Design of an Effective Radiological Effluent and Environmental Surveillance Program - History of Savannah River Site Environmental Monitoring Program Design – 15308

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ABSTRACT

An effective radiological effluent and surveillance program is critical for a nuclear facility to (1) comply with applicable regulations, (2) assess the potential impacts of operations to the environment and public, and (3) inform stakeholders and members of the public of any impacts. Radiological environmental monitoring includes three program elements − effluent monitoring, environmental surveillance, and dose assessments. The key to an effective program is defining the baseline and objectives based on regulatory requirements, identification of the critical exposure pathways, determining the spatial and temporal boundaries for the monitoring, and defining the reporting and action levels. Another key to an effective program is through continuous improvement by transforming the program based on operational facility changes and responding to technology advancements in the field of environmental monitoring.

The history of the Savannah River Site's (SRS) environmental monitoring program is an example of an effective program that has transitioned, changed, and improved over the years based on the site missions and operations. From the beginning of five production reactors and two chemical separations facilities to the current Site missions of Environmental Stewardship, National Security, and Clean Energy, the SRS environmental monitoring program has evolved. SRS has a unique ecological environment with the Site area covering 80,300 hectares, five major streams that lead to the Savannah River, various water bodies, and varied meteorological conditions. Airborne and liquid pathways to human exposure are complex and it is necessary to use a graded approach when monitoring these pathways. The SRS environmental monitoring program is designed and effective in ensuring and verifying that there is a minimal exposure impact on the public and the environment from Site operations.

INTRODUCTION

The Savannah River Site (SRS) has an environmental sampling and monitoring program for over 60 years in order to assess the impact of Site operations on the environment and to the public. The SRS was established in the early 1950s, with the primary mission to produce special nuclear materials (SNM) (such as Pu-239 and tritium) used in the production of nuclear weapons. Environmental baseline studies began during the 1950s which included baseline data on plant and animal communities, a biological study of the Savannah River by the Academy of Natural Sciences, and a landmark study of the local natural radioactivity. Tens of thousands of samples over 1.55×10^{10} square meters were collected in order to establish natural and anthropogenic background levels.

DISCUSSION

Designing an Effective Program

The general steps in designing an effective radiological effluent and environmental surveillance program include: (1) determining the baseline and objective for the monitoring, (2) determining the purpose and use of the data, (3) determining what data are needed, (4) determining where and when the data will be obtained, and (5) defining the procedures, data reporting, and action levels. All of these steps can be influenced by regulatory requirements and stakeholders. When designing the program, understanding the source term is critical in determining what data are needed. Defining the source term involves a thorough understanding of the usage of the site area characteristics from preoperational data, discharge rates, meteorological data, lifestyle, and food and water consumption information. This information helps to identify the critical exposure pathways and establish the spatial and temporal boundaries for the monitoring. Depending on the operational conditions, the frequency and type of measurements are also established. In some cases, the regulatory requirements establish strict guidelines for the monitoring.

SRS Environmental Monitoring Program

The SRS environmental monitoring program is very comprehensive and effective in achieving the objectives for the program. The SRS environmental monitoring objectives includes complying with the current federal and state regulations, Department of Energy (DOE) Orders, determining the critical pathways for exposure, and performing dose and risk assessments. The two program components of effluent monitoring and environmental surveillance are utilized to achieve those objectives and provide information for the dose assessments. Figure 1 shows the contaminant pathways for the liquid and airborne effluents.

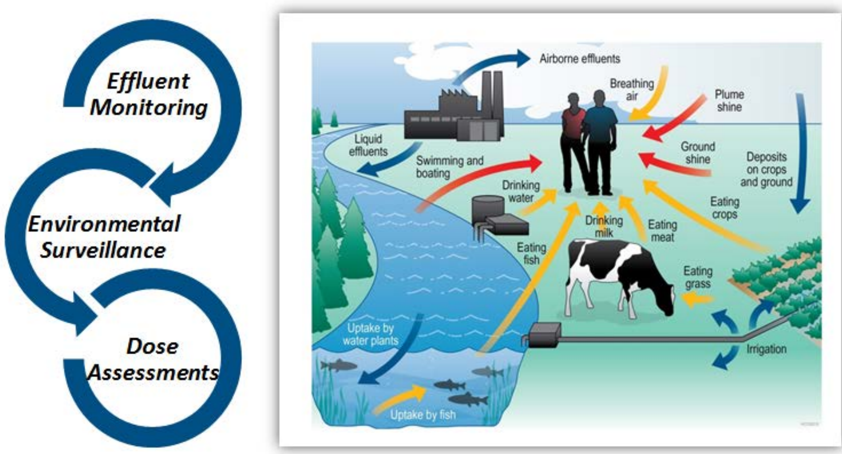

Fig. 1. SRS Effluent and Surveillance Contaminant Pathways.

General radiological effluent monitoring criteria involves use of standard monitoring techniques wherever practical, performing measurements at the point that is best representative of the contaminants released, accurately identifying and quantifying effluents, and selecting the appropriate sampling equipment and frequency.

The SRS airborne effluent program design framework is based on established standards for performance such as ANSI/HPS N13.1-1999[1] and ISO-2889-2010[2]. The SRS airborne effluent program is regulated through Environmental Protection Agency's National Emission Standards for Hazardous Air Pollutants (NESHAP) and DOE Order 458.1. SRS air emissions program utilizes a graded approach where sources are divided into four Potential Impact Categories (PICs) shown in Table I. Sources are divided into PIC categories using three years of actual emissions, potential emissions, dose calculations, and facility environmental evaluation checklists. The potential and actual emissions must be determined using EPA approved methods and dose calculations must be made using approved versions of EPA's CAP-88 dose model.

TABLE I. Airborne source potential impact category levels

Potential Impact Category (PIC Level)	Monitoring and Sampling Criteria	PEDE (mrem/yr)	Actual EDE (mrem/yr)
1	Continuous sampling and to include a real time monitor and alarm	>0.1	>1E-02
2	Continuous Sampling and off-line periodic analysis	>0.1	≤1E-02
3	Periodic quarterly sampling and off-line analysis	≤0.1	>1E-05
4	Annual administrative review of facility uses to confirm absence of radioactive materials in forms and quantities not conforming to prescribed specification and/or limits	≤0.1	≤1E-05

Note: PEDE = Potential Effective Dose Equivalent; EDE = Effective Dose Equivalent

Sampling is conducted using online or offline monitoring. There are many factors to consider when determining a representative sample for an effluent monitoring source which include air velocity, angular flow, uniform concentration of tracer gas, sample and stack flow, particle sampling, and media type representative of the contamination characteristics. NESHAP evaluations determining the PIC categories must be performed for a new source, new facility, or modification of an existing facility.

The radiological air surveillance program is based on a critical pathway analysis from the airborne effluent program results. Sampling locations are representative of the field meteorological conditions downstream of the effluent source points, at a height representative of inhalation, and using media representative of the radiological characteristics of the effluent air stream. Because there is no predominant wind direction at SRS air surveillance locations are designated at points in a ring around the site with at least one location every 45 degrees. Historically, the predominant airborne dose has been in the North direction. Figure 2 displays the sector specific dose to the representative person surrounding SRS and the air surveillance sampling locations within the 25 mile perimeter.

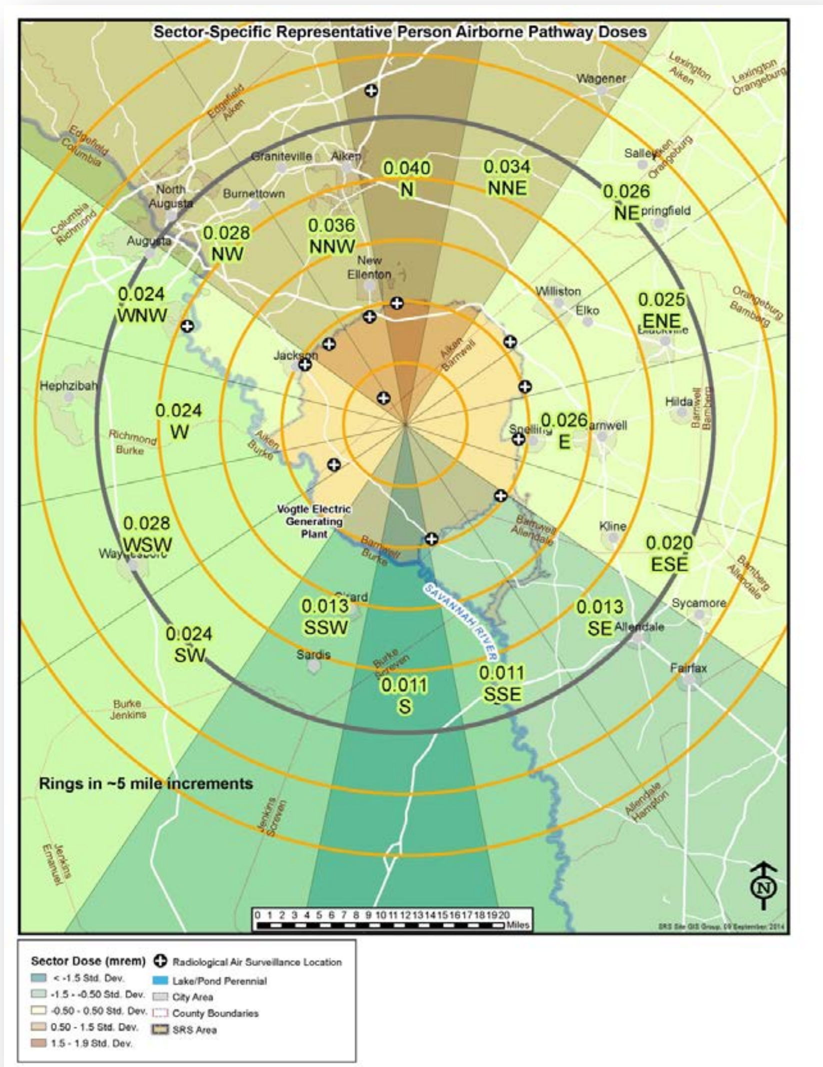

Fig. 2. 2013 Air Surveillance Locations with Sector Specific Airborne Dose.

The SRS radiological liquid effluent and surveillance program is based on DOE Order and the SRS critical pathway analysis. Established inventory limits are set at 10% of the annual limits on discharges to sanitary sewers. At SRS, these inventory amounts correspond to a representative person dose-from all pathways and to the nearest off site public receptor-of approximately 1.5×10^{-1} mrem, which is equivalent to a lifetime risk of about 1.0×10^{-7}. DOE has established

Derived Concentration Standards (DCS) that are utilized in determining when to apply the Best Available Technology (BAT) in order to reduce the dose to the public. SRS conducts activities so that liquid releases of radioactive materials from the operational activities shall be treated by the BAT if any of the following conditions exist:

- The surface waters otherwise would contain, at the point of discharge to surface waters and prior to blending, an annual average concentration of a given radionuclide that is greater than the DCS value. For multiple radionuclides, the composite DCS must be the sum of the fractional DCS values.
- The total effective dose (TED) to the public would otherwise exceed 10 mrem (0.1 mSv), with the liquid discharge.

Liquid Effluent source categories are established shown in Table II.

TABLE II. SRS liquid effluent source categories

Category	Sum of Fractions of DCS	Dose
I	Greater than 1.0	>100 mrem/year
II	Greater than 0.1, but less than 1.0	10-100 mrem/year
III	Greater than 0.001, but less than 0.1	>0.1- <10 mrem/year
IV	Less than 0.001, but radionuclide inventory is above the limits	<0.1 mrem/year
V	Less than 0.001 and radionuclide inventory is below the limits	<0.1mrem/year

Water monitoring design alternatives include online monitoring, periodic grab sampling, flow proportional sampling, and time proportional sampling. SRS utilizes all of the alternatives depending on the purpose for the monitoring. Locations of batch discharges utilize flow proportional sampling, whereas locations of continuous discharge utilize time proportional sampling.

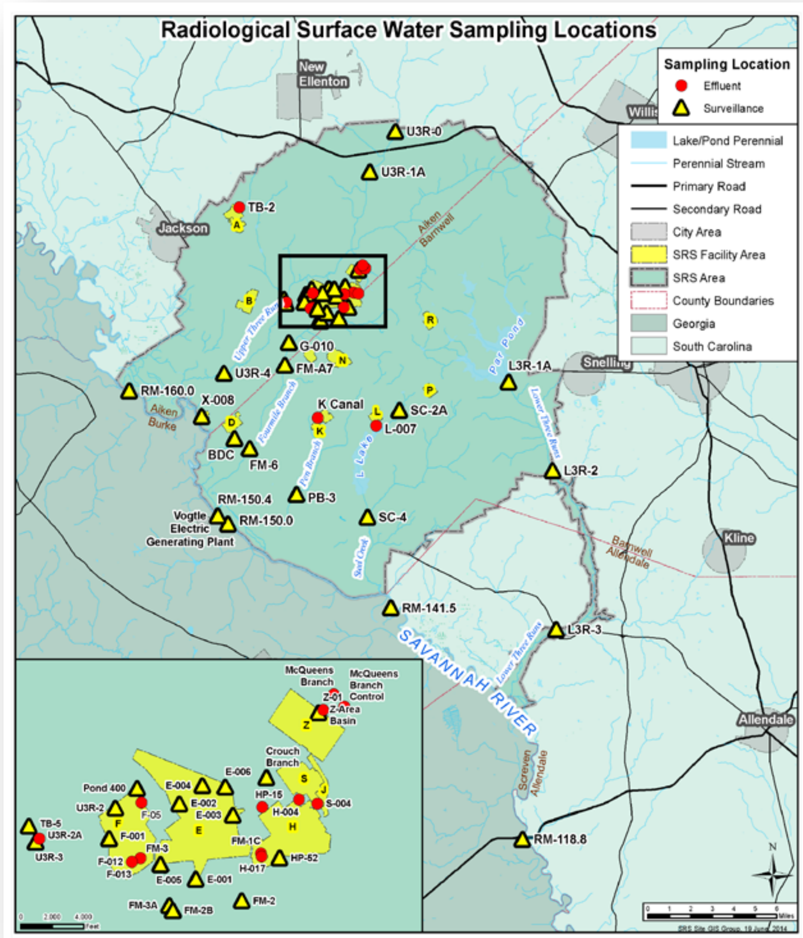

Fig. 3. Radiological Effluent and Surveillance Sampling Locations.

The SRS has five major stream pathways that discharge into the Savannah River. The Savannah River is utilized for drinking water downriver of SRS at Beaufort, SC and Savannah, GA. As shown in Figure 3, SRS has liquid effluent and surveillance sampling locations, that are located onsite and offsite in SRS streams, Savannah River, and at the effluent discharge points. SRS also has a drinking water surveillance program to monitor the drinking water upriver and downriver of SRS.

Besides surface water and air, other surveillance monitoring occurs based on the critical pathways for exposure to the biota and public. These include: groundwater, soil, sediment, food products, deer, hog, fish, and vegetation.

All of this information from both the radiological effluent and surveillance program feeds into the inventory accounting and dose evaluations that are reported in various reports to the regulators and annually in the SRS Annual Site Environmental Report which is available online at http://www.srs.gov/general/pubs/ERsum/index.html.

CONCLUSIONS

Designing an effective radiological effluent and surveillance program involves various components based upon the monitoring and regulatory objectives. These include defining: radiological sources characteristics, critical exposure pathways, spatial and temporal boundaries, and reporting and action levels. The SRS environmental monitoring program is comprehensive in meeting those requirements.

REFERENCES

1. American National Standards Institute/Health Physics Society. ANSI N-13-1-2011. Stack Sampling Considerations.
2. International Organization for Standardization. ISO 2889:2010. Sampling Airborne Radioactive Materials from the Stacks and Ducts of Nuclear Facilities.