WSRC-TR-93-473

Radioactive Effluents in Savannah River - Summary Report for 1992 (U)

by
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DOE Contract No. DE-AC09-89SR18035

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Radioactive Effluents in Savannah River
Summary Report for 1992 (U)

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Introduction

During 1992, low-level radiometric studies of the Savannah River continued to distinguish between effluent contributions from Plant Vogtle and the Savannah River Site. Measurements of these radioactive effluents are of mutual interest to both institutions, as they can address abnormal trends before they become health and legal concerns.

The Environmental Technology Section (ETS) has conducted radiometric studies of Plant Vogtle since late 1986, prior to its startup [ref 1]. The plant has two 1100 MWe pressurized water reactors developed by Westinghouse. Unit 1 started commercial operations in June 1987, and Unit 2 began in May 1989. During powered operations, ETS has routinely detected neutron-activated isotopes in controlled releases [refs 2-6] but all activities have been several orders of magnitude below the DOE guide values [ref 7]. In 1992, Vogtle effluents continue to have low activities in the river. The Vogtle release data and the ETS measurements have tracked well over the past six years.

ETS ultra low-level radiometric measurement techniques are used in this work. In general, river samples are concentrated on resins, prepared in the lab, and then counted in the Underground Counting Facility at 735-A [ref 8]. The bulk of the counting is by gamma spectrometry, but tritium is examined by liquid scintillation counting. The overall sampling/counting technique for gamma-ray analysis provides detection limits that are thousands of times lower than those routinely achievable. The tritium analysis also utilizes state-of-the-art detection sensitivity. An underwater NaI(Tl) detector at Hwy 301 Bridge provides continuous gamma monitoring of the Savannah River.

Summary

During 1992, the radioactive effluents in the Savannah River were less than those observed in 1991. Vogtle reported no significant releases in 1992, and in earlier years Vogtle improvements in pre-processing their releases had already effected a decreasing trend in release levels. Their effluents continue to be dominated by ^{58}Co, which had a maximum concentration of only 0.068 pCi/L, which is just 1/3 of the maximum observed in 1991. Many of the other man-made radionuclides observed in earlier years [refs 2-6] have now decreased to where some are not even detected, and no new radionuclides were detected in the 1992 Vogtle effluents. In addition to ^{58}Co, low levels of ^{60}Co were frequently observed, but only traces of ^{54}Mn and ^{95}Nb were observed. Contrary to earlier years, no ^{51}Cr, ^{57}Co, ^{59}Fe, or ^{95}Zr were seen in 1992. Tritium and ^{137}Cs were also monitored, but their levels generally remain consistent with known SRS sources. The maximum tritium observed near Vogtle was 2 pCi/mL. The maximum downstream tritium was higher (3.8 pCi/mL), primarily due to the tritium release from K-reactor in December 1991 [ref 9]; however, the levels had abated significantly prior to collection of the tritium samples of the present study. In addition to natural sources, the general levels in the Savannah River are due to routine releases from the effluent treatment facility and seepage basin migration into plant streams that flow into the river.

River Sampling

Samples were collected from the Savannah River at Shell Bluff, near the Vogtle outfall, and at Hwy 301 bridge. The increase in activity from Shell Bluff to Hwy 301 Bridge is due to the effluents from both Vogtle and SRS. Activities measured just upstream and downstream of the Vogtle outfall identify contributions from that plant alone. Specifically, samples were taken 0.3 mi above, 0.1 mi below, and at the Vogtle outfall. A map of the sampling sites is given in the appendix.

Resin, water, and sediment samples were collected using methods detailed in the Vogtle pre-start study [ref 1]. Each resin concentrator sample consists of ≈ 25 g of resin in a porous nylon bag. The samplers were in the river for two weeks, after which they were retrieved and returned to the lab. Water samples were collected directly, and sediment samples were scooped into a specially designed sampler pulled along the bottom of the river.

Laboratory Measurements

The resin concentrator samples provide the most comprehensive isotopic information. Each of these samples was dried and ashed, leaving a smaller volume and thus better geometry for the HPGe detector. Typically, two HPGe detectors, with ^{60}Co standard efficiencies of 20% and 25%, were used in counting these samples; both are located in the Underground Counting Facility. Also, a larger detector with ^{60}Co standard efficiency of 90% and an active/passive shield has been calibrated to examine these samples. Samples were counted overnight (or over the weekend) to assure good counting statistics for detecting low-level activities. The resulting HPGe gamma-ray spectra are analyzed with an IBM/PC-XT using the GRABGAM code [ref 8] to yield the activity (fCi) of each isotope detected in the resin sample. The average isotopic concentration (fCi/L) for the collection period is obtained by using empirical calibration data that relate the resin mass and collection time to the effective water volume (L).

The water samples were examined for tritium by liquid scintillation counting. A TRICARB™ LL 2050A low-level liquid scintillation analyzer was used. Vials with 3 mL of sample and 20 mL of OPTI-FLUOR™ scintillant were counted. Duplicate samples with 0.25 mL of tritium standard checked that the automatic quench corrections were being performed accurately.

Sediment samples were transferred to 1-L Marinelli beakers and then counted on the HPGe detectors as described above. The sample isotopic activities (fCi) from the gamma-ray analysis are divided by the dry weight (g) of each sample to yield the corresponding concentrations (fCi/g).

Underwater NaI(Tl) Measurements

The underwater NaI(Tl) detector operates from a stationary pontoon boat near Hwy 301 bridge. The detector has a 9" diameter by 4" long NaI(Tl) detector, four photo-multiplier tubes, and a high voltage/preamp unit - all contained in a waterproof stainless steel housing. The detector views its surroundings through a thin hemispherical dome.

The detector receives operating power via a waterproof cable connected to a ≈25 V DC supply in the cabin of the pontoon boat. A unit within the detector assembly boosts this voltage to about 1000 V for photo-tube operation. The AC-coupled detector signals are transmitted via the same cable to the cabin, where they are amplified and input to a multichannel analyzer.

Spectral data are collected on the multichannel analyzer, which comprises a COMPAQ 286 computer and an ACE MCA card from EG&G ORTEC. Spectra are stored on floppy disk in sequenced 24-hr periods for 2-3 weeks. The disks are retrieved and analyzed at the laboratory. This detector system provides better time resolution (1 day) than the resin concentrator method (2 weeks), but its sensitivity is lower by more than an order of magnitude [refs 3-6].

The performance of the underwater NaI detector during 1987-1991 illustrates that it has tracked the notable Vogtle releases quite reliably by its detection of ^{58}Co [ref 10]. By contrast, the NaI detector did not readily track SRS effluents during this period, as the concentrations of the dominant ^{137}Cs of SRS river effluents were below the detection limit for the NaI detector.

Results

The resin sampler analyses continued to indicate ^{58}Co, ^{60}Co, and ^{137}Cs, the most significant gamma-emitting radionuclides detected in the earlier studies [refs 2-6]. The 1992 results for these isotopes are given in Tables 1-3, along with plots in Figures 1-3. The other detected manmade gamma-emitting radionuclides are given in Table 4, where they are compared with the ^{58}Co levels.

Water analysis for tritium followed techniques used earlier [ref 1,2]. The 1992 tritium results are summarized in Table 5.

Sediments were analyzed for ^{58}Co, ^{60}Co, and ^{137}Cs to appraise whether any deposition is occurring during the transport of these isotopes in river water. The corresponding results are shown in Table 6.

Data for the underwater NaI(Tl) detector are presented in Figures 4 and 5. Figure 4 is an isometric plot of count rate vs gamma energy and date. Figure 5 compares the ^{58}Co detected by the underwater NaI(Tl) with that detected with the resin concentrator samples.

Discussion

In 1992, the decreasing trend of manmade radioactivity in the Savannah River continued. This was due to the fact that no major Vogtle releases occurred in 1992 and those that did occur benefited from earlier improvements in Plant Vogtle processing of effluent waste. River water samples show that Vogtle effluents contain fewer detectable nuclides, including ^{54}Mn, ^{58}Co, ^{60}Co, and ^{95}Nb. No evidence of ^{51}Cr, ^{57}Co, ^{59}Fe, or ^{95}Zr was observed in 1992, consistent with their overall decreasing trend from 1987 to 1991. Aside from these Vogtle contributions, the other activities were essentially consistent with levels of SRS radionuclides ^{3}H, ^{60}Co, and ^{137}Cs detected prior to Vogtle startup in 1987. The sediment samples complement the results observed for the river water. The underwater NaI(Tl) detector again provided continuous tracking of Vogtle effluents. As in the past, all measured radionuclide concentrations are well below DOE guides for drinking water.

The Vogtle effluents continue to be dominated by ^{58}Co. The reduced effluent discharges from Vogtle are consistent with the reduced levels of ^{58}Co observed in the samples analyzed by SRTC in 1992. The bulk of the ^{60}Co is also from Plant Vogtle, as the ^{60}Co levels measured immdeiately down stream of the outfall are the largest [Table 2]. Relative to ^{58}Co, the river concentrations of other Vogtle-produced isotopes [Table 4] are generally lower than in earlier years [refs 2-6].

During 1992, SRS still continued to be the major source for the ^{3}H and ^{137}Cs concentrations in the river. Excluding the tritium release from K reactor in late December [ref 9], Table 5 indicates that the average ^{3}H at Hwy 301 Bridge was 2.1 pCi/mL, which is similar to the 3.0 pCi/mL measured prior to Vogtle startup. The maximum ^{3}H concentration observed in this work was 3.8 pCi/mL at Hwy 301 Bridge on January 15. Also, ^{137}Cs concentrations ranging up to a maximum of 26 fCi/L were observed at Hwy 301 bridge, and these are consistent with an overall decreasing trend observed in recent years. The values near Vogtle were lower, averaging 3.9 ± 0.4 fCi/L and 3.2 ± 0.4 fCi/L for respective samples 0.3 mi above and 0.1 mi below the Vogtle outfall. This indicates no detectable ^{137}Cs contribution from Vogtle.

The sediment samples contained detectable ^{137}Cs, but little if any ^{58}Co or ^{60}Co [Table 6]. All activities observed in 1992 are lower or comparable to those observed in 1991. In general, the ^{137}Cs values are comparable to those observed in earlier years [refs 2-6].

The underwater NaI(Tl) detector at Hwy 301 Bridge continued to monitor Plant Vogtle effluents by detection of the ^{58}Co activity [ref 10]. An isometric plot of count rate vs gamma energy and time is given in Figure 4, where the peak near 800 keV

is identified with the 811 keV gamma of ^{58}Co. Figure 5 compares a time plot of this peak with a similar one for ^{58}Co concentrations measured with the resin samples. In 1992 only very low levels of ^{58}Co were observed at Hwy 301 Bridge, as illustrated by the data for the two profiles. The 795 keV gamma of naturally occuring ^{228}Ac contributes to the peak near 800 keV in the spectra, due to resolution limits of the underwater NaI(Tl) detector [ref 4]. No such resolution problem existed for the resin samples because they were counted on HPGe detectors. Thus in Figure 5, the underwater NaI(Tl) plot of Co-58 includes a background component whereas the corresponding plot for HPGe-counted resins does not.

Table 7 compares the maximum-detected river concentrations with the DOE guide limits for drinking water [refs 7,11]. All concentrations are well below the guide limits. Furthermore, the table illustrates that maximum concentrations in 1992 were all lower than those during 1987-1991.

Continuation of Study

These studies have continuously monitored the Savannah River since their inception in 1986. They will continue on a routine basis, as they provide early detection/correction of abnormal trends before actual health and legal concerns evolve. The program is mutually beneficial to both Vogtle and SRS, and cooperative efforts between the two sites continue to enhance the measurements program.

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Table 1. Co-58 Concentrations in 1992

(Values in fCi/L)[a]

Date	Plot X	Shell Bluff fCi/L	Above Vogtle fCi/L	Below Vogtle fCi/L	H301 Bridge fCi/L
12/18-01/15/92	1/2	6.81	7.72	32.68	6.88
01/15-01/29/92		-5.06	-6.29	4.87	-6.09
01/29-02/12/92	2/5	-2.84	-5.87	61.78	-5.53
02/12-02-26/92		-4.11	-3.85	19.96	-5.59
02/26-03/10/92	3/3	-5.50	-4.53	-7.15	-5.82
03/10-03/24/92		-4.55	-6.39	67.70	-5.08
03/24-04/07/92	4/1	-4.81	-3.84	24.46	-1.96
04/07-04/21/92		-3.46	-4.53	12.07	-5.51
04/21-05/05/92	4/28	-5.12	-2.52	25.57	-1.95
05/05-05/19/92		-1.53	-4.70	49.83	-3.53
05/19-06/02/92	5/26	-3.31	-2.70	49.69	2.18
06/02-06/16/92		-3.48	-5.16	28.44	-4.72
06/16-06/29/92	6/23	-3.22	-1.85	14.85	-4.58
06/29-07/14/92		-2.39	-2.66	7.60	6.62
07/14-07/29/92	7/21	-4.09	-3.83	26.84	-5.14
07/29-08/11/92		-3.20	-1.08	18.65	-3.68
08/11-08/25/92	8/18	-4.74	-2.54	13.03	-6.19
08/25-09/08/92		-2.84	-5.66	28.07	-10.49
09/08-09/22/92	9/15	-5.55	-6.30	14.11	-3.41
09/22-10/06/92		-6.60	-5.32	10.08	-3.04
10/06-10/20/92	10/13	-4.73	-4.12	14.15	-7.02
10/20-11/03/92		-6.04	-7.41	8.67	-9.77
11/03-11/18/92	11/10	-1.48	-3.24	25.84	-2.39
11/18-12/01/92		-5.98	-6.45	7.03	-3.17
12/01-12/15/92	12/8	-5.97	-6.15	-4.51	-9.44
12/15-12/29/92		-5.97	-8.40	7.68	-5.35

a) Counting error estimated at $\leq 0.82\sqrt{V}$ where V is entry value. Values with minus(-) are minimum detectable amounts or MDAs.

Table 2. Co-60 Concentrations in 1992

(Values in fCi/L)[a]

Date	Plot X	Shell Bluff fCi/L	Above Vogtle fCi/L	Below Vogtle fCi/L	H301 Bridge fCi/L
12/18-01/15/92	1/2	-6.10	-7.30	8.80	-7.20
01/15-01/29/92		-5.40	-5.80	4.40	-5.80
01/29-02/12/92	2/5	-2.80	-5.60	24.80	-5.20
02/12-02-26/92		-4.00	-3.90	18.00	-5.20
02/26-03/10/92	3/3	-5.70	-4.90	-5.80	-5.80
03/10-03/24/92		-4.30	-6.30	3.90	-4.80
03/24-04/07/92	4/1	-4.60	-3.80	-7.50	-1.10
04/07-04/21/92		-3.80	-4.80	8.00	-5.10
04/21-05/05/92	4/28	-4.60	-2.20	-5.60	-1.30
05/05-05/19/92		-1.60	-4.00	4.60	-3.00
05/19-06/02/92	5/26	-3.60	-2.60	4.10	-1.40
06/02-06/16/92		-3.10	-4.60	-5.10	-3.80
06/16-06/29/92	6/23	-3.60	-1.80	-2.70	-4.10
06/29-07/14/92		-2.30	-2.70	2.40	-4.20
07/14-07/29/92	7/21	-3.90	-3.60	4.40	-4.10
07/29-08/11/92		-3.10	-0.90	5.50	-3.40
08/11-08/25/92	8/18	-5.60	-2.30	6.30	-4.90
08/25-09/08/92		-5.90	-5.00	6.30	-8.40
09/08-09/22/92	9/15	-5.40	-5.40	1.60	2.70
09/22-10/06/92		-6.40	-4.60	-3.90	-2.80
10/06-10/20/92	10/13	-4.60	-4.20	5.40	-5.80
10/20-11/03/92		-5.60	-6.90	-7.30	-8.50
11/03-11/18/92	11/10	-1.50	-2.80	9.60	-2.30
11/18-12/01/92		-6.10	-6.70	-3.70	-2.30
12/01-12/15/92	12/8	-5.00	-5.10	4.50	-6.40
12/15-12/29/92		-5.10	-7.20	7.80	-4.90

a) Counting error estimated at $\leq 0.75\sqrt{V}$ where V is entry value. Values with minus(-) are minimum detectable amounts or MDAs.

Table 3. Cs-137 Concentrations in 1992

(Values in fCi/L)[a]

Date	Plot X	Shell Bluff fCi/L	Above Vogtle fCi/L	Below Vogtle fCi/L	H301 Bridge fCi/L
12/18-01/15/92	1/2	-3.66	-4.01	-2.14	14.77
01/15-01/29/92		-2.98	-3.72	1.76	11.50
01/29-02/12/92	2/5	5.08	4.00	3.83	17.16
02/12-02-26/92		2.80	5.55	5.02	19.04
02/26-03/10/92	3/3	-2.75	3.65	6.41	19.58
03/10-03/24/92		4.54	6.73	4.70	16.43
03/24-04/07/92	4/1	3.74	5.78	-3.48	4.63
04/07-04/21/92		3.93	3.39	-2.80	7.98
04/21-05/05/92	4/28	-1.96	-1.61	-2.97	5.97
05/05-05/19/92		-1.06	3.05	-1.18	3.53
05/19-06/02/92	5/26	3.13	-1.62	-0.84	6.63
06/02-06/16/92		-1.99	6.25	-1.16	11.62
06/16-06/29/92	6/23	2.91	3.46	2.67	9.23
06/29-07/14/92		-1.51	-1.33	-0.96	12.24
07/14-07/29/92	7/21	-2.26	-2.32	-1.70	4.76
07/29-08/11/92		1.90	1.31	-1.82	5.69
08/11-08/25/92	8/18	4.29	3.99	3.50	18.37
08/25-09/08/92		5.15	5.79	3.92	26.44
09/08-09/22/92	9/15	4.15	-3.39	3.95	20.45
09/22-10/06/92		-3.83	3.34	5.18	7.95
10/06-10/20/92	10/13	-2.54	7.59	3.66	17.61
10/20-11/03/92		-3.25	-4.03	-3.11	7.92
11/03-11/18/92	11/10	-1.00	1.81	2.81	3.85
11/18-12/01/92		-0.97	8.79	7.73	14.78
12/01-12/15/92	12/8	5.16	-1.88	-2.53	11.14
12/15-12/29/92		-3.14	-3.34	-2.91	10.75

a) Counting error estimated at $\leq 0.58 \sqrt{V}$ where V is entry value. Values with minus(-) are minimum detectable amounts or MDAs.

Table 4. Relative Isotopics Below Vogtle During 1992[a,b]

(Sample site 0.1 mi downstream of Vogtle)

Date	Plot X	Co-58	Isotopics % of Co-58 Activity below Vogtle								
		fCi/L	Cr-51	Mn-54	Co-57	Co-58	Fe-59	Co-60	Nb-95	Zr-95	Cs-137
12/18-01/15/92	1/2	32.68	0.00	0.00	0.00	100.00	0.00	26.79	18.87	0.00	-12.83
01/15-01/29/92		4.87	0.00	0.00	0.00	100.00	0.00	107.50	0.00	0.00	85.00
01/29-02/12/92	2/5	61.78	0.00	11.97	0.00	100.00	0.00	40.15	0.00	0.00	11.67
02/12-02-26/92		19.96	0.00	0.00	0.00	100.00	0.00	90.15	0.00	0.00	47.78
02/26-03/10/92	3/3	-7.15	0.00	0.00	0.00	*100.00	0.00	80.82	0.00	0.00	+175.34
03/10-03/24/92		67.70	0.00	0.00	0.00	100.00	0.00	5.74	0.00	0.00	13.75
03/24-04/07/92	4/1	24.46	0.00	0.00	0.00	100.00	0.00	-30.85	0.00	0.00	-27.86
04/07-04/21/92		12.07	0.00	0.00	0.00	100.00	0.00	66.36	0.00	0.00	-46.36
04/21-05/05/92	4/28	25.57	0.00	0.00	0.00	100.00	0.00	-21.80	0.00	0.00	-22.75
05/05-05/19/92		49.83	0.00	0.00	0.00	100.00	0.00	9.15	0.00	0.00	-4.91
05/19-06/02/92	5/26	49.69	0.00	6.15	0.00	100.00	0.00	8.34	0.00	0.00	-2.74
06/02-06/16/92		28.44	0.00	0.00	0.00	100.00	0.00	-17.93	0.00	0.00	-7.97
06/16-06/29/92	6/23	14.85	0.00	0.00	0.00	100.00	0.00	-18.28	0.00	0.00	35.13
06/29-07/14/92		7.60	0.00	0.00	0.00	100.00	0.00	31.40	0.00	0.00	-23.14
07/14-07/29/92	7/21	26.84	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	-12.39
07/29-08/11/92		18.65	0.00	0.00	0.00	100.00	0.00	29.39	0.00	0.00	-19.08
08/11-08/25/92	8/18	13.03	0.00	0.00	0.00	100.00	0.00	48.12	0.00	0.00	51.88
08/25-09/08/92		28.07	0.00	0.00	0.00	100.00	0.00	22.41	0.00	0.00	27.30
09/08-09/22/92	9/15	14.11	0.00	0.00	0.00	100.00	0.00	11.64	0.00	0.00	53.42
09/22-10/06/92		10.08	0.00	0.00	0.00	100.00	0.00	-38.62	0.00	0.00	100.53
10/06-10/20/92	10/13	14.15	0.00	0.00	0.00	100.00	0.00	38.33	0.00	0.00	50.66
10/20-11/03/92		8.67	0.00	0.00	0.00	100.00	0.00	-84.21	0.00	0.00	-71.93
11/03-11/18/92	11/10	25.84	0.00	9.22	0.00	100.00	0.00	37.12	0.00	0.00	20.09
11/18-12/01/92		7.03	0.00	0.00	0.00	100.00	0.00	-51.90	0.00	0.00	212.66
12/01-12/15/92	12/8	-4.51	0.00	0.00	0.00	*100.00	0.00	+100.00	0.00	0.00	*109.80
12/15-12/29/92		7.68	0.00	0.00	0.00	100.00	0.00	101.23	0.00	0.00	-77.78

a) All values are relative activities on resin sample, except for ^{137}Cs, which is corrected for collection efficiency.

b) MDA values of ^{58}Co are denoted with a minus(-) sign. Isotopic % is denoted with an astrick(*) for MDA cases, and with a plus(+) for detected cases.

Table 5. Tritium Concentrations in 1992

(Values in pCi/mL)[a]

Date	Shell Bluff	Vogtle Vicinity[b]			Hwy 301[c]
		+0.3 mi	0.0 mi	-0.1 mi	
1/15/92	<2.0	<1.4	<0.8	<1.7	3.8±1.0
2/12/92	<1.4	<0.9	<0.9	<1.1	2.7±0.9
3/10/92	<0.8	<2.0	<1.5	2.4±0.9	<1.3
4/07/92	<1.0	<1.0	<1.0	<1.0	1.6±0.6
5/05/92	<0.8	<0.5	<0.7	<0.5	2.2±0.5
6/02/92	<0.8	<0.7	1.8±0.5	1.0±0.4	2.7±0.5
7/14/92	<0.6	<0.7	<1.0	<1.1	1.9±0.5
8/11/92	<0.8	<0.6	<1.8	<0.8	2.6±0.9
9/08/92	<0.8	<0.8	<1.1	<2.4	1.4±0.8
10/06/92	<1.5	1.7±0.6	<1.4	<1.0	2.7±0.7
11/03/92	<0.6	<0.6	<0.9	<0.9	2.1±0.7
12/15/92	<0.5	<0.2	<0.3	<1.0	<0.6

(a) Errors are 2σ values (other errors in report are 1σ).

(b) Miles are measured upstream of Vogtle outfall.

(c) Level had peaked at 63 pCi/mL on 12/28/91 following tritium release from K-Reactor, before returning to normal levels below (details per ref 9).

Table 6. Sediment Concentrations in 1992

(Values in fCi/g = pCi/kg)

Isotope	Date	Vogtle Vicinity[a]			Hwy 301
		+0.3 mi	0.0 mi	-0.1 mi	
^{58}Co	03/31/92	<2.0	<4.2	<4.1	<5.3
	07/21/92	2.1 ± 0.7[b]	<1.9	<5.4	<7.0
	11/10/92	<4.4	<5.7	<4.2	<4.8
^{60}Co	03/31/92	<1.7	<2.5	<3.0	<3.9
	07/21/92	<1.7	<2.2	<3.4	<4.3
	11/10/92	<3.6	<4.3	<3.3	<3.6
^{137}Cs	03/31/92	15.2 ± 1.0	<4.4	5.2 ± 1.4	121 ± 3
	07/21/92	3.5 ± 0.8	5.3 ± 1.1	6.5 ± 1.3	126 ± 3
	11/10/92	7.7 ± 1.6	<5.2	15.9 ± 1.7	94 ± 3

(a) Miles are measured upstream of Vogtle outfall.

(b) Marginally detected - possibly a false positive.

Table 7. Comparison of Maximum 1987-1992 Levels with DOE Guides for Drinking Water

All measured levels are from samples 0.1 mi downstream of Vogtle outfall unless specified otherwise.

Isotope	Maximum Concentration (pCi/L)						
	1987	1988	1989	1990	1991	1992	DOE Guide[a]
^{3}H	47,300[b]	4200[c]	5800[c]	42,600[b]	10,000[d]	3800[e]	2,000,000
^{51}Cr	3.7	2.8	0.31	0.08	---[f]	---[f]	1,000,000
^{54}Mn	0.06	0.40	0.61	0.03	0.02	0.01	50,000
^{57}Co	0.02	0.02	0.01	0.005	---[f]	---[f]	100,000
^{58}Co	16.8	15.5	3.90	2.37	0.21	0.07	40,000
^{59}Fe	0.22	0.49	0.05	0.02	---[f]	---[f]	20,000
^{60}Co	0.14	0.49	0.23	0.08	0.11	0.03	5,000
^{95}Nb	0.10	0.50	0.10	---[f]	0.12	0.02	40,000
^{95}Zr	0.17	0.23	0.04	---[f]	0.03	---[f]	60,000
^{137}Cs	0.15[c]	0.39[c]	0.12[c]	0.09[c]	0.05[c]	0.03[c]	3,000

a) DOE 5400.5 (details per reference 11).

b) Value at Vogtle outfall.

c) Value at Highway 301 Bridge.

d) Value at Vogtle outfall, measured prior to 12/91 K Reactor tritium release (details per reference 8).

e) Value at Highway 301 Bridge, measured well after 12/91 K Reactor tritium release (details per reference 8).

f) Not detected at any location.

FIGURE 1. Co-58 in Savannah River in 1992

Locations are defined as: SB = Shell Bluff
VA = 0.3 mi Upstream of Vogtle
VB = 0.1 mi Downstream of Vogtle
BR = Highway 301 Bridge

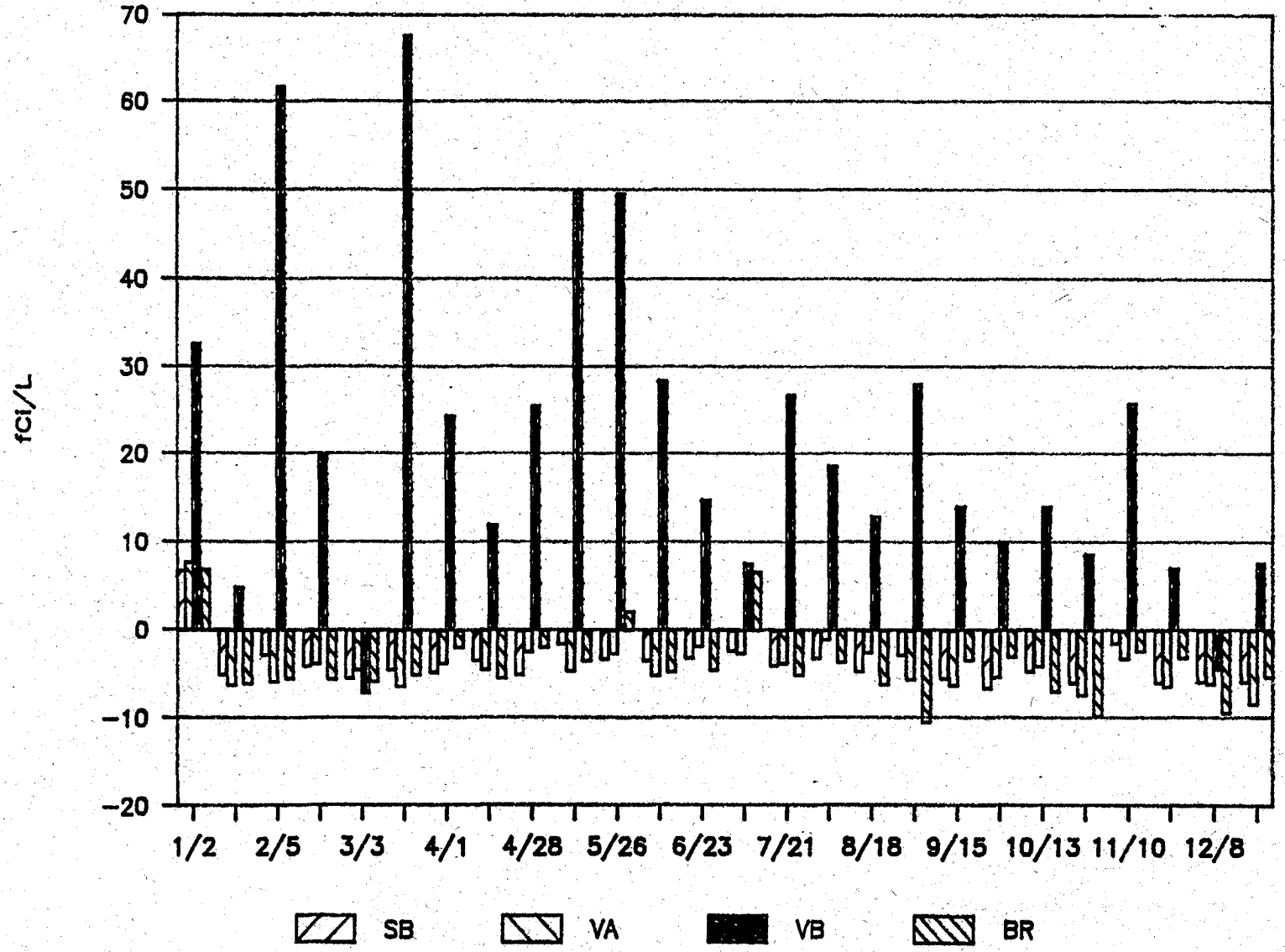


FIGURE 2. Co-60 in Savannah River in 1992

Locations are defined as: SB = Shell Bluff
VA = 0.3 mi Upstream of Vogtle
VB = 0.1 mi Downstream of Vogtle
BR = Highway 301 Bridge

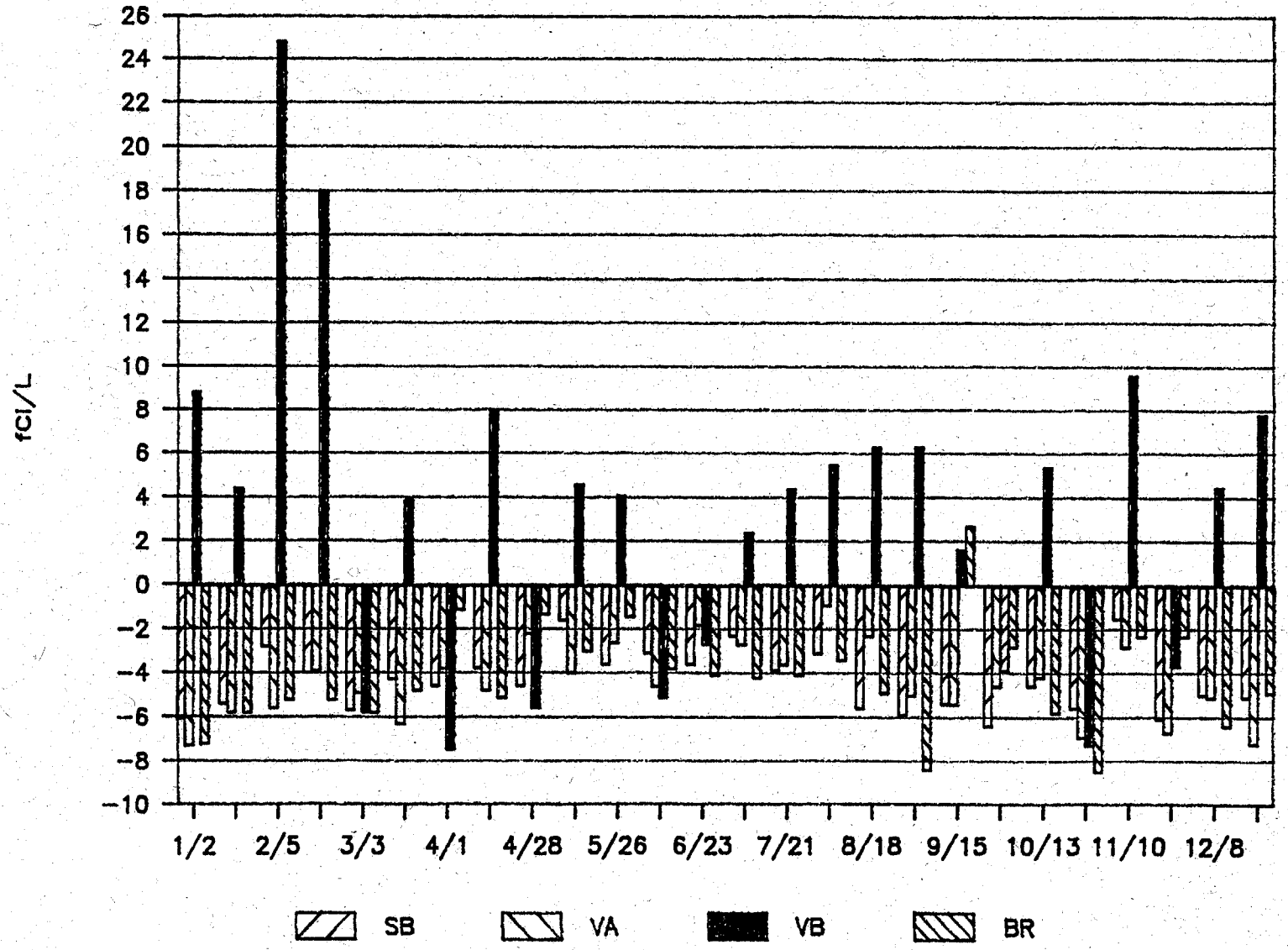
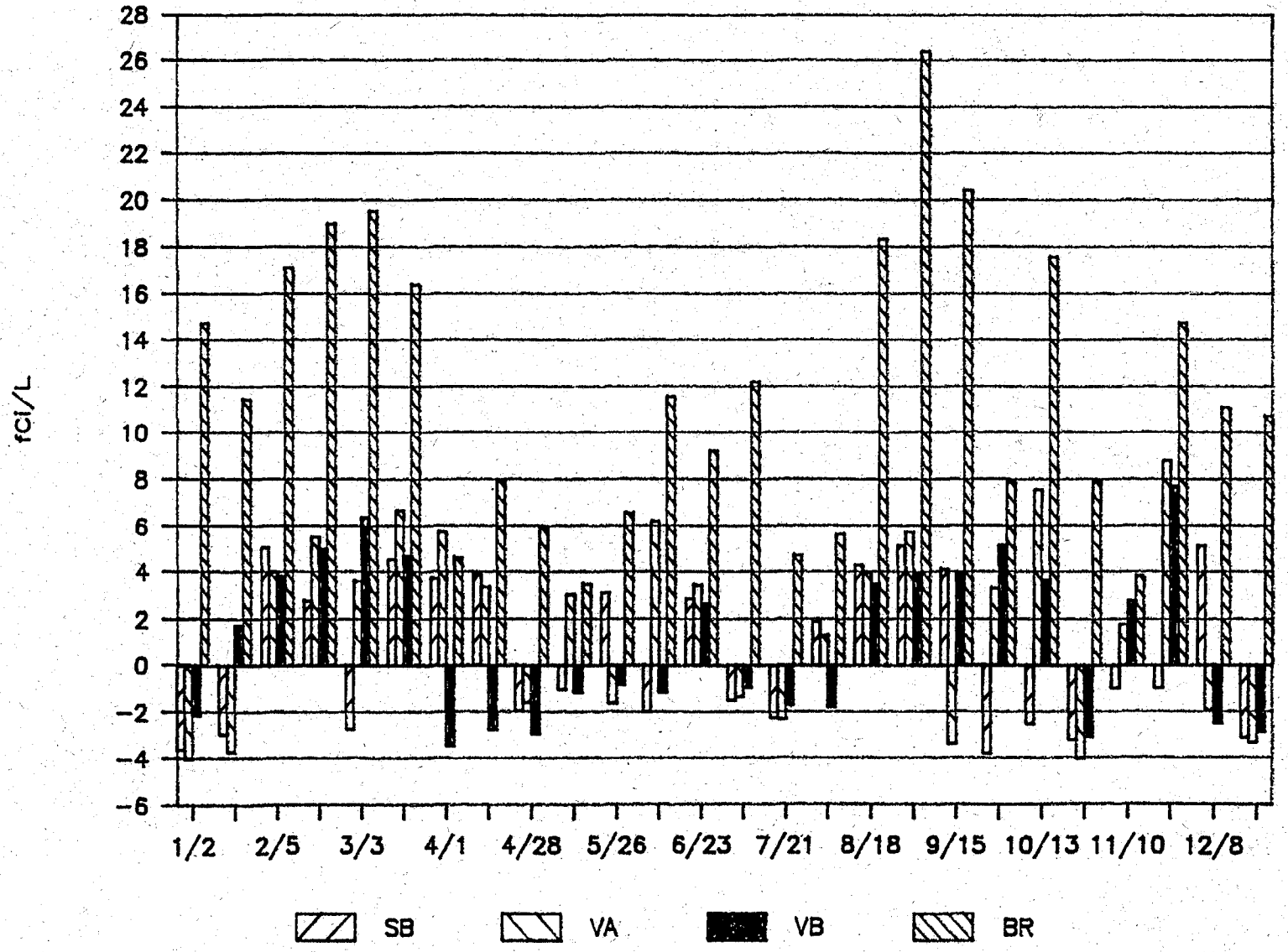


FIGURE 3. Cs-137 in Savannah River in 1992

Locations are defined as: SB = Shell Bluff
VA = 0.3 mi Upstream of Vogtle
VB = 0.1 mi Downstream of Vogtle
BR = Highway 301 Bridge



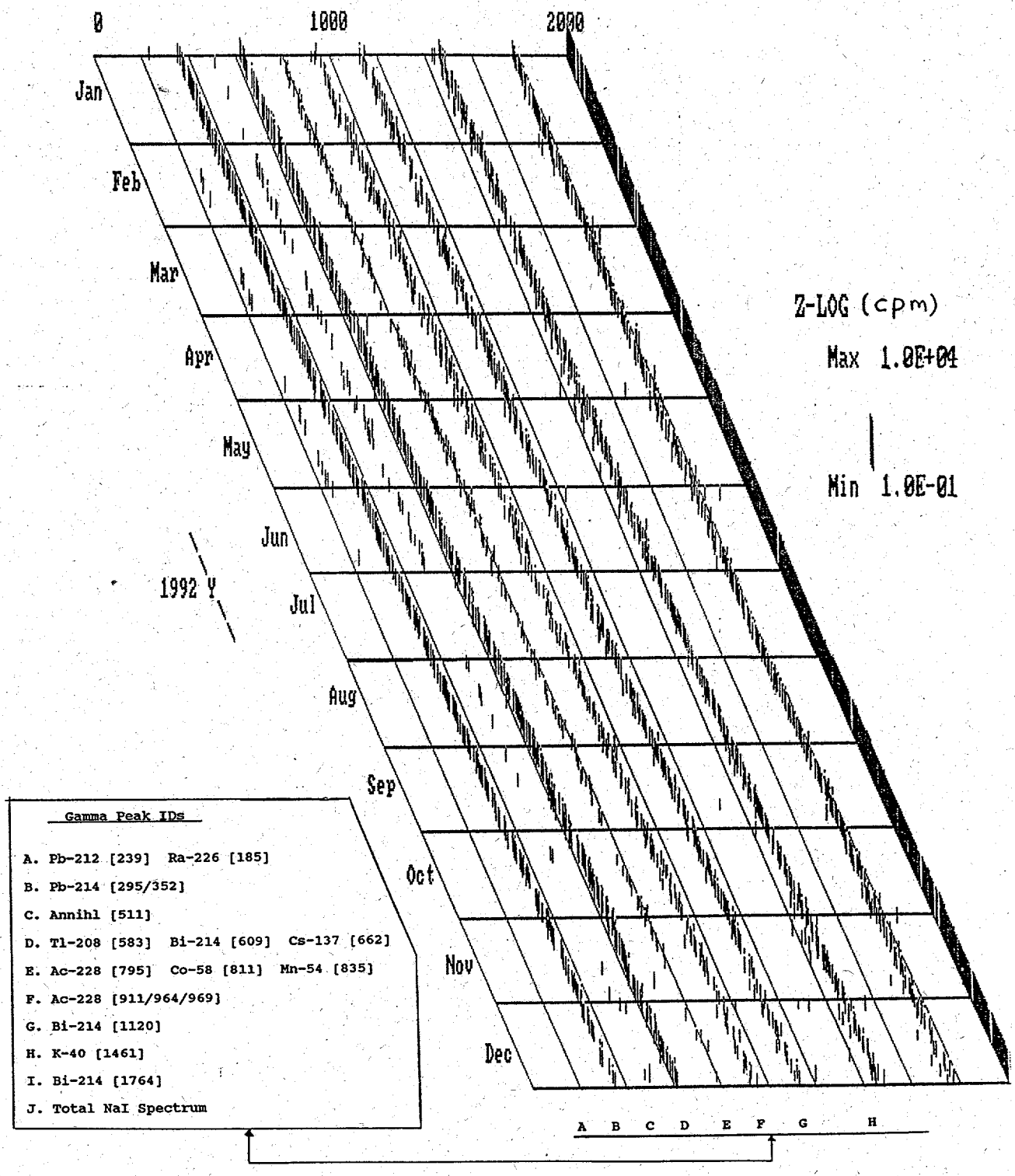
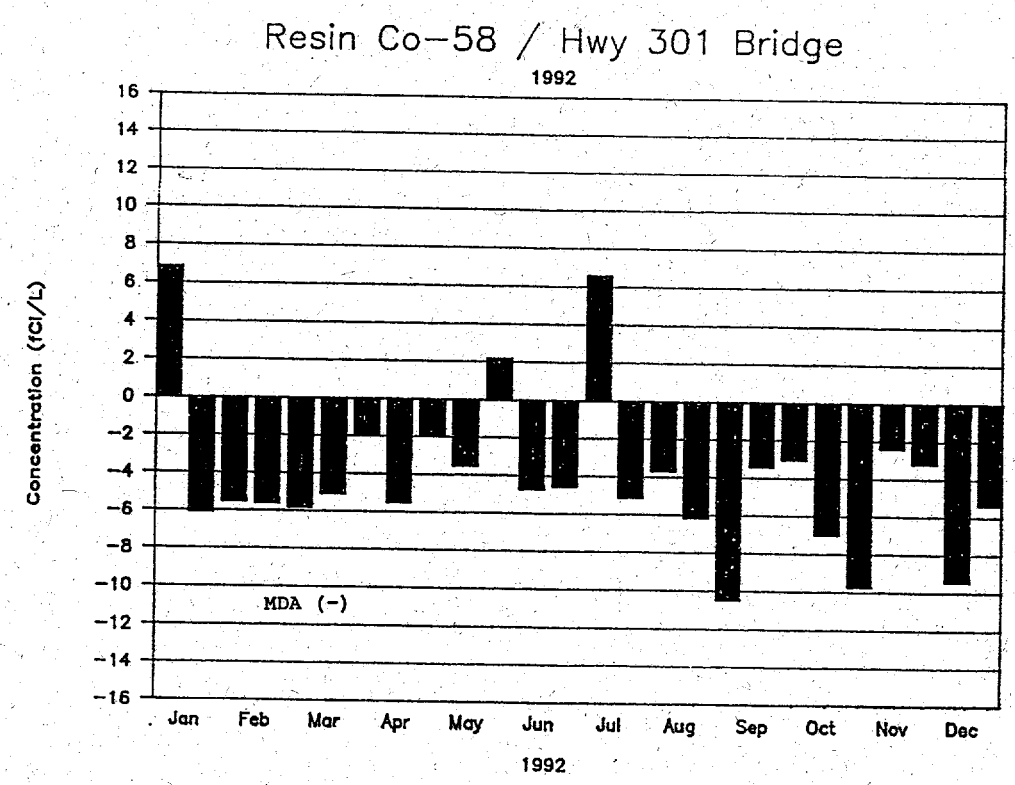


FIGURE 4. Results for Underwater NaI Detector at Hwy 301 Bridge



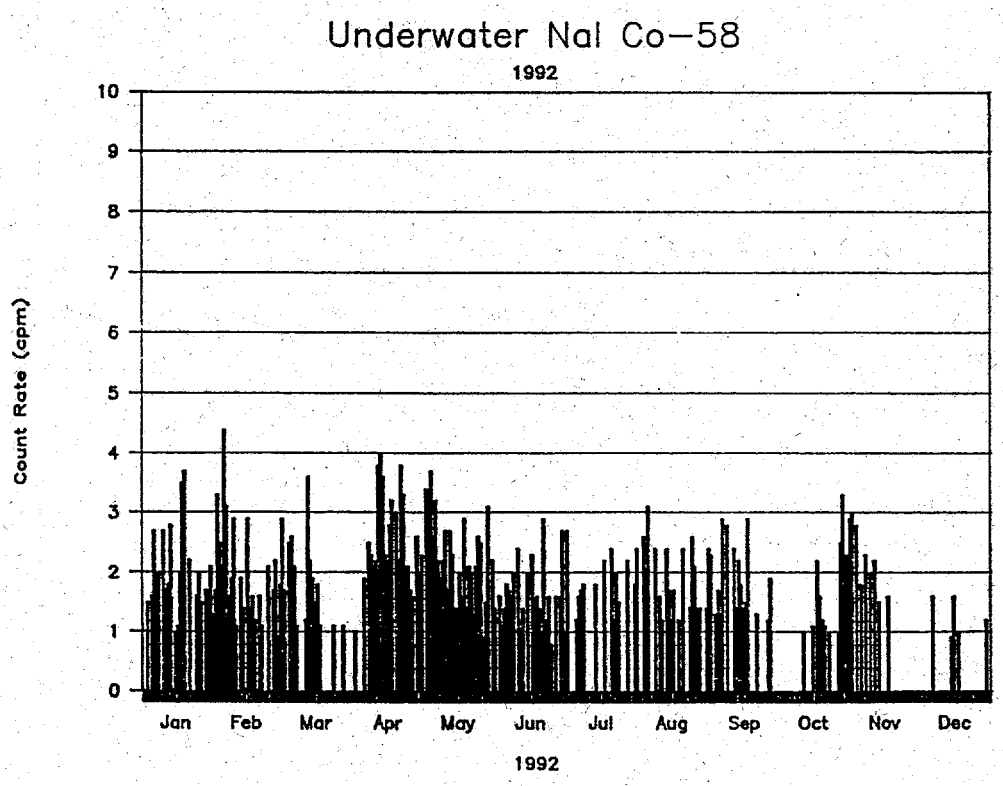


FIGURE 5. Comparison of Underwater NaI and Resin Sample Results for Co-58 detection at Hwy 301 Bridge

Appendix - Map of Sample Locations