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USE OF MODELS AS A RATIONALE FOR THE DESIGN OF ENVIRONMENTAL MONITORING PROGRAMS (U)

by

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Use of Models as a Rationale for the Design of Environmental Monitoring Programs

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Use of Models as a Rationale for the Design of Environmental Monitoring Programs

Slide 1. Discussion Topics.

This discussion will describe methods for using the output of comprehensive dose assessment models to assist in developing a defensible rationale for the determining environmental sample locations, sampling media, and radionuclides for analyses. Methods for using models and examples for a power reactor and a large diversified nuclear complex will be included. The discussion will focus on termoluminescent dosimeter (TLD), air, liquid, and groundwater monitoring. The use of modeling techniques can then serve as the basis for reducing empirical measurements.

Slide 2. TLD Monitoring.

For TLD monitoring, calculate the theoretical width of the plume as a percentage of the centerline concentration and as a function of downwind distance and atmospheric stability class. Percentages of 50 and 30 were chosen for this exercise. With this data, an optimum distance from the source and distance between monitoring stations can be determined. The final selection can then be made using site specific meteorological, topographical, and demographical data. Other factors such as accessibility and likelihood of tampering with the TLD's should also be considered.

Slide 3. Width of Plume as a Function of Distance and Stability.

This slide shows the significant part of a table that was prepared for the Savannah River Site. The table shows only stability classes D, E, and F at a few distances but will illustrate the technique. Note that for stability class F the percentage is roughly half of those for stability class D and that the higher the stability class (tending toward more stable conditions) the closer the interval between required monitoring stations.

Slide 4. SRS TLD Map.

At the Savannah River Site (SRS), three operational production reactors, two chemical reprocessing plants, and tritium facilities are 12 kilometers (7.5 miles) or greater from the site boundary. However, the Reactor Fuel Facility and the Savannah River Laboratory on the northern side of the site are within 1.6 kilometers (one mile) of the site boundary. In addition, a commercial nuclear power plant (Vogtle Electric Generating Station) is located approximately 1.6 kilometers (one mile) from the site boundary on the southwestern side.

Using this rationale, monitoring locations are required at 1.6 km intervals around the 128 kilometer (80 mile) boundary of the SRS to provide the ability to detect approximately 50% of the plume centerline concentration for the facilities near the center of the Site. At the Fuel Fabrication-Savannah River Laboratory Area and the Vogtle Electric Generating Station the spacing interval is reduced to approximately 0.4 kilometers (one-fourth mile). This spacing requires approximately 180 TLD's around the SRS site boundary. Next we'll discuss air monitoring.

Slide 5. Air Monitoring.

This slide provides a brief description of the methods for using models to assist in determining air monitoring station locations. This method uses atmospheric dispersion from the output of the code that is generally used to determine annual site doses. The code uses site specific source term, radioactive release, and meteorological data. For this exercise, the code was run for a one curie release of a particulate (^{137}Cs) an semivolatile (^{131}I) and a gaseous (^{3}H) radionuclide.

The concentrations at various distances were plotted on a United States Geological Survey map of the area. This information was then combined with demographic, topographic, and other applicable information including regulatory requirements and public perception to determine the most appropriate sample locations. An illustration of air monitoring station placement is not given because of the limited time, but the technique is rather straightforward. Rather, the atmospheric dose distribution will be reviewed.

Slide 6. Atmospheric Dose Distribution, Power Reactor.

The atmospheric dose distribution by pathway and radionuclide provides a rationale for choosing the radionuclides that should receive significant attention in a monitoring scheme. Comprehensive dose assessment codes provide pathway and radionuclide distributions as part of the output. This slide contains a part of the output from AIRDOS-EPA code using Three Mile Island average meteorology for 1980, 1981 and 1982 and releases from a reactor similar in construction to Three Mile Island.

The data indicate that the principal pathway is immersion in the plume that results from releases of the noble gases ^{85}Kr and ^{133}Xe. Since these noble gases are difficult and expensive to measure in the environment it would be prudent to give strong emphasis to measurements of ^{85}Kr and ^{133}Xe in the in-plant stacks and use models to determine environmental concentrations. The models should be verified with periodic measurements in the environment.

Slide 7 Atmospheric Dose Distribution, Savannah River Plant

As might be expected, the dose distribution for both pathway and radionuclide at the Savannah River Site are significantly different from a power reactor. Tritium releases from the heavy water production reactors and tritium processing facilities is the principal contributor to offsite dose. Tritium also heavily influences the pathway analysis as shown by the three principal pathways included on the slide. Tritium domination is expected because tritium readily exchanges with hydrogen in most environmental media.

The dose from ^{41}Ar can be measured by TLD's but the dose at the Site boundary is generally to small to distinguish the ^{41}Ar from natural background radiation. Therefore periodic measurements are made with a mobile van that contains an array of sodium iodide detectors.

The radionuclide distribution also indicates that monitoring for the difficult to measure ^{129}I and ^{14}C isotopes should be an important part of the environmental monitoring program.

Slide 8. Liquid Dose Distribution, Savannah River Site

Now I would like to direct your attention to monitoring for radionuclides that are released in liquids effluents. The procedure for determining important pathways and radionuclides is essentially the same as for air monitoring. This slide contains the most significant part of the pathway and radionuclide distribution provided by the liquid dose model LADTAP used at the Savannah River Site. These results indicate that monitored for cesium, tritium and strontium in fish and water should receive a strong emphasis in the monitoring program with some emphasis on monitoring for ^{129}I.

Slide 9. Determination of Important Radionuclides in Sediment and Aquatic Biota.

To further assess the impact of liquid releases, consideration should also be given to the potential for buildup of radionuclides in sediments and aquatic biota. To assist in this assessment, one can multiply the source term for each radionuclide by its appropriate distribution coefficient (Kd) for sediments or bioaccumulation factor for aquatic biota. The larger the resulting product the greater the relative importance of the radionuclide as is illustrated in the next slide.

Slide 10. Radionuclide Distribution in Sediment, Fish and Algae, Power Reactor.

This slide contains the five most important radionuclides that resulted form multiplying the source term for a power reactor similar in construction to Three Mile Island by the appropriate factor for sediment, fish and algae. These data indicate that the best overall indicator is ^{58}Co followed by ^{137}Cs. Except for ^{90}Sr, all of the radionuclides shown can be determined by gamma spectroscopy which makes the monitoring task relatively easy in this case.

Using liquid model output, the distribution coefficient for sediment, and the bioaccumulation factor for aquatic biota yield important information in the design of monitoring program for liquid released radionuclides. Next we will consider groundwater monitoring.

Slide 11. Groundwater Monitoring Considerations.

As you are probably aware, models for determining dispersion and dose for radionuclides in groundwater are not as well developed as for air and surface water and there are few models available. The information is this talk is based on the EPA PARESTO family of models. This slide list some of the most important consideration associated with use of groundwater models. Most of these considerations such as movement, mass transport, source term, geological properties, and hydrological properties are strongly dependent on site specific data.

Slide 12. Groundwater Monitoring Technique.

As with sediments and aquatic biota, it is important to consider the distribution coefficients for radionuclides released to the earth. The radionuclides with the smallest coefficients are likely to be more readily transportable and therefore the radionuclides that should receive the initial attention in a groundwater monitoring scheme. As can be seen from the slide, tritium is likely the best measurable indicator because of the difficulty in measuring ^{14}C, ^{99}Tc and ^{129}I. On the other hand, the total quantity of the radionuclide available for release (source term) must also be considered. Therefore, a measure of relative potential importance for each radionuclide can be determined by dividing the potential source term by the Kd. Use of these concepts can assist in developing a groundwater monitoring program. Now let's discuss one of the principal benefits from analyzing an environmental monitoring program.

Slide 13. Reduction of Empirical Environmental Measurements.

In addition to using models as a rationale for the design of an environmental monitoring program, models use can be expanded, with minor changes, to provide calculated environmental radionuclide concentrations on a daily, weekly or monthly basis. Most nuclear facilities have the capability to provide the meteorological and source term data that are needed as input. If this capability were more fully used, the number of environmental samples collected and analyzed could possibly be reduced to only those required to verify the models and to satisfy regulatory agencies. Models could also provide additional value because they can calculate the concentration at virtually any point on the map within the normal monitoring range.

Slide 14. Conclusions.

This brief discussion has presented ideas for the use of models in developing a rationale for the design and/or enhancement of environmental monitoring programs. When used in this manner, the monitoring program is defensible and aids in accomplishing environmental monitoring objectives. If development and use of models was extended further, this development could lead to a significant reduction in the need for empirical environmental measurements.

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Discussion Topics

- Thermoluminescent Dosimeter (TLD) Monitoring
- Air Monitoring
- Liquid Monitoring
- Groundwater Monitoring
- Reduction of Empirical Measurements
- Conclusions

TLD Monitoring

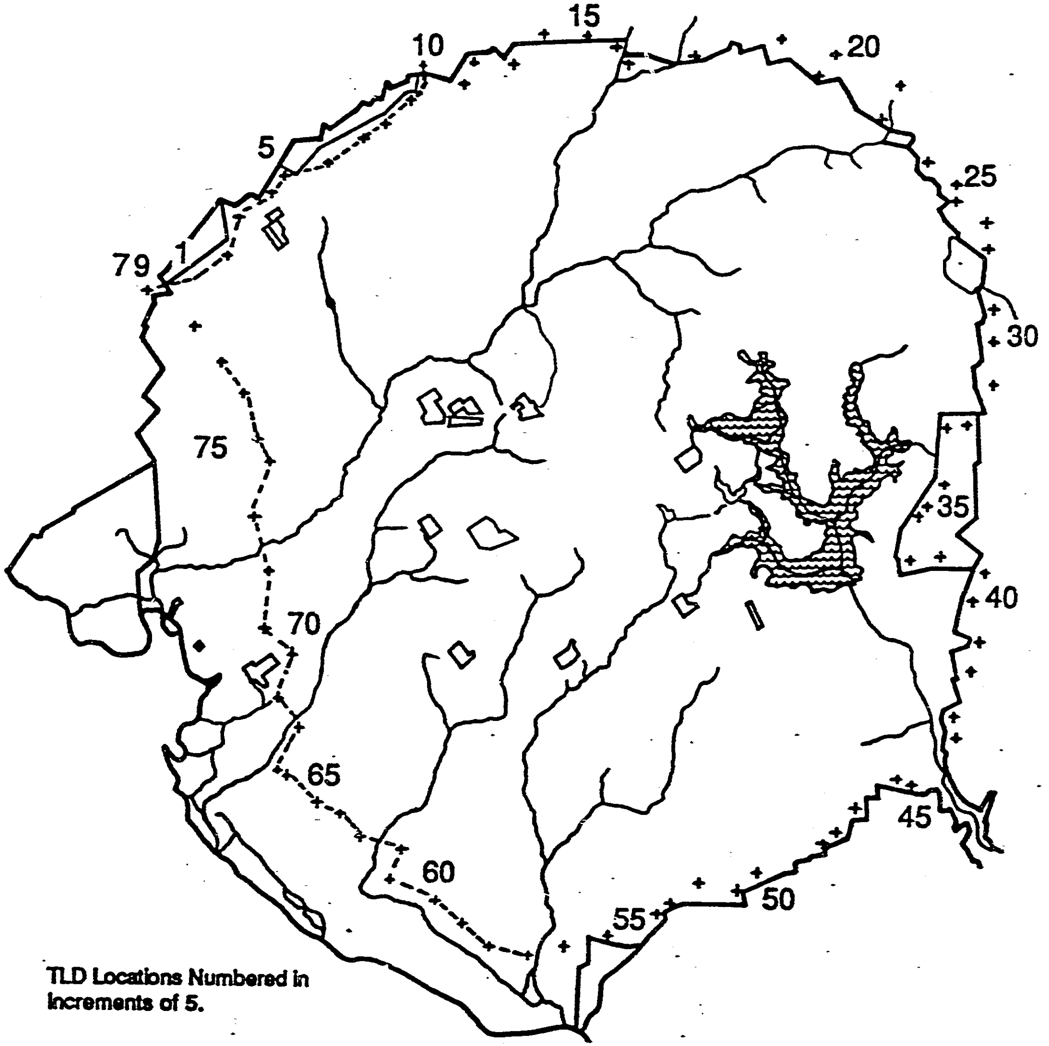
- Calculate Plume Width as a Percent of Centerline Concentration
- Choose Optimum Distance From Source
- Combine Distance with Site-Specific Data to Determine Spacing of TLD's

Width of Plume as a Function of Distance and Stability

Stability Class	Distance km	Plume Width, Km 50%*	 30%*
D	2	0.33	0.43
	4	0.59	0.78
	12	1.50	1.90
E	2	0.23	0.30
	4	0.42	0.56
	12	1.05	1.40
F	2	0.17	0.22
	4	0.30	0.40
	12	0.74	0.97

*Percent of Centerline Concentration

SRS Perimeter TLD Monitoring Stations



TLD Locations Numbered in Increments of 5.

Air Monitoring

- Obtain an average of several years of site-specific meteorological data.
- Run code for a particulate, a semivolatile and a gaseous radionuclide.
- Relate the air concentration to specific map locations.
- Obtain data on demographics, regulatory requirements, etc.
- Determine monitoring locations on map.

Atmospheric Dose Distribution
Power Reactor

By Pathway

	Max.Dose mrem	Percent of total
Plume	0.98	97.6
Ground	0.015	1.5
Vegetation	0.003	0.2

By Radionuclide

85Kr	0.56	56
133Xe	0.42	42
3H	0.003	0.3

Atmospheric Dose Distribution - SRS

By Pathway

	Max. Dose mrem	Percent of total
Vegetation	0.22	37.7
Plume	0.16	26.5
Inhalation	0.12	19.3

By Radionuclide

^{3}H	0.31	51.4
^{41}Ar	0.14	23.6
^{129}I	0.09	14.9
^{14}C	0.03	5.6

Liquid Dose Distribution - SRS

By Pathway

	Max. Dose (mrem)	Percent of total
Fish	0.6	87
Water	0.1	13
Shoreline	0.001	0.1

By Radionuclide

137Cs	0.6	85
3H	0.1	13
90Sr	0.01	1
129I	0.001	0.1

Determination of Important Radionuclides in Sediment and Aquatic Biota

- Sediments:
  (Source Term) x (Distribution Coefficient)
- Aquatic Biota:
  (Source Term) x (Bioaccumulation Factor)
- Give Emphasis to Radionuclides with Largest Result

Radionuclide Distribution
Power Reactor

Radio- nuclide	Sediment ST x Kd*	Fish ST x BF#	Algae ST x BF#
51Cr	$2\text{x}10^{12}$	$2\text{x}10^{11}$	$2\text{x}10^{12}$
58Co	$7\text{x}10^{13}$	$1\text{x}10^{12}$	$1\text{x}10^{13}$
90Sr	$2\text{x}10^{10}$	$2\text{x}10^{7}$	$2\text{x}10^{9}$
134Cs	$7\text{x}10^{12}$	$3\text{x}10^{11}$	$1\text{x}10^{12}$
137Cs	$1\text{x}10^{13}$	$6\text{x}10^{11}$	$2\text{x}10^{12}$
144Ce	$4\text{x}10^{12}$	$4\text{x}10^{9}$	$4\text{x}10^{11}$

*(Source Term) x (Distribution Coefficient, Kd)
#(Source Term) x (Bioaccumulation Factor)

Groundwater Monitoring Considerations

- Few Models Available - EPA PARESTO
- Models Not Well Developed
- Movement of Carrier Fluid (Water)
- Mass Transport of Radionuclide
- Source Term
- Chemical Form, Geological and Hydrological Properties
- Distribution Coefficient (Kd), Half Life

Groundwater Monitoring Technique

- Focus on Radionuclides with Small Kd (3H, 14C, 99Tc, and 129I)
- Determine Relative Potential Importance

$$\frac{\text{Source Term}}{\text{Kd}}$$

Reduction of Empirical Measurements

- Expand Model Usage to Daily, Weekly or Monthly
- Use Empirical Measurements to Verify Models
- Reduce Sample Collection and Analyses

Conclusions

Models Can Provide:

- A Rationale For the Design of an Environmental Monitoring Program.
- A Defensible Basis for Accomplishing Environmental Monitoring Objectives.
- The Basis for Reducing Empirical Environmental Measurements.

END

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