MONITORING RADIONUCLIDES IN GEORGIA RIVERS BELOW NUCLEAR FACILITIES

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INTRODUCTION

Three nuclear power stations and a large nuclear facility operated by a contractor for the Department of Energy discharge radioactive liquid effluent into three major rivers in Georgia (see Figure 1 and Table 1).

The U.S. Nuclear Regulatory Commission and Department of Energy, respectively, require each operator to measure the types and amounts of released radionuclides, to undertake environmental monitoring, and to report results annually. In addition, the Georgia Department of Natural Resources (DNR) preforms confirmatory radiological environmental monitoring and presents the findings in periodic reports. Aquatic monitoring results obtained from the beginning of this program in 1978 until now are summarized here.

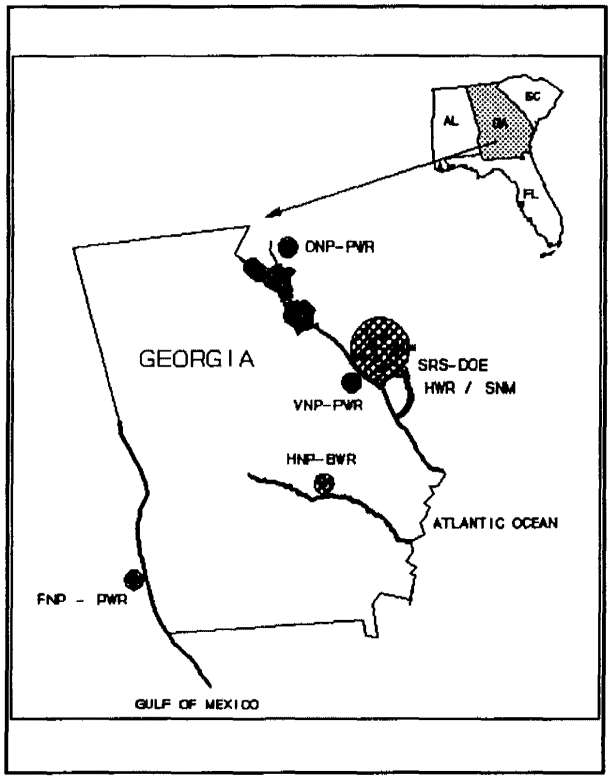

Figure 1. Nuclear Facilities at Georgia Rivers.

The annual discharges of radionuclides reported by these facilities in 1989 (Table 2) are typical. The largest discharge is of tritium (H-3), and the major discharger is the Savannah River Site (SRS). The amounts of all other radionuclides are much lower; however, because the radiation dose per curie (Ci) of tritium is relatively small, some of these lesser amounts of other radionuclides may contribute significantly to the total dose. Typical concentrations of radionuclides at points of release can be calculated from the mean river flows given in Table 1, e.g. the mean tritium concentration in the Savannah River was 5.52×10^{-8} Ci/ft^3 or 3030 pCi/L.

The sample types and sampling frequency of the DNR aquatic monitoring program are shown in Table 3. Because of the larger radionuclide discharges by SRS and multiple release sites, sampling is more extensive at that facility. The location is also unusual because Plant Vogtle on the Georgia side of the Savannah River faces SRS in South Carolina, hence liquid effluent from the two facilities mingle in the river.

Table 1. Rivers Monitored for Radionuclides

River System	Average Flow (cfs)	Facility	Operation
Savannah River	9993	Vogtle N.P.	2-Unit PWR
Savannah River	9993	SRS	H-3 Prod. & Sep. Pu Prod. & Sep.
Altamaha River	11190	Hatch N.P.	2-Unit BWR
Chattahoochee River	10710	Farley N.P.	2-Unit PWR

* Note: Flows are averaged for years of record (W.R. Stokes III et al., 1992.)

Table 2. Radionuclide Discharges to Surface Waters Reported for 1989.

Radionuclide	Amount, Ci (% of Water Pathway Dose)			
	SRS	Vogtle	Hatch	Farley
H-3	17,400 (24%)	913	46	1303
Sr-90	0.3 (3%)	ND	NR	NR
I-129	0.02 (0.3%)	NR	NR	NR
Cs-137	0.2 (71%)	0.0014	0.087	0.0045
Pu-239	0.01 (1.7%)	NR	NR	NR
Cs-134	NR	0.0008	0.036	0.001
Co-60	NR	0.037	0.023	0.023
Total Dose	0.3 mrem	0.04 mrem	0.3mrem	0.08mrem

A) Information for releases and dose calculations is from facility annual reports.
B) NR = not reported ; ND = not detected.

Table 3. Radiological Monitoring Program in Rivers near Nuclear Facilities.

Facility Number of Samples (Monthly, Quarterly, Annually)				
	Water	Sediment	Fish	Vegetation
SRS/Vogtle	7M, 8Q	40A	16A	11A
Hatch	2M, 2Q	22A	14A	7A
Farley	2Q	8A	6A	-

MONITORING

Samples of water, fish, shellfish and aquatic vegetation are collected upstream, near points of discharge, and at several locations downstream during periodic sampling trips by DNR or facility personnel. These samples are analyzed for radionuclide content at the Environmental Radiation Laboratory of the Georgia Institute of Technology. All samples are first analyzed in bulk by gamma-ray spectrometry to determine photon-emitting radionuclides such as cesium-137 (Cs-137), cesium-134 (Cs-134), iodine-131 (I-131), cobalt-60 (Co-60), cobalt-58 (Co-58), zinc-65 (Zn-65), and manganese-54 (Mn-54). Water samples are screened by measuring their gross alpha and beta particle activity.

The radionuclides tritium, strontium-89 (Sr-89), and strontium-90 (Sr-90) are determined radiochemically because they emit no photons: they are separated from contamination and measured by counting beta particles with liquid scintillation counters (for tritium) and low-background gas-flow proportional counters (for Sr-89 and Sr-90). For radiostrontium analysis, samples of fish and vegetation are first ashed, then fused, and finally dissolved in dilute mineral acid. I-131 is also determined radiochemically in water to attain lower levels of detection.

Tritium results for biota are for water content reported in picocurie per liter (pCi/L). Results for solids are reported in pCi per kilogram dried at 110' C. Tritium detection limits were initially 300 pCi/L, but were reduced to 100 pCi/L in 1990. Detection limits for photon-emitting radionuclides are 15 pCi/L in water, but in other media vary from about 10 to several hundred pCi/L, depending on the amount of sample, the measurement time interval and the size of the photon detector. Detection limits for radiostrontium and I-131 are about 2 pCi per sample, which could be a liter of water or several grams (dried weight) of solids.

All results are corrected for detector background, which is checked weekly for photon detectors and daily for beta particle detectors. Detectors are calibrated with radionuclide sources from or traceable to NIST. The laboratory participates in the US EPA radionuclide intercomparison program, in which the EPA distributes blind samples periodically to laboratories, and the results are reported to the distributor for evaluation.

RESULTS AND DISCUSSION

The only radionuclide consistently detected in water that could be attributed to nuclear facilities was tritium in Savannah River water due to SRS. As shown in Figure 2, from 1980 to 1992, the tritium concentration in water gradually decreased from approximately 4,000 to 2,000 pCi/L just below SRS points of discharge.

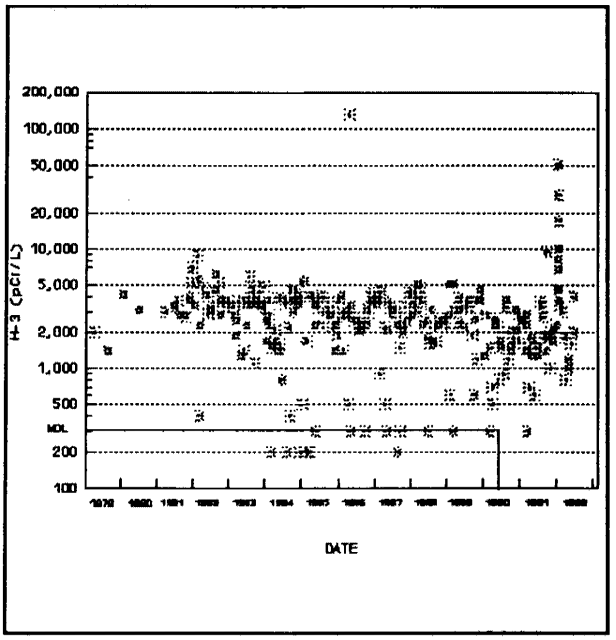

Figure 2. Tritium in Savannah River at R.M. 120.5 (US 301 Bridge).

About the same levels were in the river to its mouth, notably at the intake of the only downstream public water supply in Georgia at Port Wentworth, just above Savannah. The concentrations in downstream river water are consistent with the quotient of the average annual release rates and the river flow. Several miles above SRS in the Savannah River, the concentration was several hundred pCi/L. These levels are attributed to airborne tritium from SRS in moist air and precipitation.

On the two occasions shown in Figure 2, monitoring indicated peaks due to accidental releases of tritium at SRS. The second occasion, at the end of 1991, was the subject of detailed studies at the downstream public water intake (Hardeman, 1992).

A few samples of Chattahoochee River Water at tritium levels just above the detection limit were found below the Plant Farley outfall, probably during times of liquid waste discharges. Tritium levels just above the detection limit also were found in the Altamaha River below Plant Hatch, mostly as the result of an incident during which tritium-containing water was released in 1979.

Tritium concentrations in aquatic vegetation were the same as in water. Fish had similar levels, except for some higher levels in fish that are believed to have come from creeks at SRS where tritium concentrations in water were elevated.

Concentrations of Sr-90 were 0.2 pCi/L, and of Cs-137, 0.06 pCi/L, measured by SRS staff in the Savannah River downstream from SRS (Cummins et al., 1990), compared to 0.14 and 0.012 pCi/L, respectively, upstream. The downstream values are consistent with releases at SRS plus the upstream environmental background due to fallout from past nuclear tests in the atmosphere. These levels are extremely low and require concentrating large water samples for analysis. The radionuclides were not found at levels above the detection limits for this program in water at any of the sites.

Concentrations of Cs-137 and Sr-90 in fish in the streams below the four facilities generally ranged from below the 10 pCi/kg detection limit to about 1,000 pCi/kg, while upstream levels were up to several hundred pCi/kg. An exception to the above was the higher levels in fish collected near the mouths of creeks flowing into in the Savannah River at SRS. Cs-137 concentrations were as high as 22,000 pCi/kg in bass and 8,000 pCi/kg in sucker. Corresponding Sr-90 levels were as high as 15,000 and 20,000 pCi/kg in whole fish. Higher tritium levels in these fish (see above) suggested that the fish had recently been in creeks where radionuclide concentrations in water were higher before dilution by the Savannah River.

Sediment and vegetation below points of release at SRS, Plant Vogtle and Plant Hatch (but not Plant Farley) on some occasions contained photon-emitting radionuclides at levels above background. At SRS, the observed radionuclide was Cs-137 at levels of several hundred to several thousand pCi/kg, with the highest values in the mid-1980s. At Plant Hatch, the activation products Co-60, Zn-65, Mn-54, and the fission products Cs-137 and Cs-134 were at levels of several hundred pCi/kg in river sediment, and one to two orders of magnitude higher in sediment from an adjoining swamp into which radioactive water was released accidentally in 1986. At Plant Vogtle, radionuclides in the Savannah River were at similar levels and consisted of Co-60, Co-58, Mn-54, and Cs-137. Upstream samples contained only Cs-137 at about 100 pCi/kg attributed to fallout. These radionuclides presumably either settled in insoluble form or were sorbed by clay or other materials.

Aquatic ecosystem samples also contained naturally occurring radio-nuclides. The terrestrial radionuclides uranium plus daughters, thorium plus daughters and potassium-40, and cosmic-ray produced beryllium-7 were found in biota and sediment.

The total radiation dose due to effluents in the water pathway to nearby persons computed by each facility operator (see Table 1) was 0.3 mrem per year or less. At SRS, this radiation dose was calculated for persons consuming water at one of two public water supplies downstream or exposed through fishing, boating, and swimming downstream. At the nuclear power stations, continual consumption of river water at the point of discharge is assumed, although this does not occur.

These values should be compared to dose limits for persons not occupation- ally exposed -- i.e., members of the population at large -- of 100 mrem per year from all man-made sources and pathways (USNRC, 1991); of 25 mrem per year to such persons from the nuclear fuel cycle for commercial nuclear power stations; and of 4 mrem per year through consuming water from a public supply.

CONCLUSIONS

The only radionuclide continually at readily measurable levels in water in the monitored streams in Georgia was tritium discharged at SRS into the Savannah River. Some other effluent radionuclides were found in fish, sediment, and aquatic vegetation at specific locations and occasions. The observations generally confirmed values reported by the facility operators.

The radiation doses calculated to result from human exposure to the radionuclides at levels either measured in the environment or predicted from measured releases were well below regulatory limits at all four facilities in all three streams. The maximum annual dose was 0.3 mrem at two facilities.

The environmental monitoring program, in general, appears to meet the needs for monitoring routinely discharged radionuclides in liquid effluent, and has also identified and quantified unusual releases. Some program expansion appears desirable at SRS, as indicated by measurements of elevated levels of some radionuclides in fish near the facility. Analyses for radionuclides such as

plutonium that are in liquid effluent at SRS but are not currently monitored would also be useful additions.

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