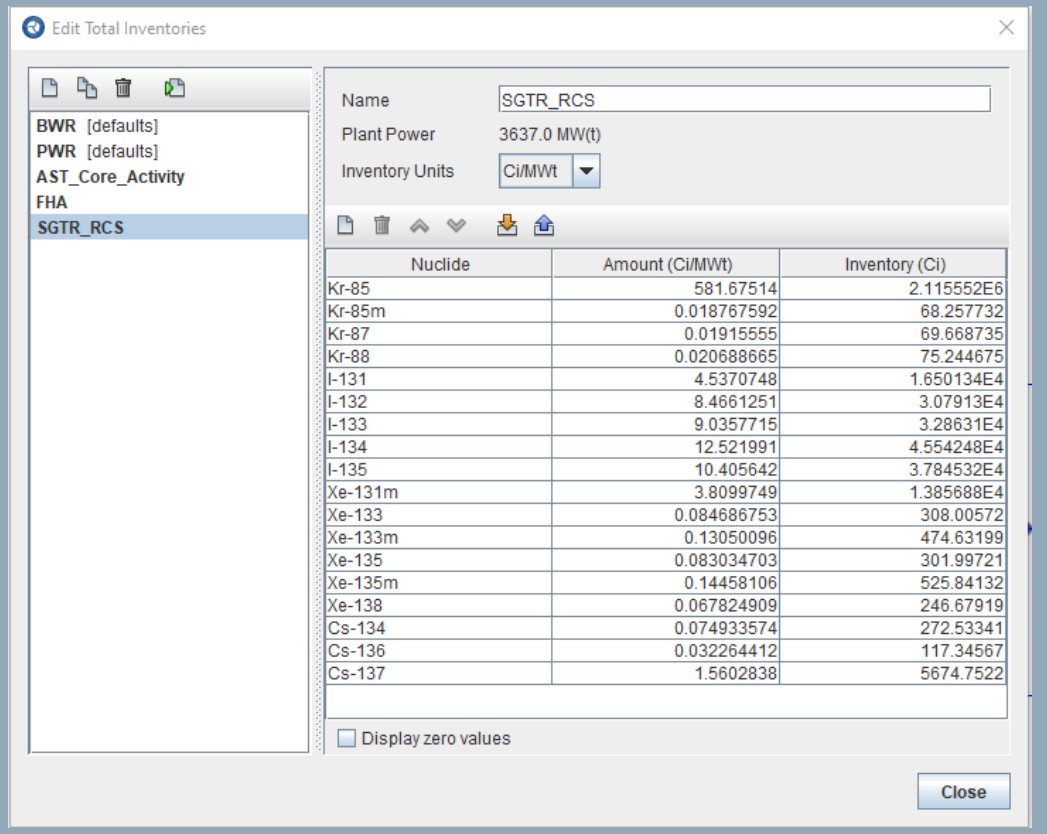
- An abrupt failure of the main reactor coolant pipe is assumed to occur. Activity from the reactor coolant system (RCS) is released to containment and a portion of this activity is released to the environment through the following pathways:
  - The mini-purge system prior to containment isolation
  - An assumption is made that the emergency core cooling systems (ECCS) fails to prevent the core from significant damage and activity is released from the core to the containment then to the environment.
  - Once circulation of the ECCS is established, iodine activity in the sump solution may be released to the environment by means of leakage from engineered safety featured (ESF) equipment outside containment in the auxiliary building.
  - Leakage from the ESF to the refueling water storage tank (RWST) with subsequent leaking or venting.

Step 1: Preliminary Setup

- You should have Exercise 3 (REA) open in your Model Editor
- In the Navigator Window, select “Model Options”
- Change the Title to “LOCA_simple”
- Select the job stream in the Navigator Window and change the “Name” to “LOCA_simple”
- Change the “Relative Location” in your job stream
  - Consider changing the location to “LOCA_simple” in order to prevent the files from the previous exercise from being overwritten
- Save the model as “LOCA_simple.med”
- **NOTE: If provided, ExerciseData spreadsheet includes all table values that can be copied and paste into model editor.**

Step 2: Importing SGTR_RCS Nuclide Inventory

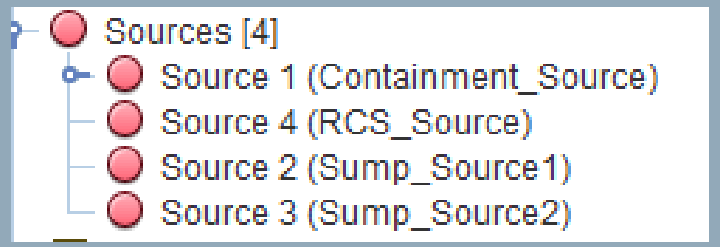
- Click on Nuclide Data then expand box ( ) next to Total Inventories
- Click on the icon to create a new inventory, and rename it to SGTR_RCS
- Next, click on the icon and select the SGTR_RCS.icx inventory created in the last exercise.
- The image shows what the values should be for the SGTR_RCS inventory.
- If a bunch of nuclides with 0 values is present, make sure to check the box: Display zero values



Step 3: Source Creation

- A total of 4 sources will need to be created.
- The AST Core Activity inventory will be used for the sources for the containment, ECCS leakage (sump_source1), and the RWST leakage (sump_source2).
- The SGTR_RCS inventory will be used to create an RCS source.
- Right-click on Source 1 (FHA Source) and select copy. Then, right-click on the white space in the view window and select paste. Repeat this process until you have 4 sources.
- Rename the Sources to Containment_Source, Sump_Source1, Sump_Source2, and RCS_Source.
- The component numbers must be changed so they are in sequential order as well (i.e., a source should be component 1, another should be 2, etc.

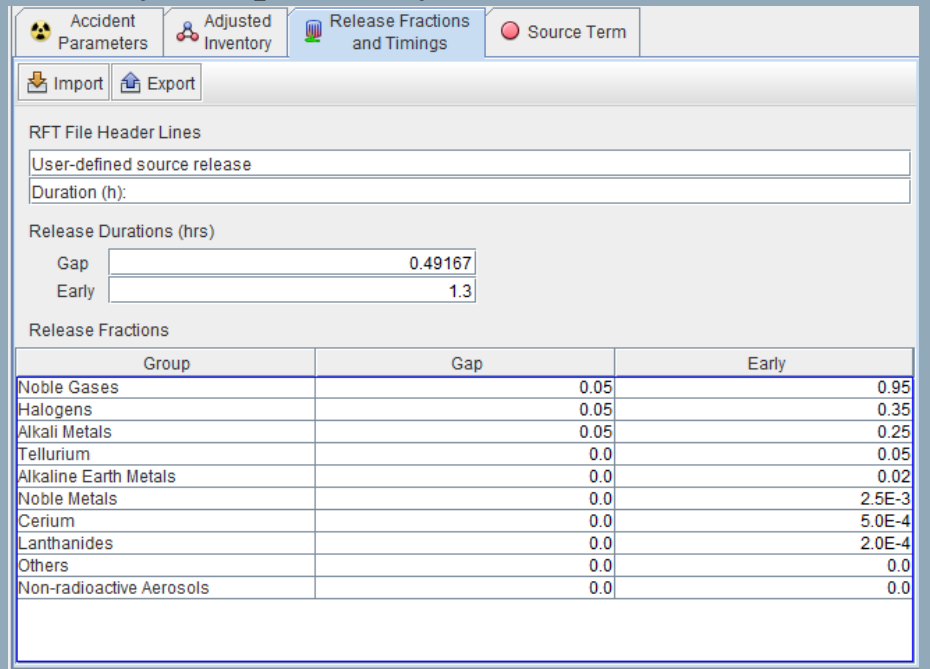
- Your sources should look like the image, the order and component numbers may differ.



Step 3: Source Creation (cont.)

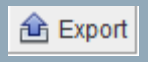
- The Source Scenarios for all of the Sources will need to be created as well.
- Select the Containment_Source and expand the Source Scenarios tab.
- Select the icon to create a new scenario and select the AST_Core_Activity inventory created in a previous exercise.
- Press OK and rename the Scenario Name to Containment_Source and press enter.
- Make sure the drop-down options for Active Scenario and Accident Types are set to Conatinment_Source and Use Total Inventory, respectively.

- Go to the Release Fractions and Timings tab and fill out the information using the image.



Group	Gap	Early
Noble Gases	0.05	0.95
Halogens	0.05	0.35
Alkali Metals	0.05	0.25
Tellurium	0.0	0.05
Alkaline Earth Metals	0.0	0.02
Noble Metals	0.0	2.5E-3
Cerium	0.0	5.0E-4
Lanthanides	0.0	2.0E-4
Others	0.0	0.0
Non-radioactive Aerosols	0.0	0.0

Step 3: Source Creation (cont.)

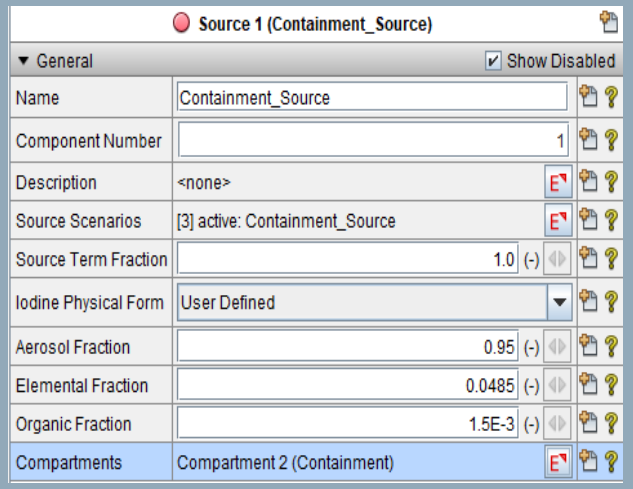
- All the sources will use the same Release Fractions and Timings data. So, we can export this data by pressing the 

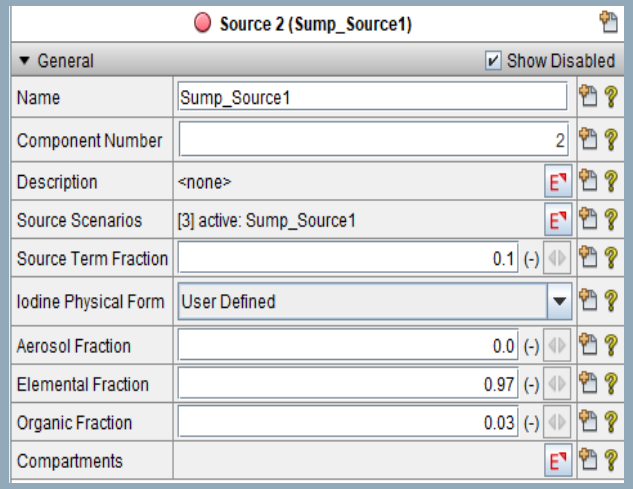
icon. Then you will want to save it as ReleaseFraction.srx. The .srx file extension is needed in the name.
- The same process will need to be repeated for the other 3 sources with the following exceptions:
  - The Release Fractions and Timings data can be imported by click the 

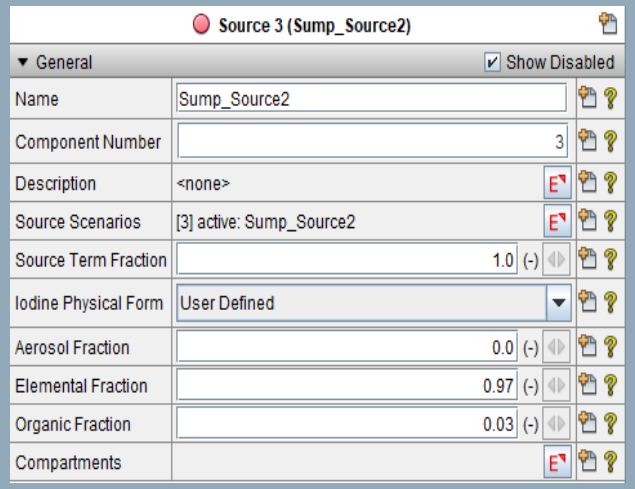
icon and selecting the ReleaseFraction.srx we created.
  - The inventory for the RCS_Source will be the SGTR_RCS inventory we uploaded previously. The two sump sources will have the AST_Core_Inventory like the Containment_Source.

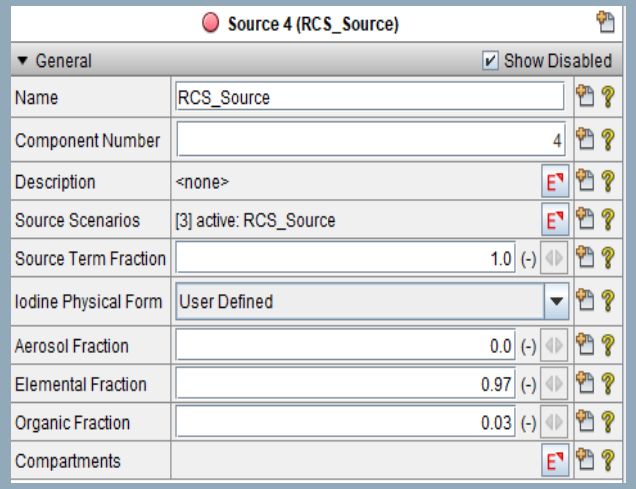
Step 3: Source Creation (cont.)

- After the Source Scenarios are completed, the Source Term Fractions, Aerosol Fractions, Elemental Fractions, and Organic Fractions of the sources need to match the picture below.
- NOTE: the Compartments that the sources are connected to will be added later and my differ for now.









Step 4: Flow Pathways

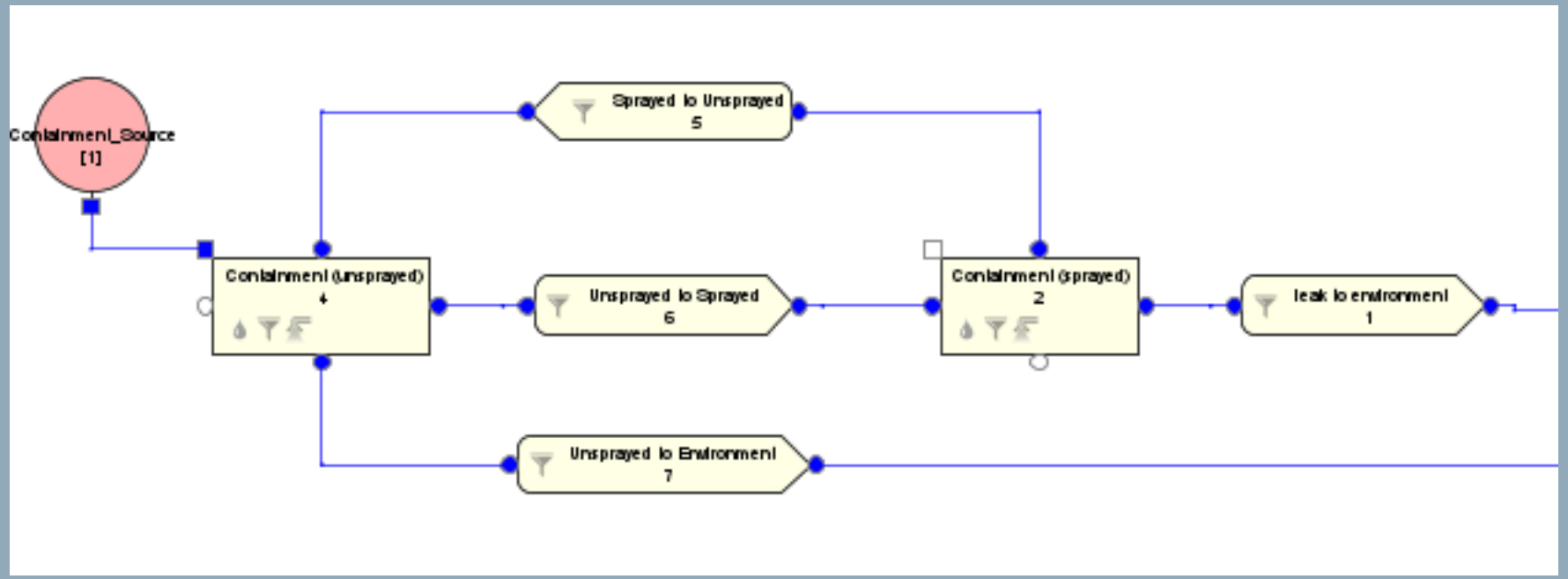
- The model will require the following 4 release pathways:
  - **Containment Leakage Pathway:** Models all activity released from the fuel to go into the unsprayed portion of containment before being mixed with the sprayed portion of the containment.
  - **ECCS Leakage Pathway:** Assumes all iodine activity released from the fuel is in the sump solution immediately. The only removal of activity from the sump is by radioactive decay or leakage to the auxiliary building. When ECCS recirculation is established following the LOCA, leakage is assumed to occur from ESF equipment in the auxiliary building. Recirculation is modeled to initiate at the start of the event and continues throughout the event.
  - **RWST Back-Leakage Pathway:** A portion of the ECCS recirculation is assumed to leak into the RWST. All iodine activity released form the fuel is assumed to be in the sum solution immediately.
  - **Containment Purge Release Pathway:** All the initial primary coolant activity is instantly released from the RCS and is evenly distributed throughout the containment volume.

Step 4.1: Containment Leakage Pathway

- The environment to control room block will not be changed and can be moved out of the way for now. Do this by highlighting all the components (Environment, Control room, and the 3 flows) and moving them to the side.
- If there isn't enough space in the view window, click on the white space and increase the Canvas size. For this example, the width was increased to 2500, and the control room block was moved to the right.
- Then we are going to need two containment compartments and 2 filtered and 2 air leakage pathways for this flow path.
- The containment and the leak to environment flow path can be used. The containment will need to be renamed to Containment (sprayed).
- Create another compartment and rename it to Containment (unsprayed)
- Create 2 filtered flow pathways named Sprayed to Unsprayed, Unsprayed to Sprayed, and 1 air leakage pathway named Unsprayed to Environment.

Step 4.1: Containment Leakage Pathway

- Once all those components have been created, use the image to setup the connections using the connection tool ( ). Any unwanted connections can be removed by selecting the selection tool ( ), selecting the blue line, then pressing Delete.
- NOTE: the 3 other Sources are not included in this image but should be in the view and the pathways Leak to Environment and Unsprayed to Environment are connected to the Environment compartment.



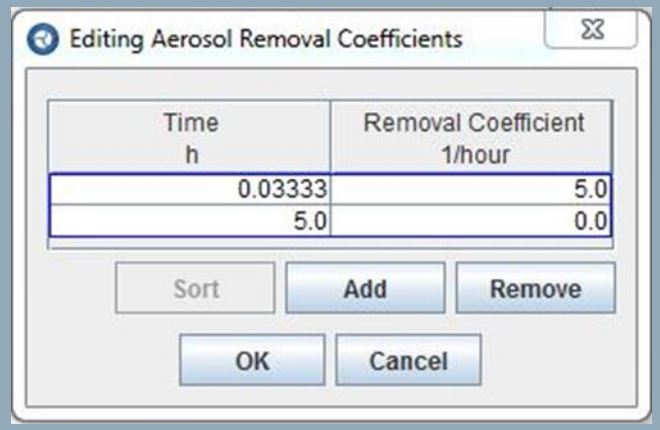
Step 4.1: Containment Leakage Pathway

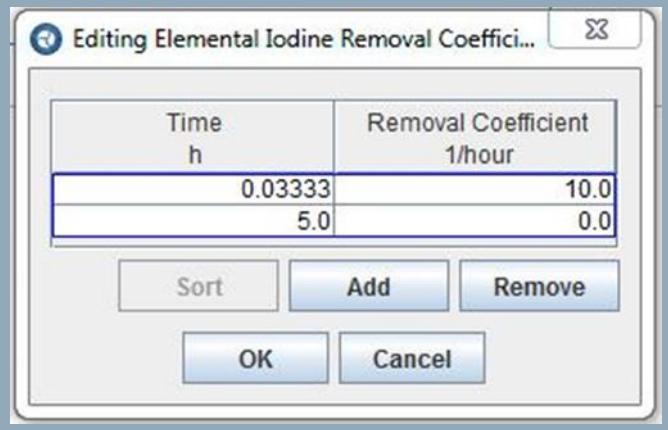
- There is time-dependent removal of elemental iodine and particulates from the containment atmosphere by sprays and natural deposition. Therefore, we will need to add spray and deposition components.
- To create the spray component, right-click sprays > new
- Rename the spray to Containment Spray and change the rest of the component to match the image provided. (Table values for the Coefficients will be provided on the next slide).

Name	Containment Spray
Component Number	1
Description	<none>
Aerosol Removal Model	User Defined Coefficients
Aerosol Removal Coefficients	Rows: 0 []
Elemental Iodine Removal Model	User Defined Coefficients
Elemental Iodine Removal Coefficients	Rows: 0 []
Organic Iodine Removal Model	None
Aerosol DF Limit Enabled	○ True ◉ False
Aerosol Lambda /10 DF Limit Enabled	◉ True ○ False
Aerosol Lambda /10 DF Limit	50.0 (-)
Elemental-I DF Limit Enabled	◉ True ○ False
Elemental-I DF Limit	200.0 (-)
Powers Model Spray Table	*Disabled*
Powers Model Spray Ratio	*Disabled*
Powers Model Percentile	*Disabled*
Organic Iodine Removal Coefficients	*Disabled*
Aerosol DF Limit	*Disabled*

Step 4.1: Containment Leakage Pathway

- Expand the Aerosol Removal Coefficients and Elemental Iodine Removal Coefficients tables and fill them with the values shown below.

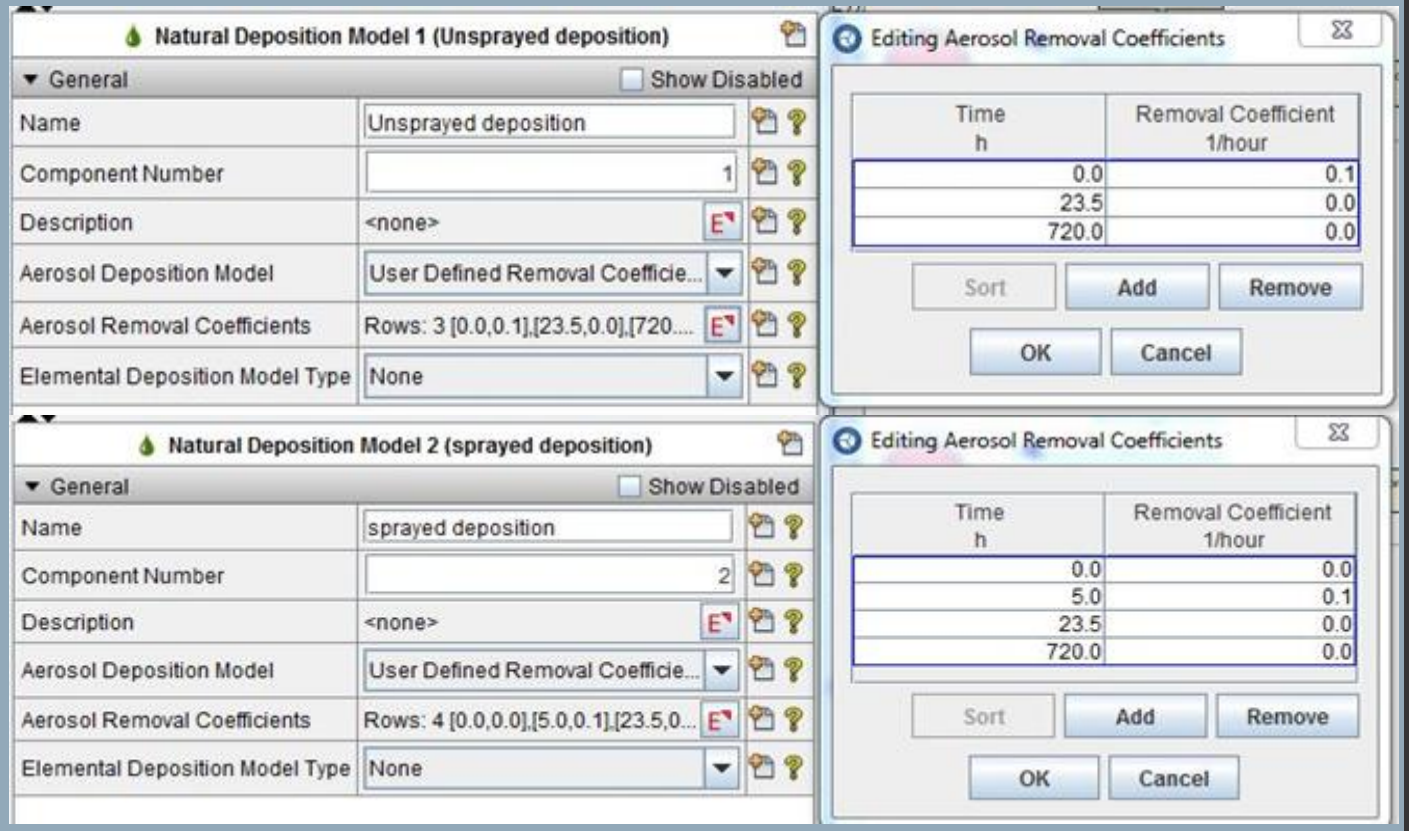




- Once those tables are completed, select Containment (sprayed). Press the select icon ( ) next to Spray and select Spray 1 (Containment Spray)

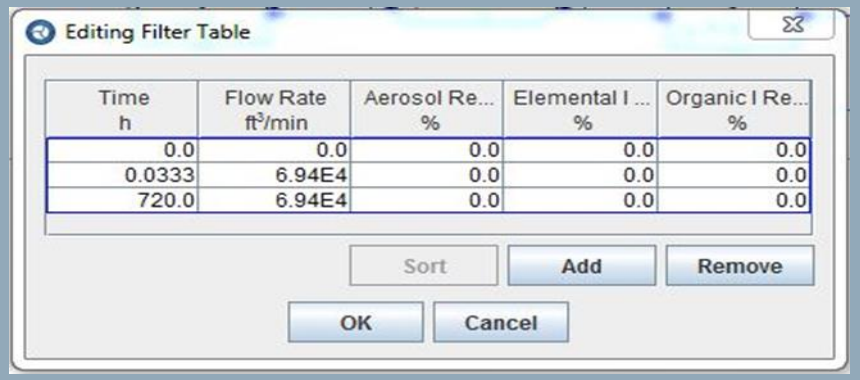
Step 4.1: Containment Leakage Pathway

- Two deposition components will need to be created due to timing differences, Sprayed and Unsprayed Deposition.
- Right-click on Natural Deposition and create the two deposition components.
- Use the images to fill out the information needed for both depositions.
- After the components have been completed, add the Unsprayed Deposition to the Unsprayed Containment and the Sprayed Deposition to the Sprayed containment the same way the Spray was added.



Step 4.1: Containment Leakage Pathway

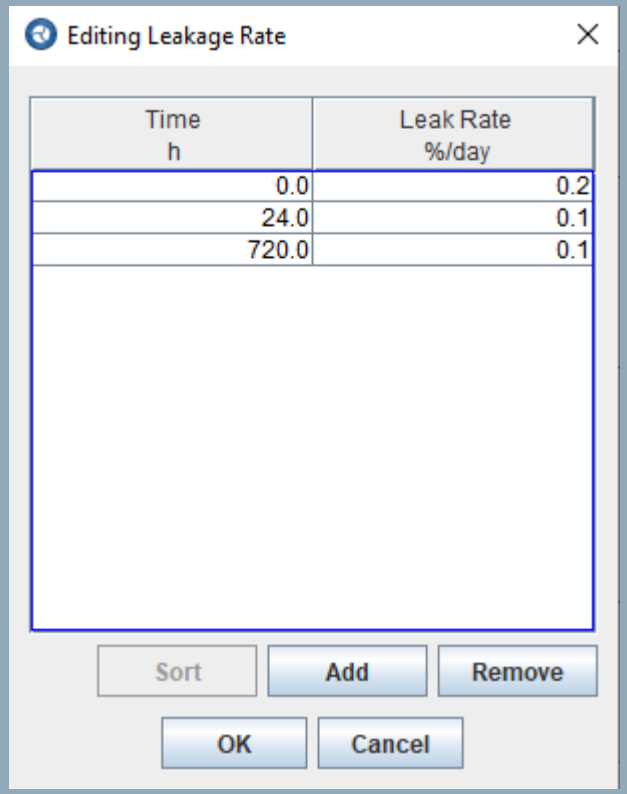
- A filter modeling the recirculation between the sprayed and unsprayed portions of the containment.
- Right-click > new on the filters and rename the filter to Containment_Mixing.
- Expand the Filter Table and include the follow values:



- Add this filter to the Unsprayed to Sprayed and Sprayed to Unsprayed flow pathways.

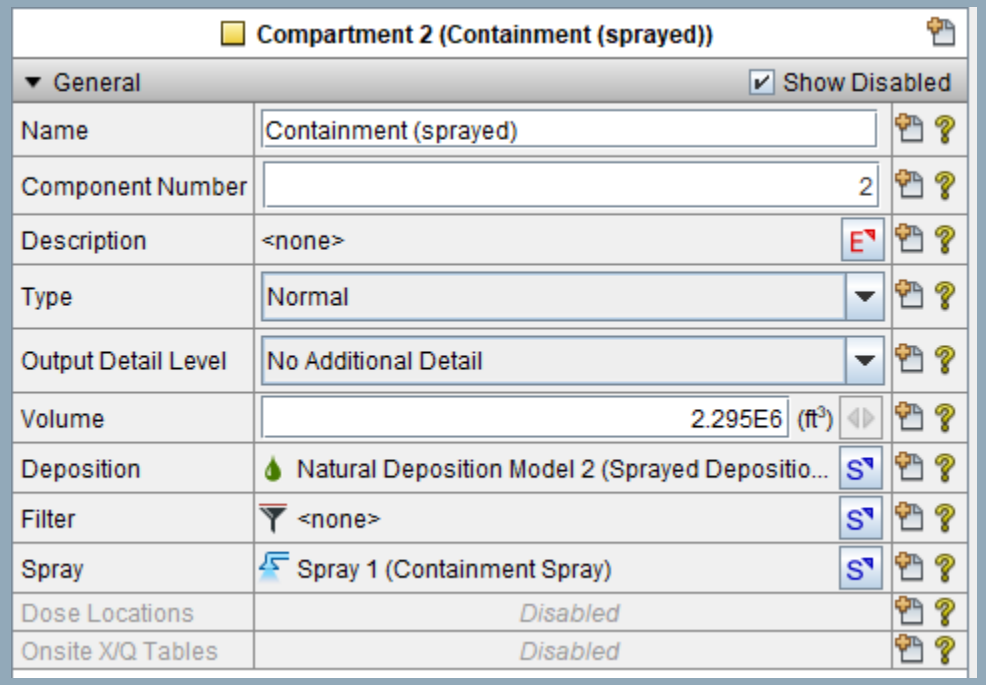
Step 4.1: Containment Leakage Pathway

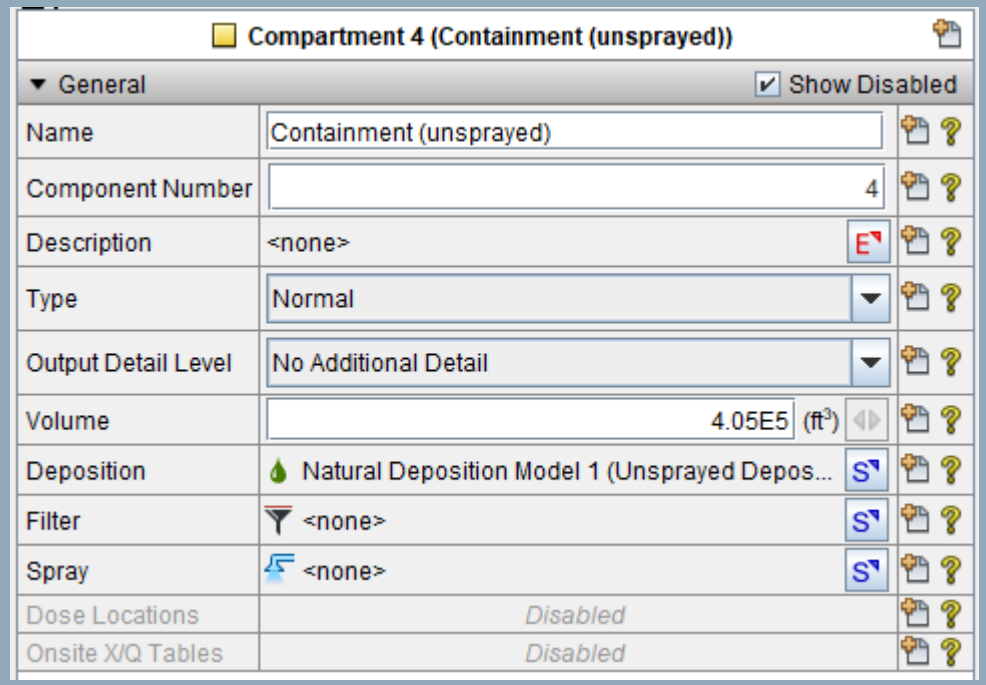
- The leakage rates for the Unsprayed to Environment pathway and the Leak to Environment pathway will be the same and is shown in the image below.



Step 4.1: Containment Leakage Pathway

- The information needed for the unsprayed and sprayed containments should look like the following (component numbers may differ):



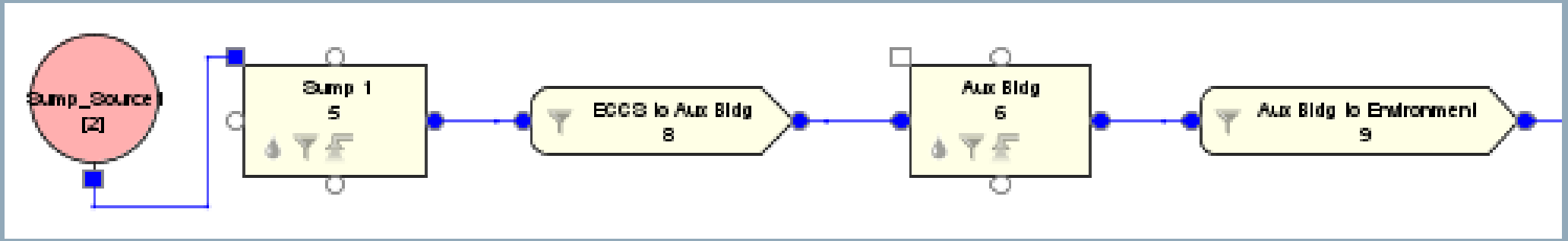


Step 4.2: ECCS Leakage Pathway

- The source Sump_Source1 will be used for this Pathway.
- Two more containment components will be needed for the sump 1 and auxiliary building.
- Two more flow pathways will be needed for the sump 1 to auxiliary pathway and the auxiliary to environment pathway.
- Two filters for each pathway will be needed, but no deposition or sprays are modeled.

Step 4.2: ECCS Leakage Pathway

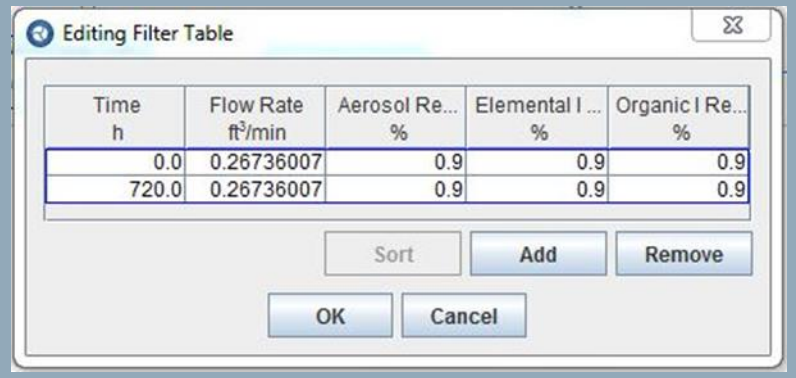
- Create two new compartment components (right-click compartments > new) and rename them Sump 1 and Aux Bldg.
- Create two new filtered pathways (right-click pathways > new) and rename them ECCS to Aux Bldg and Aux Bldg to Enironment.
- Use the image below to set up the connections (the Aux Bldg to Environment is connected to the Environment compartment)



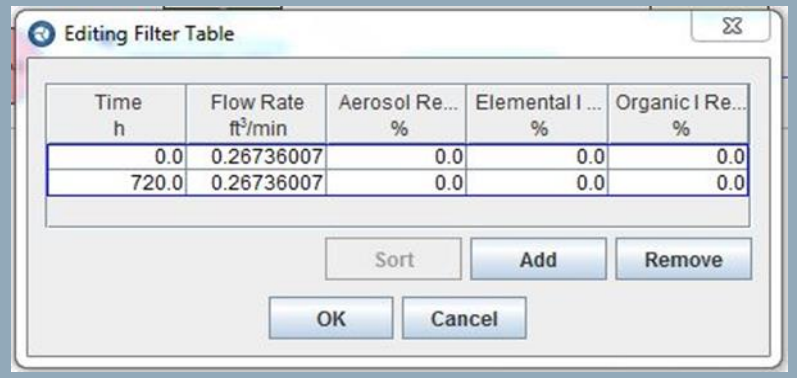
Step 4.2: ECCS Leakage Pathway

- Create two new filters named ECCS to Aux Bldg and Aux Bldg to Environment.
- Use the following images to populate the filter tables for each filter:

Aux Bldg to Environment



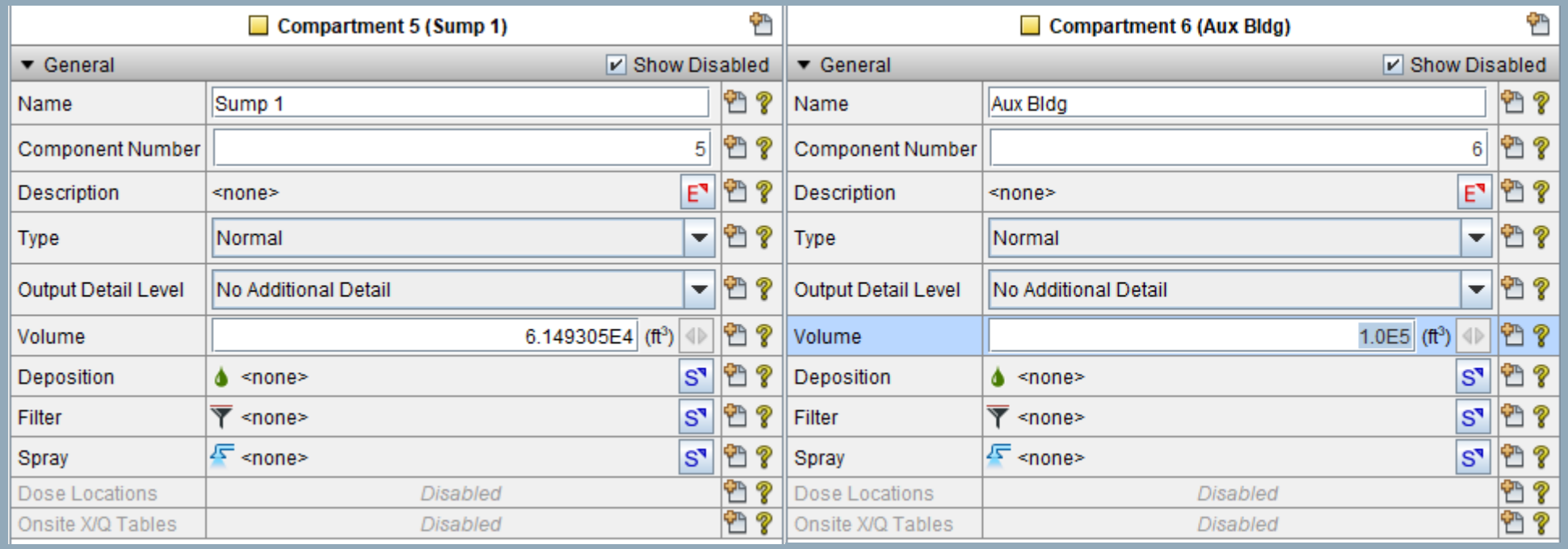
ECCS to Aux Bldg



- Add each filter to each corresponding pathway

Step 4.2: ECCS Leakage Pathway

- The following two images should be used to fill in data for the Sump 1 and Aux Bldg compartments (component numbers may differ).



Compartment 5 (Sump 1)	
General	Show Disabled
Name	Sump 1
Component Number	5
Description	<none>
Type	Normal
Output Detail Level	No Additional Detail
Volume	6.149305E4 (ft³)
Deposition	<none>
Filter	<none>
Spray	<none>
Dose Locations	Disabled
Onsite X/Q Tables	Disabled

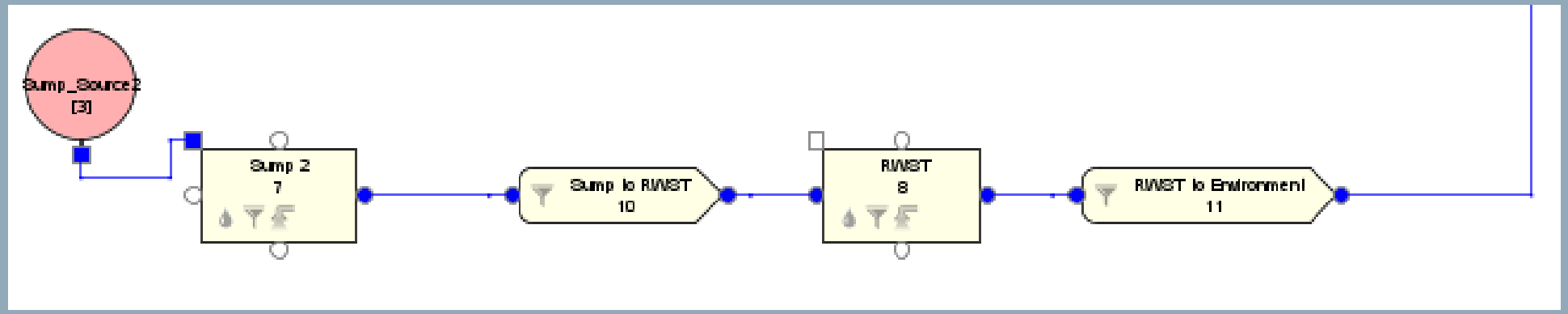
Compartment 6 (Aux Bldg)	
General	Show Disabled
Name	Aux Bldg
Component Number	6
Description	<none>
Type	Normal
Output Detail Level	No Additional Detail
Volume	1.0E5 (ft³)
Deposition	<none>
Filter	<none>
Spray	<none>
Dose Locations	Disabled
Onsite X/Q Tables	Disabled

Step 4.3: RWST Back-Leakage Pathway

- The source Sump_Source2 will be used for this Pathway.
- Two more containment components will be needed for the sump 2 and the RWST.
- Two air leakage (not filtered) flow pathways will be needed for the sump 2 to RWST pathway and the RWST to environment pathway.
- Two filters for each pathway will be needed, but no deposition or sprays are modeled.

Step 4.3: RWST Back-Leakage Pathway

- Create two compartments and rename them Sump 2 and RWST.
- Create two Air Leakage (not filtered) pathways and name them Sump to RWST and RWST to Environment.
- Use the image below to create the connections between the components (RWST to Environment connects to the Environment compartment).

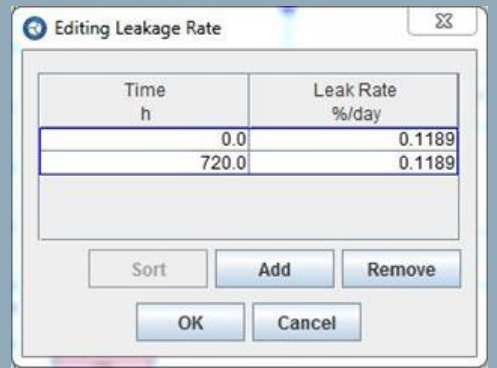


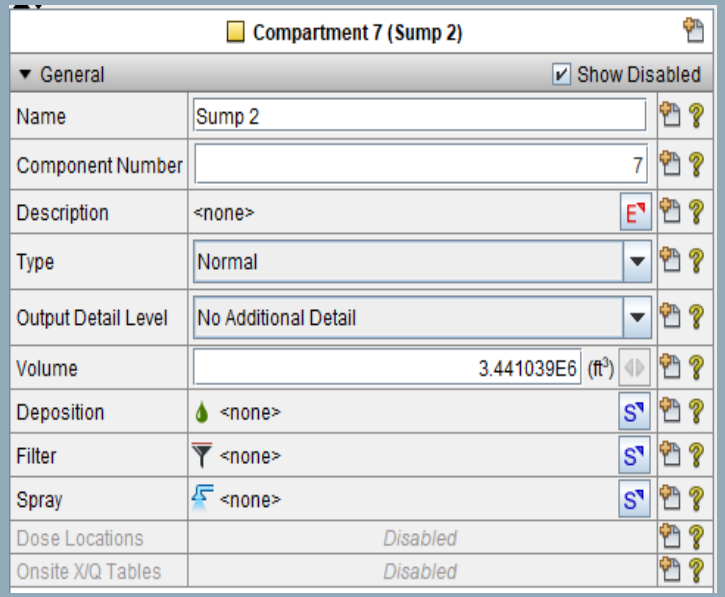
Step 4.3: RWST Back-Leakage Pathway

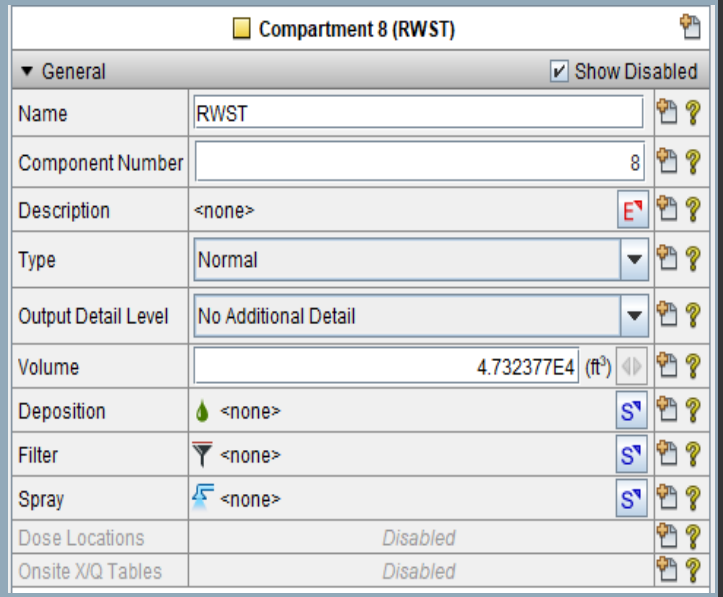
- Use the images provided to fill Leakage Rates of the pathways and the information for the two compartments (component numbers may differ).

Sump to RWST

RWST to Environment

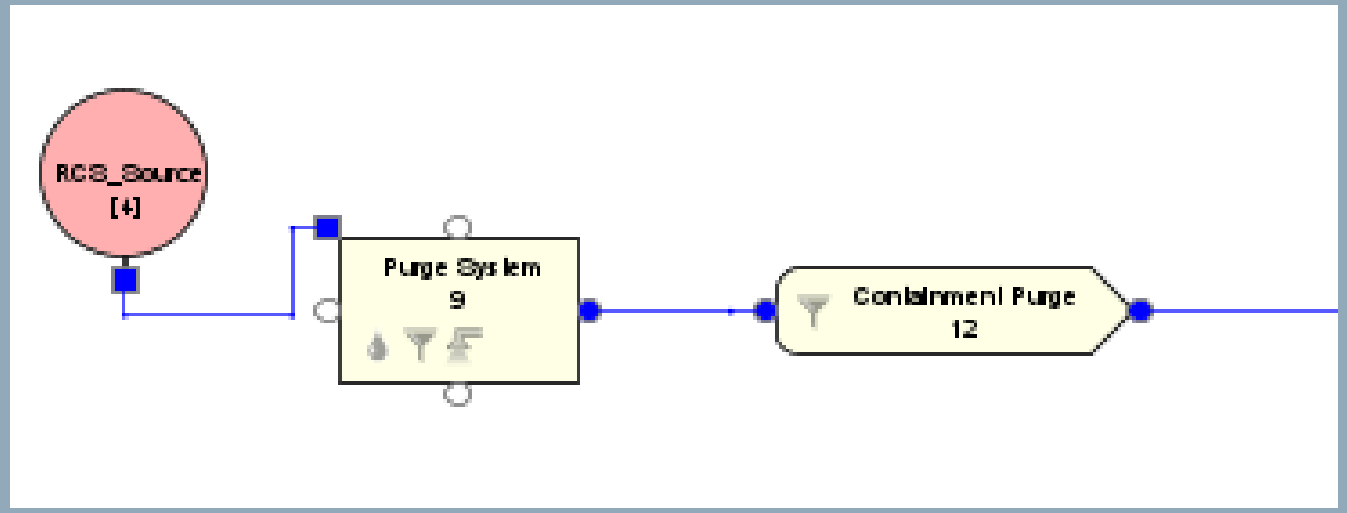






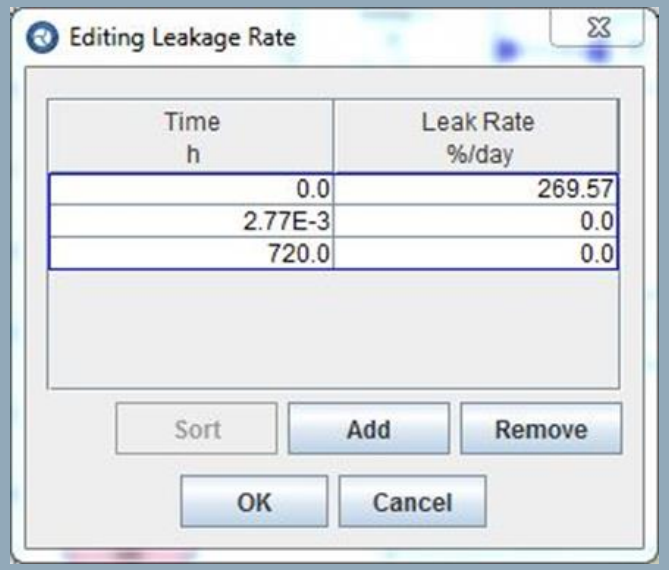
Step 4.4: Containment Purge Release Pathway

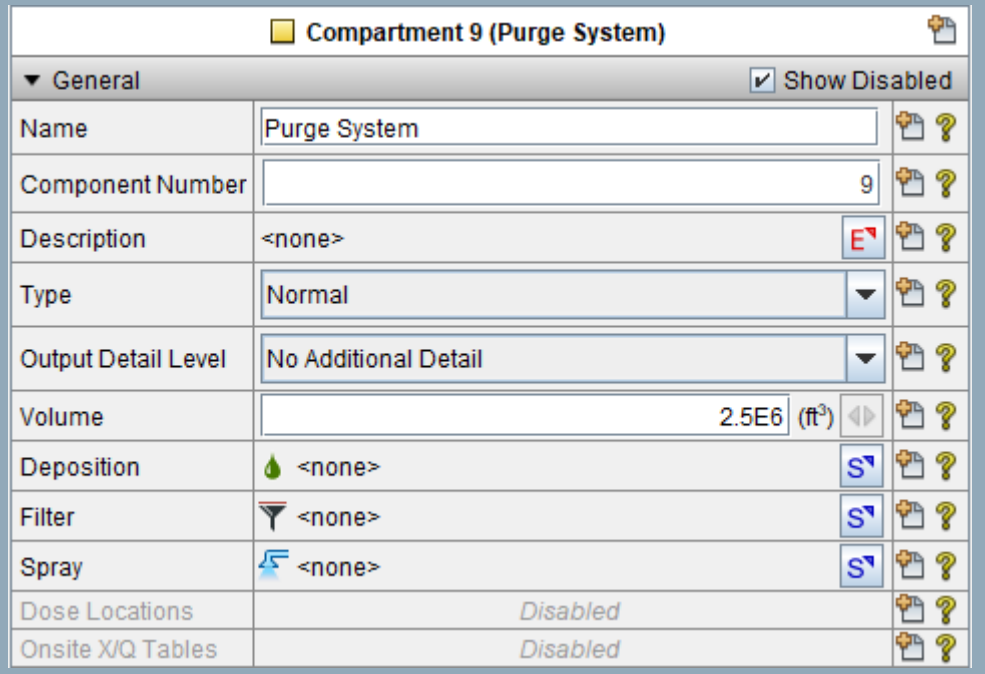
- The source RCS_Source will be used for this Pathway.
- Create one containment component and rename it Purge System
- Create one Air Leakage Pathway and rename it Containment Purge.
- Use the image to setup the connections (containment purge is connected to the Environment component.



Step 4.4: Containment Purge Release Pathway

- Use the images to fill in the leakage rate table for the Containment Purge pathway and the information for the Purge System containment.





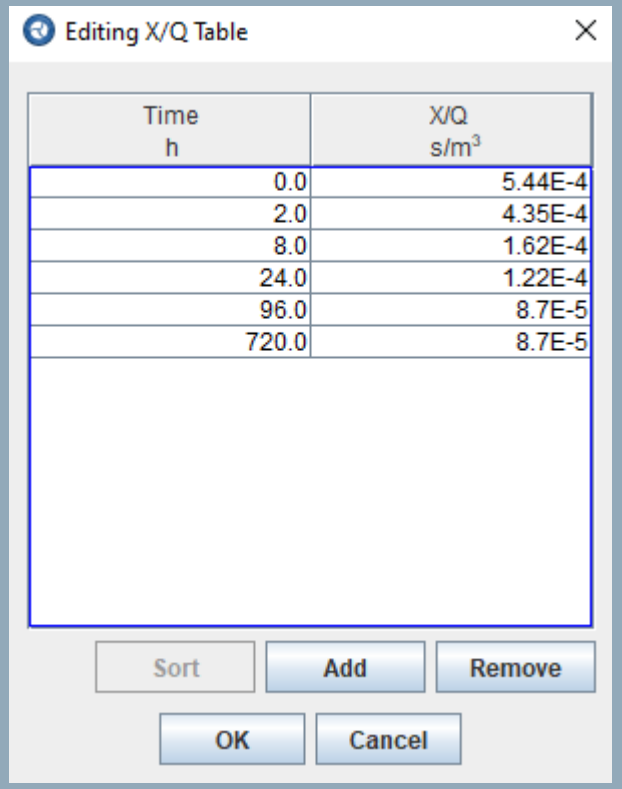
Step 5: X/Q Tables

- The five X/Q tables will be needed:
  - Exclusion Area Boundary
  - Low Population Zone
  - Control Room – Containment Leakage
  - Control Room – Containment Purge & ECCS Leakage (used for the RCS_Source pathway and the Sump_Source1 pathway)
  - Control Room – RWST Back-Leakage
- The X/Q tables for the EAB and LPZ are already created and won't need to be adjusted.
- X/Q Table 3 will need to be renamed and adjust to new values.
- X/Q Tables 4 and 5 will need to be created.

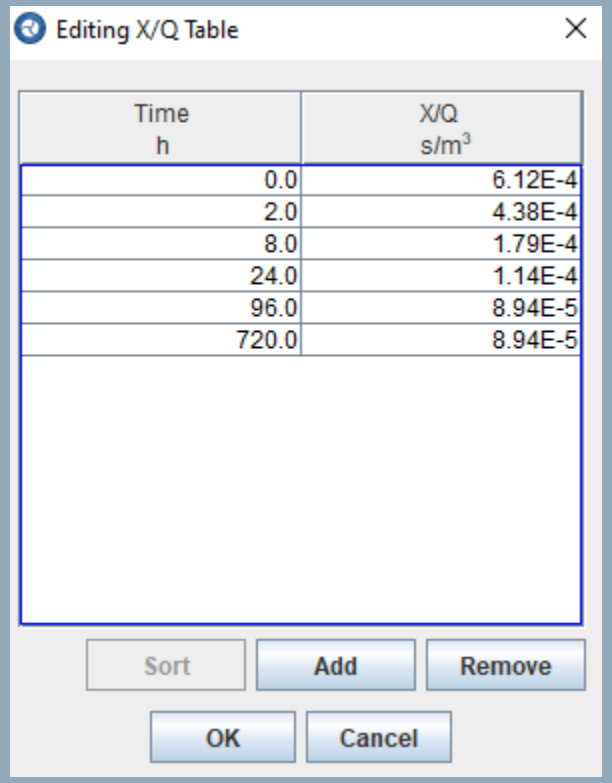
Step 5: X/Q Tables

- Use the images to fill in the X/Q tables

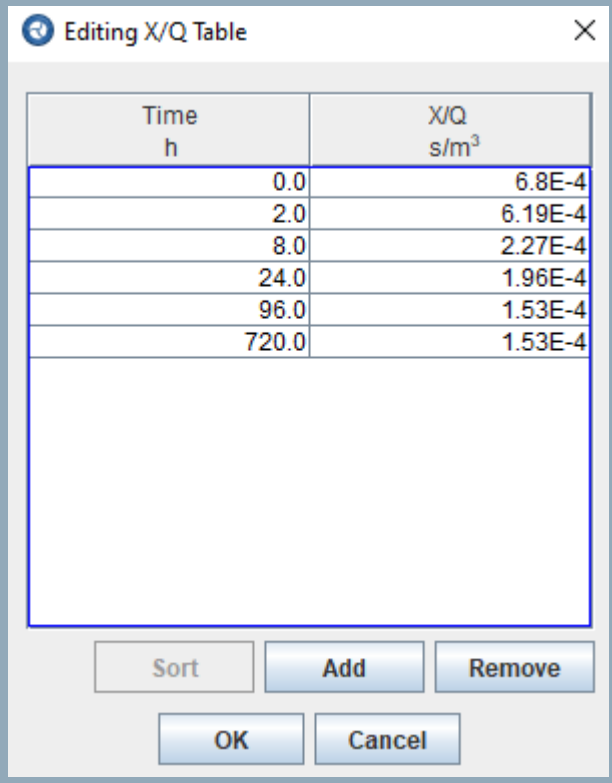
Control Room- Containment Leakage



Control Room- Containment Purge and ECCS Leakage

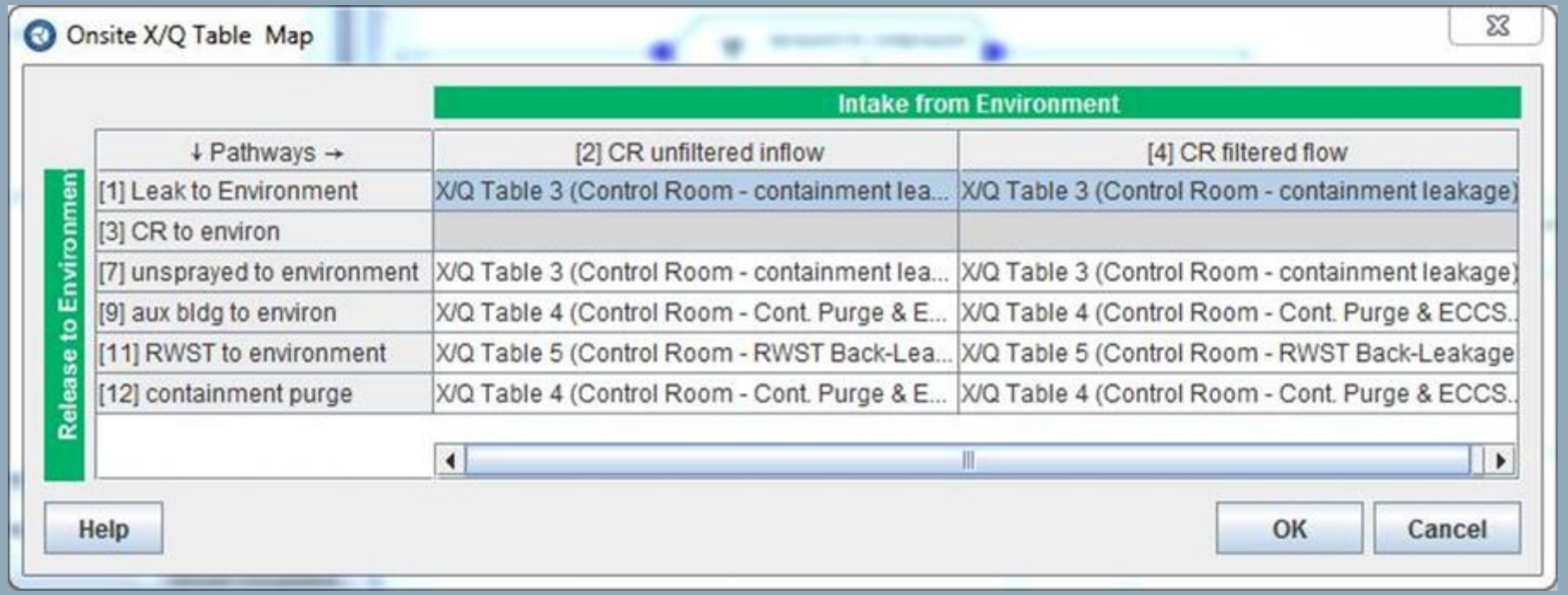


RWST Back-Leakage



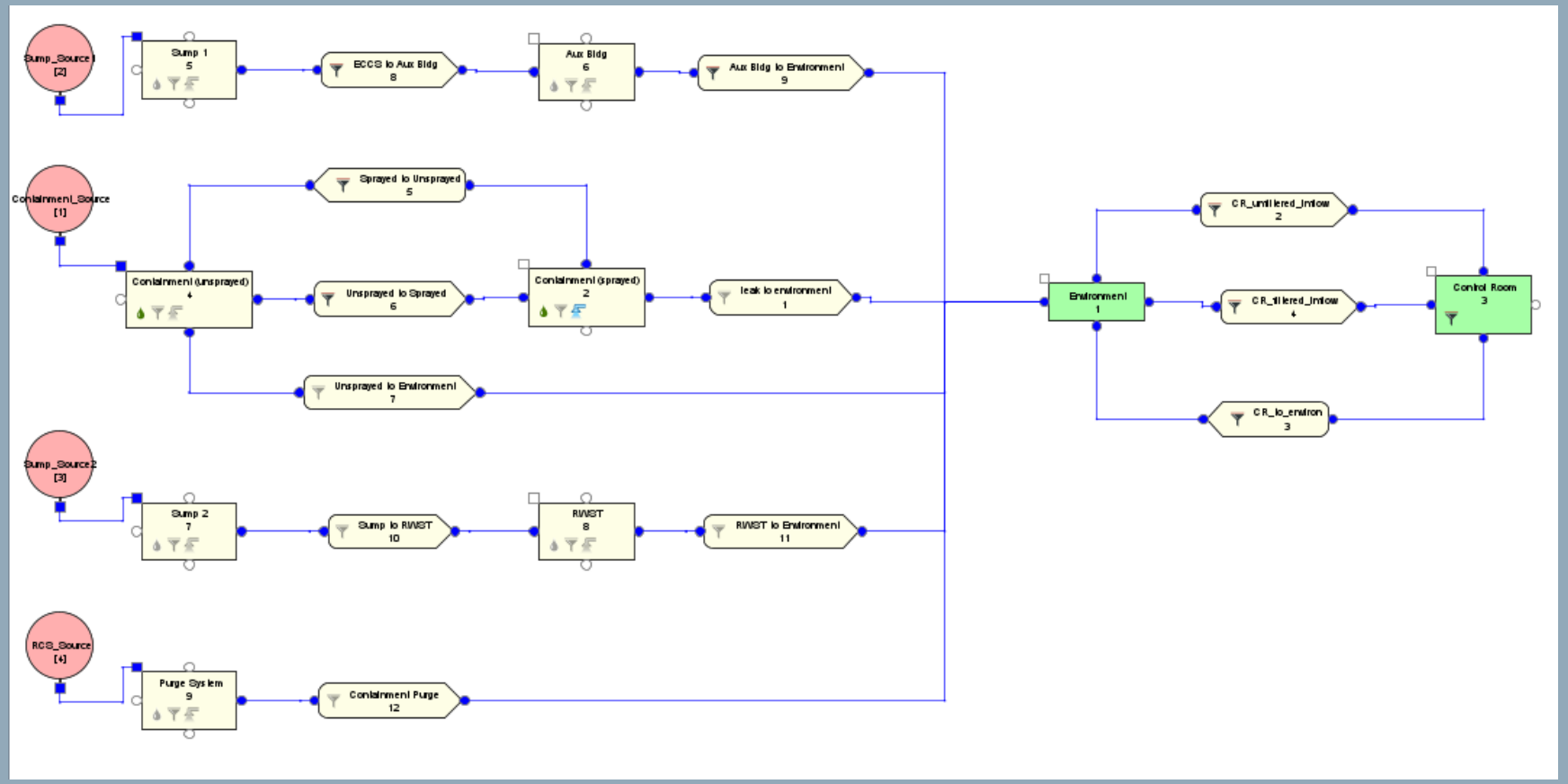
Step 5: X/Q Tables

- Now that the X/Q tables have been setup, click on the Environment compartment and expand Onsite X/Q Tables. Use the following image to setup the X/Q tables for the flow to the control room.



Step 6: Running the Simulation

- Everything should be in place to submit the job. Double check that the model you have looks like the image provided. Pay attention to which components have sprays, deposition models, and filters (component numbers may differ).



Step 6: Running the Simulation

- Click the  icon to check to see if there are any errors in the model. If no errors show up, click tools > submit job and run the simulation.
- Once the simulation is completed, open the radtrad.out file and compare your results with the following:

```
################################################################################
                        Worst Two-Hour Doses
################################################################################

Exclusion Area Boundary
     Time          Whole Body     Thyroid         TEDE
     (hr)            (rem)         (rem)          (rem)
    0.3-2.3        6.3627e-01    7.5824e+01    3.3000e+00

################################################################################
                             Final Doses
################################################################################

Low Population Zone
   Time    Whole Body     Thyroid         TEDE
   (hr)      (rem)         (rem)          (rem)
  720.0    4.8311e-01    5.7820e+01    2.9357e+00

Control Room
   Time    Whole Body     Thyroid         TEDE
   (hr)      (rem)         (rem)          (rem)
  720.0    1.6142e-01    4.8913e+01    2.4929e+00

================================================================================
```