SRS Dose Reconstruction Project, Phase III

The SRS Dose Reconstruction Project, Phase III, examined doses and associated cancer risks to hypothetical individuals in the vicinity of the Savannah River Site (SRS). Doses and risks were estimated based on releases from the SRS for the period 1954 to 1992, when most of the production of nuclear weapon materials occurred. This Project is sponsored by the Radiation Studies Branch, National Center for Environmental Health, Centers for Disease Control and Prevention (CDC), U.S. Department of Health and Human Services. Phase III found that these doses and cancer risks are small compared to those from background radiation.

SRS is a 300 square mile site located in South Carolina about 19 miles (32 km) south of Aiken, South Carolina, and about 22 miles (36 km) southeast of Augusta, Georgia. It borders the Savannah River for about 17 miles. It was operated from 1954 to 1992, first by E.I. DuPont de Nemours and Company (DuPont) and later by Westinghouse Savannah River Company for the U.S. Department of Energy (DOE) and its predecessor agencies. SRS operated five reactors, two chemical separations operations, and numerous laboratories and support facilities to produce and purify plutonium, tritium, and other radioactive isotopes. The primary mission was production of ^{239}Pu and tritium. By 1992 the production reactors and separations facilities had all ceased operation. Some processing and support, waste management, and environmental remediation facilities still operate in 2006.

Dose Reconstruction Phases

In 1992 CDC designed the SRS Dose Reconstruction Project to consist of five phases.

- Phase I was a search of SRS to find and copy documents and other records of potential value to the project.

- Phase II began in 1995 to develop an estimate of the releases of the most significant radionuclides and chemicals from various facilities at SRS from 1954 to 1992. In 1998 CDC provided the results of the Phase II study to outside reviewers, including the National Academy of Sciences and the Savannah River Site Health Effects Subcommittee (SRSHES). After considering and addressing comments, the final Phase II report was produced in 2001.

- CDC's original plan for Phase III was to use "scenarios provided by CDC and a screening protocol approved by CDC" to "perform screening calculations to determine which radionuclide releases from the Savannah River Site may have biological significance." In late 2002 and early 2003, CDC adjusted the scope of Phase III to include more detailed estimation of representative doses and risks.

Key Conclusions

- Estimated doses and risks are small compared to background radiation.

- The largest median individual dose over 39 years was 11 mSv, or 1.1 rem.

- Eating fish from the Savannah River and Lower Three Runs Creek was the most important exposure pathway.

- For people who did not eat fish from these waters, the most important exposure pathway was drinking milk and eating meat acquired locally.

- Larger annual doses corresponded to years of larger radioactive releases from the SRS, especially iodine-131 releases in the 1950s.

- Children born in 1964 had lower doses than children born in 1955, who were exposed to the larger, early releases of iodine-131.

Technical Approach

The dose reconstruction process employed for Phase III starts with the release of radionuclides from SRS; continues with the transport by air, water, and the food chain; models the exposure of hypothetical families to contaminated air, water, soil, and food; and results in estimation of doses and risks.

Phase III uses seven scenarios developed by CDC and the SRSHES. Each scenario describes a hypothetical family of four (Adult male, Adult Female, Child Born in 1955, and Child Born in

1964) that lived in the vicinity of SRS. Exposures were modeled at ten locations for radionuclides released to the air and two locations for radionuclides released to water, as shown in Figure 1. 30 radionuclides and 18 exposure pathways were used to model doses. (Table 1 lists the pathways.) The use of hypothetical scenarios to demonstrate the interactions of a range of receptor behaviors with the site and releases of radioactivity proved to be an effective analytical tool.

The dose calculations were automated using GENII Version 2, a dose assessment computer code developed at Pacific Northwest National Laboratory (PNNL) to support radiological exposure and risk assessment for the U.S. Environmental Protection Agency's Office of Indoor Air and Radiation, together with two computer programs developed specifically for this project: a preprocessor to generate input files and a postprocessor to read and extract GENII-V2 output files and prepare data suitable for further analysis.

The first step of the analysis estimated doses by selecting appropriate values for each of several hundred variables required by the computation. This provided a point estimate dose for each hypothetical individual. In the second step of the analysis, a few critical variables were subjected to uncertainty analysis, leading to mean and median values of the dose for each individual as well as probability distributions of those doses.

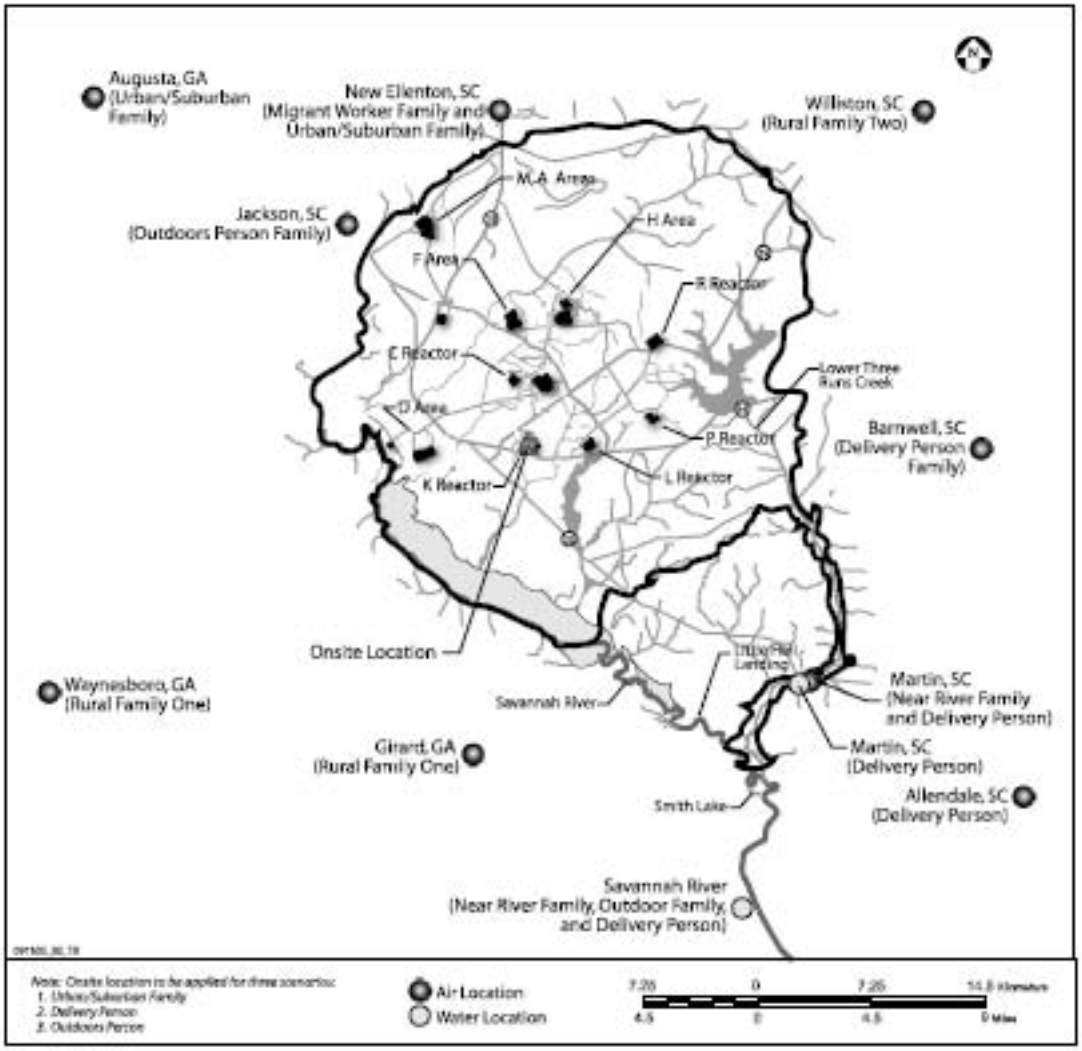

Figure 1. Exposure Locations

Conclusions

- Doses and risks are small for all receptors and scenarios relative to doses and risks from background radiation. The largest median dose for an individual was 11 mSv (1.1 rem) over the 39-year period studied. The corresponding risk of cancer incidence is 0.11% and the corresponding risk of cancer fatality is 0.027%.

- For people who ate fish from the Savannah River or Lower Three Runs Creek, this was the most significant pathway and the most important radionuclides were generally cesium-137, phosphorus-32, and strontium-90.

- For people who did not eat fish from these bodies of water, milk and beef were the most significant pathways and iodine-131 and tritium were the most important radionuclides.

- Immersion in argon-41 was a significant, , constant contributor to dose, but generally small.

- Large doses occurred in years corresponding to large radioactive releases from the SRS, especially iodine-131. For the Adult Male, Adult Female, and Child Born in 1955 in the scenarios, a large fraction of the total dose was received during the years 1955-1961.

- There were important differences in doses, pathway significance, and radionuclide significance between children born in 1955 and children born in 1964. Those born in 1955 experienced the large iodine releases early in the site's history, while those born in 1964 did not.

- Doses caused by eating fish from Lower Three Runs Creek were significantly higher than doses caused by eating fish from the Savannah River.

- The step-two doses generally could be higher or lower than the corresponding point-estimate result. However, the mean values of these distributions of dose were generally within a factor of 2 of the corresponding point estimate value. The individual receptor with the largest point estimate dose, 9.4 mSv (0.94 rem) received the largest mean dose of 13 mSv (1.3 rem) and the largest median dose of 11 mSv (1.1 rem). Extreme values of dose, in this case representing the highest and lowest 2.5% of doses for the same receptor, were 60.3 mSv (6 rem) and 2.53 mSv (0.25 rem) respectively. (In some cases the mean dose is larger than the median dose.)

Table 1. Exposure routes and pathways for air and water pathways

Exposure Route & Pathway	Air Releases	Water Releases
External radiation		
Air Immersion	X	
Ground Contamination	X	
Shoreline		X
Swimming		X
Boating		X
Ingestion		
Leafy Vegetables	X	
Root Vegetables	X	
Fruit	X	
Grain	X	
Beef	X	
Poultry	X	
Milk	X	
Eggs	X	
Soil	X	
Fish		X
Inadvertent Swimming Ingestion		X
Inhalation		
Air Inhalation	X	
Resuspended Soil	X	

Table 2. Values for mean doses, median doses, and the 95% confidence interval within which the median dose is believed to lie, for three individuals with the highest, smallest, and medium values of dose.

Scenario	Family Member	Mean Dose (mSv)	Rank of Median Dose (mSv)	Lower Confidence Interval (mSv)	Median Dose (mSv)	Upper Confidence Interval (mSv)
Outdoor Family	Child Born in 1955	13	1	8.6	11	13
Outdoor Family	Child Born in 1964	3.0	14	2.0	2.4	2.9
Rural Family One	Child Born in 1964	0.093	28	0.072	0.083	0.096

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