COMMUNITY SUMMARY

The Centers for Disease Control and Prevention (CDC) is conducting a dose reconstruction study (see Figure 1) of the Savannah River Site (SRS). The study is being conducted to determine if the health of people who lived near the Site was affected by past releases of chemicals and radioactive materials from the Site. The study is divided into five phases:

- Review of records
- Reconstructing historical releases of radioactive materials and chemicals
- Screening calculations to select materials to be included in the next phases.
- Developing detailed methods for assessing pathways and doses.
- Calculating exposures and doses.

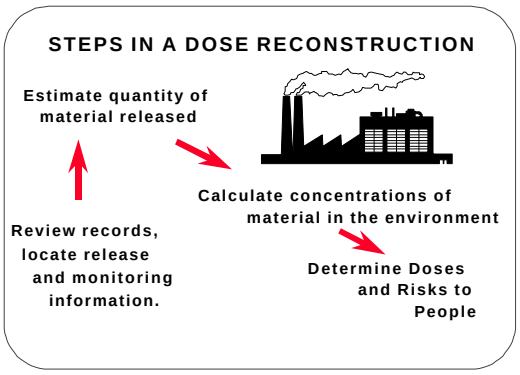

Figure 1. A dose reconstruction evaluates the effects of past releases on offsite residents.

In Phase II, we estimated the amounts and types of chemical and radioactive materials released from the SRS to the environment. This report presents highlights of these estimates.

The SRS is located along the Savannah River between Georgia and South Carolina (see Figure 2). Its five production reactors operated from 1953 to about 1990. They are now permanently shut down. Some processing, support, waste management and environmental remediation facilities are still operating. Figure 2 shows some of the key areas. Five nuclear reactors at the SRS were used to make plutonium and tritium. Radioactive fuel from these reactors was taken to H-Area and F-Area. Chemicals were used to extract the plutonium and tritium. These products were used by the United States Government in nuclear weapons. Other areas at the SRS supported this work. The reactors created other radioactive materials, and the SRS used a large number of chemicals. Over the years the Site released some of those materials to air and water. Some people living nearby during these past operations are concerned that those releases may have damaged their health.

In 1992, the CDC hired *Radiological Assessments Corporation* (*RAC*)* of Neeses, South Carolina to begin the first phase of the study. In Phase I, *RAC* searched through all the records stored at the Site. This totaled about 50,000 boxes of records. They also talked with many SRS workers. Several thousand useful documents were found. *RAC* researchers and CDC staff created a computer database to store information about these records. The important records were also copied. Many of them were formerly secret reports that were declassified. These reports are now available to the public,

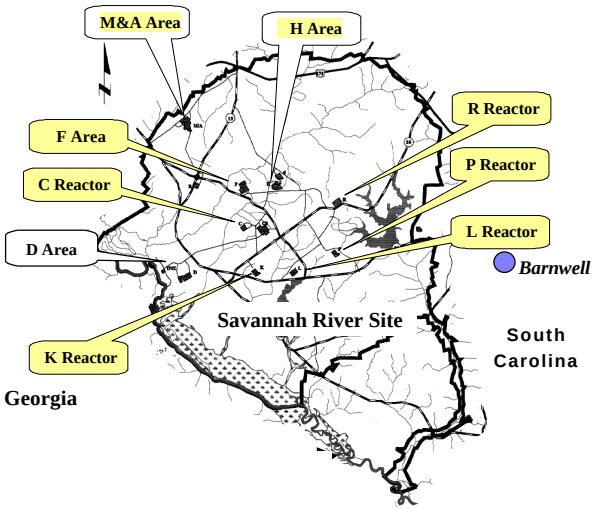

Figure 2. The Savannah River Site

* *Radiological Assessments Corporation* changed its name to *Risk Assessment Corporation* (*RAC*) in 1998.

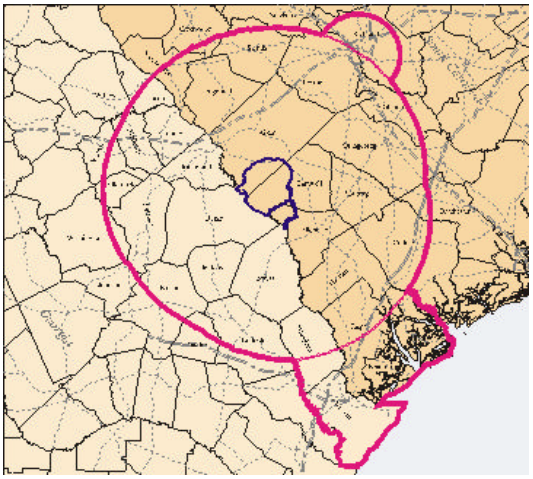

Figure 3. The Phase II study area

many for the first time, in the USC Aiken reading room or by request to the CDC.

RAC also performed Phase II of the study and looked carefully through the documents found in Phase I. Information was carefully analyzed about radioactive materials and chemicals released from the Site. Results were used to reconstruct the amounts of radioactive and chemical materials released to the environment. These release estimates will be needed later to estimate chemical exposure, radiation doses and risks to people who have lived offsite. In addition, *RAC* reviewed the results of past environmental monitoring done around the Site. The Phase II report describes the history and results of the environmental monitoring programs for air and rain, foods and vegetation, milk, wild game, sediments and soil, fish, and water from the Savannah River, community water supplies and water treatment plants. These data are valuable in a dose reconstruction study because they provides direct information about the concentrations of contaminants in the environment at particular places and times. The study area around the SRS is shown in Figure 3.

RAC reported the results of the Phase II study to the CDC in September 1998 for initial review. Outside experts including a citizens' SRS Health Effects Subcommittee are now reviewing a draft report that summarizes the findings of Phase II. *RAC* will revise the report after comments are received. The CDC plans to publish the final report late in 1999. The report will include a computer disk covering the information found in the study. The Phase II report is about 1400 pages long and contains hundreds of tables and figures.

Examples of Study Results

During Phase I, *RAC* listed the radioactive materials and chemicals used or produced at the Site. Phase II began by deciding which of these materials should be examined in detail. We made the decision by estimating which chemicals and radioactive materials were most likely to have moved offsite in air or water. These are the materials that might have affected the health of people who lived nearby. We also considered how harmful these materials might have been to humans and how much might have been released. The Health Effects Subcommittee, a citizens group appointed by the CDC to review this and other SRS research, helped make these decisions. Figure 4 shows other sources of radiation in the environment that must be considered and compared to releases from the Site.

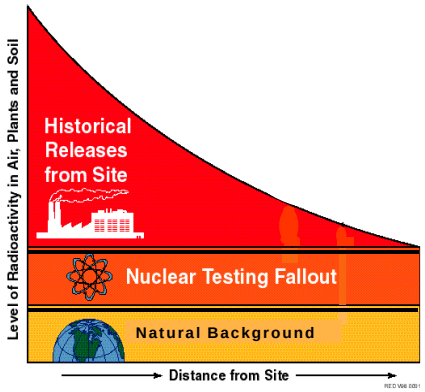

Figure 4. Radiation in the environment.

Selecting radioactive materials to study

We estimated the impact of specific radioactive materials by approximating the radiation dose that people may have received. (The dose is a measure of human exposure to radioactive materials.) We call this selection process a screening analysis. Table 1 shows those radioactive materials that we determined to be possibly important to a person who lived near the Site.

Table 1. Key Radioactive Materials

Releases to Air	Releases to Water
Iodine-131	Cesium-137
Tritium	Tritium
Argon-41	Strontium-90
Iodine-129	Cobalt-60
Plutonium-239,240	Phosphorus-32
	Iodine-131

Table 2. Chemicals and Heavy Metals

Arsenic	Benzene
Cadmium	Chromium
Coal	Coal Ash
Hydrogen Sulfide	Hydrazine
Gasoline	Diesel Fuels
Lead	Manganese
Mercury	Nickel
Nitric Acid	Nitrogen Dioxide
Sulfur Dioxide	Tetrachloroethylene
Trichloroethylene	Trichloroethane
Uranium	Zinc

Selecting chemicals to study

We used a similar method to select the chemicals to be studied. Thousands of chemicals were considered. Table 2 shows the chemicals we decided to include.

We focused our research on these key chemicals and radioactive materials.

Estimates of Releases from the SRS

Results of scientific studies have elements of uncertainty. This uncertainty results from random variations in measurements, and from a lack of knowledge about some processes. Our release estimates in the Phase II report are presented as intervals with central estimates called the median values. The lower and upper boundaries of the interval are called the 5th and the 95th percentiles and show our confidence in our estimates. We present here summaries of our release estimates for key SRS materials.

Radioactive material releases to air

Records of SRS tritium releases have been kept since the SRS opened. Most of the routine tritium releases came from the reactors and the tritium facilities. There were also about 3000 tritium release incidents. Figure 5 shows annual tritium releases to air from the reactors and from the tritium facilities. Throughout this report, radioactive materials releases are measured in curies. This unit is a measure of the radioactivity of a material.

To fit all of the information into Figure 5, we "stacked" the tritium releases for all 10 of the major facilities at the SRS into single bars for each year. The order of facilities in the figure legend matches the releases shown by the bars. As Figure 3 shows, the largest releases in the early years were from the buildings in which tritium was processed. Estimates of tritium releases to air are described fully in Chapter 4.1 of the Phase II report.

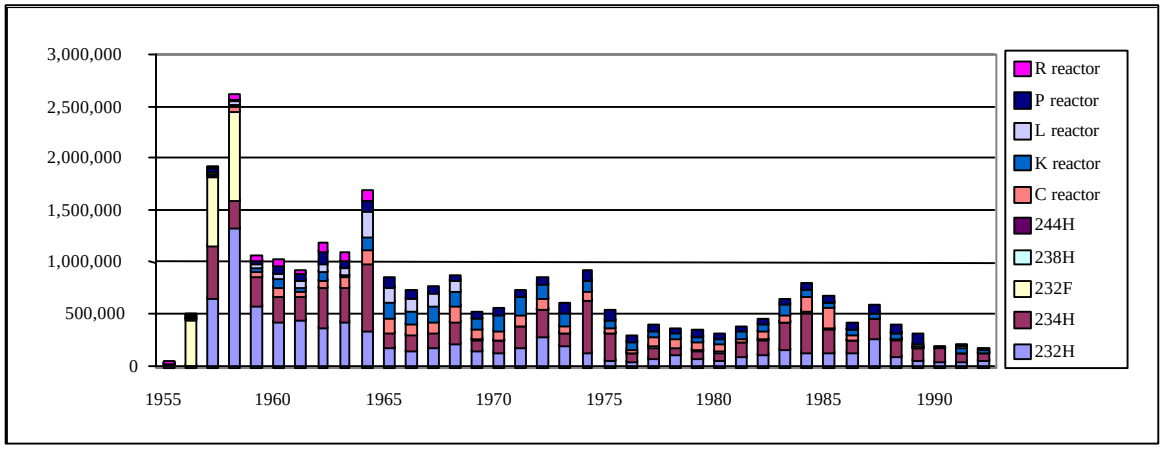

Figure 5. Annual tritium release estimates in curies per year for key facilities at the SRS.

Iodine-131 is another important radioactive material released to the air from the SRS. Figure 6 shows Site release estimates for iodine-131. This material was released into the air when reactor fuel was processed. There were SRS measurements available for the fuel processing plants, but the measurement methods were not adequate in the early years. We made corrections for sampling losses and for materials not collected. The results of our corrections give estimates of iodine-131 releases that are about 20 times higher than those reported by the SRS. This information is from Chapter 4.2 of the Phase II report. Figure 6 includes our estimates for both forms (elemental and organic) in which iodine-131 was released.

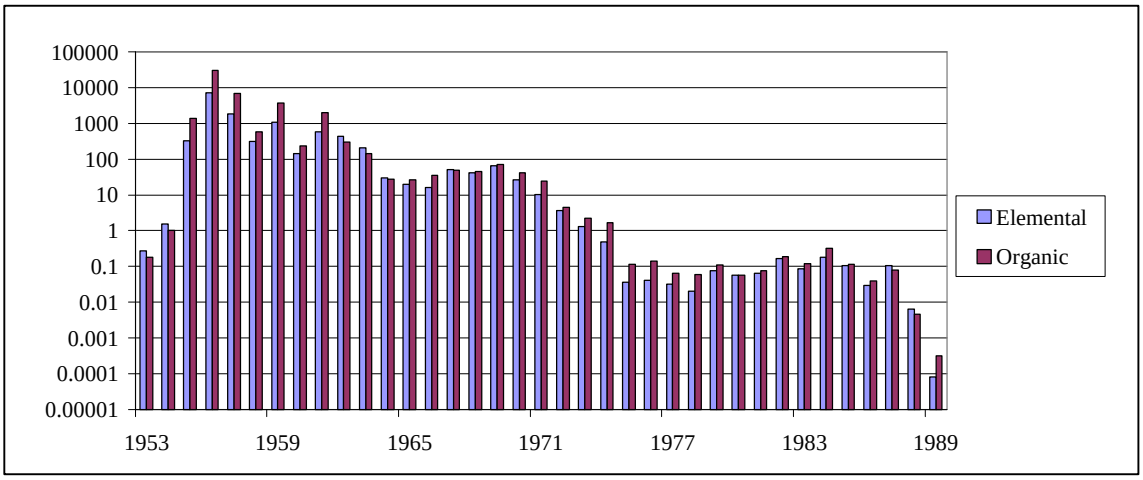

Figure 6. Iodine-131 release estimates in curies per year.

Radioactive material releases to water

Tritium, cesium-137 and strontium-90 were the main radioactive materials of concern for releases to surface streams and the Savannah River. We calculated detailed release estimates for these materials (see Chapter 5 of the Phase II report). We developed less detailed release estimates for several other less significant radioactive materials released to surface water. They are: iodine-131, phosphorus-32, and cobalt-60. Releases of radioactive materials to surface water were highest in the early to middle 1960s and became smaller into the 1980s. Figure 7 shows annual release estimates of tritium and cesium-137 to surface water. Strontium-90 release estimates are summarized in the Conclusions section of this report.

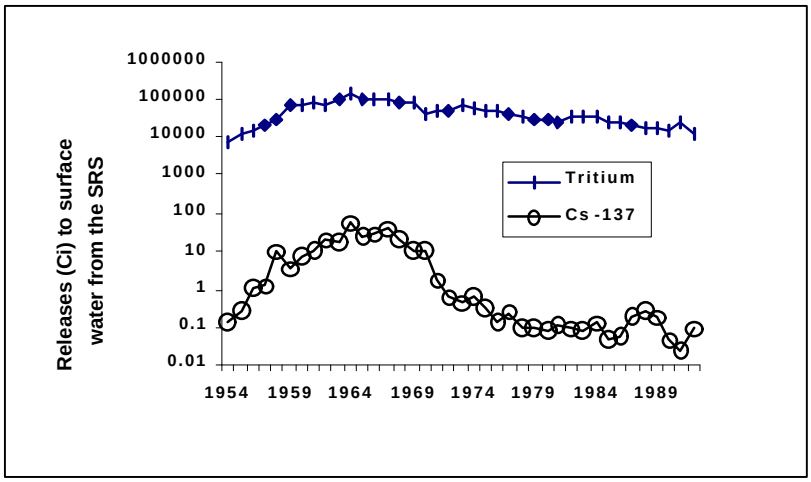

Figure 7. Median release estimates (in curies per year) of tritium and cesium-137 to surface water from the SRS.

Chemical releases to air

Radioactive materials monitoring (measuring the amounts in air or water) began early in the Site's operation. However, chemical releases were not regularly monitored until the 1980s. It was hard to find information about releases of chemicals for the early years. We often had to estimate chemical releases based on how they may have been used, rather than on measurements. Table 3 shows estimates of releases to air for chemicals of concern for which we found enough information. Here we show median release estimates and ranges of possible release values for several chemicals. Most of the nitrogen dioxide and sulfur dioxide was released from the coal-burning power plants at the SRS. Tables 3 and 4 are from Chapter 17 of the Phase II report.

Table 3. Release Estimates and Uncertainty Ranges for Chemicals Released to Air (tons per year)

Chemical	Median annual release	Uncertainty range
Coal ash	4200	2300–7100
Mercury	0.3	0.18–0.51
Nitrogen dioxide	6050	4320–8480
Sulfur dioxide	11000	8470–14400

Table 4 shows release ranges for additional chemicals, based on a more limited number of values reported in the records reviewed.

Table 4. Release Estimate Ranges for Some Chemicals Released to the Air

Chemical	Range of release estimates (tons per year)
Benzene	1.8–18
Lead	0.05–0.12
Manganese	0.07–1.9
Nickel	0.11–0.42
Nitric acid	30–150

Chemical releases to water

The Phase II report describes the sources and potential releases of arsenic, cadmium, chromium, coal and coal ash, gasoline, hydrogen sulfide, lead, manganese, mercury, nickel, nitrates, uranium, and zinc to water. Table 5 summarizes the release estimates for some of these chemicals. In addition, an undetermined amount of chromium used to treat high level waste tank cooling coil water was released.

Table 5. Summary of Estimated Releases of Chemicals to Surface Water

Release estimate (maximum or range)	Released to SRS creek or basin
2.2 lb per year of cadmium	To Tim's Branch
2000 lb per year of hydrogen sulfide	To Beaver Dam Creek
20–100 lb per year of lead	To Tim's Branch
30–1400 lb per year of lead	To the Separations Area Seepage Basins
3300–7700 lb per year of mercury	To the Separations Area Seepage Basins
0.2–18 lb per year of mercury	To Four Mile Creek in groundwater
250–4400 lb per year of nickel	To Tim's Branch
0–1383 tons per year of nitrate	To the Separations Area Seepage Basins
Up to 3890 tons per year of nitrate	To Four Mile Creek in groundwater
27–200 tons per year of nitrate	To Tim's Branch

Review of environmental measurements around the SRS

Looking ahead toward later phases of the study, *RAC* and CDC spent a great deal of time collecting and reviewing information on environmental measurements around the SRS. This information is not only published in the Phase II report, but is also available on the computer disks (CD-ROMs) created during the study. In a dose reconstruction, after researchers have made estimates of the amounts of toxic material that moved offsite and eventually reached people, environmental monitoring information can be used to check the estimates to see if the results make sense. Several chapters in the report, beginning with Chapter 7, present the results of our environmental monitoring data review.

CONCLUSIONS

These examples of the study's release estimates are snapshots of what is covered in the Phase II report. We can make some general statements about what we have found. One objective of the study was to find out if there was enough information in the SRS records to make estimates about the key materials released to the environment. The answer to this question is yes. CDC will use this information to carry out the Phase III of the study.

Another finding of the study is that there are some differences between our estimates of releases and those reported by the Site. For the important radioactive materials, these differences are not large in most cases. However, our release estimates to air for iodine-131 correct for a measurement problem found in the early records. They are much larger than the SRS-reported values. We also have calculated plutonium-239,240 release values to air that are about four times higher than reported SRS numbers. Plutonium-239 and plutonium-240 are commonly measured and reported together as plutonium-239,240.

This study found information that can be used to fill gaps where data were missing. This includes detailed information on reactor, reprocessing canyon and tritium production in Chapter 2 of the report. We also reported uncertainties in release estimates, which had not previously been calculated.

Overall release estimates for some key materials

We have summarized below some of the important results of the study. These release estimates are for the main operating period of the SRS, from about 1954 to about 1992. To simplify the results, we provide a central estimate and a range for most of the materials. The range consists of an upper and a lower value between which we think the actual released amount falls. We think that there is about a one-in-ten chance that the range doesn't include the actual amount released. Where we are less certain than this, we have added a comment about the range.

Radionuclide releases to air.

About 26 million curies of tritium were released from the SRS to the air. The range is 24 million to 28 million curies. Annual estimates of tritium releases for each facility are discussed in Chapter 4.1 of the Phase II report. Uncertainty ranges for releases from individual facilities for certain years are larger than the overall range given here. Because the half-life of tritium is about 12.5 years, much of the released tritium decayed away over the life of the SRS.

The estimated total release of iodine-131 to air is 57,000 curies. This estimate is the sum of the mean releases of both organic and elemental iodine from fuel processing and the reactors. The range is 28,000 to 86,000 curies. Most of this release occurred before 1962. About 80% of the iodine-131 releases were in organic form. Releases in that form are less likely to be transferred to cow's milk and to humans. Iodine-131 has a short half-life (about 8 days). As it was released, it decayed to very small levels within about two months. In contrast, the estimated 5.6 curies of iodine-129 released is still present in the environment. The iodine-129 range is 5.1 to 6.2 curies. The SRS-published iodine-131 release estimate is about 2500 curies, but it refers only to measured releases. The early measurement methods at the fuel processing facilities were not adequate. Our corrected release estimate is about 20 times higher than the SRS value, because we corrected for the early measurement problems.

Our estimate of total argon-41 release to air is based on SRS measurements after 1971, and SRS-estimated values before 1971. An estimated 6.4 million curies of argon-41 were released during SRS operations; most was released during the 1960s. Because of the short half-life of argon-41 (1.83 hours), offsite exposures would be very dependent on wind speed and direction. Only a very small fraction of the released gas would have been present in the offsite environment at any given time.

The estimated total atmospheric release of plutonium is 16 curies. This is about a factor of four greater than the amount reported by SRS, because we corrected for losses in sampling lines. The range is 6–44 curies. Virtually all of the releases were from the F and H fuel processing plants. Most of the total releases were due to filter failures, and occurred during 1955 and 1969.

Radionuclide releases to streams or to the Savannah River

Surface water releases of radionuclides were highest in the early to middle 1960s. Our estimate of total tritium released to the Savannah River is 1.8 million curies. The range is 1.3 million to 2.5 million curies. The Savannah River Site's release estimate was 1.6 million curies.

Our estimate of the total cesium-137 released to the Savannah River is about 250 curies. The release range is 100 to 600 curies.

Our estimate of the total strontium-90 to the river for all years is about 100 curies, with a range of 45 to 250 curies. The SRS original release estimate to SRS streams was about 100 curies.

Releases of chemicals and heavy metals to air and water

We have provided release estimates for the chemicals and heavy metals of concern. These numbers are summarized in the tables located just before this Conclusions section. The estimates are based on our understanding, after a long review, of the way chemicals were used and disposed onsite. There were very few actual release measurements taken earlier than the 1980s for these materials. However, the available environmental monitoring information does not indicate that there were significant releases of toxic chemicals or heavy metals from the SRS to surface water or ambient air.