Radioactive Effluents in Savannah River - Summary Report for 1996

by

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Savannah River Site
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Radioactive Effluents in Savannah River
Summary Report for 1996 (U)

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Introduction

During 1996, low-level radiometric studies of the Savannah River continued to monitor effluent contributions from Plant Vogtle and the Savannah River Site. Measurements of the radioactive effluents are of mutual interest to both institutions, as they can address abnormal trends before they become health and compliance concerns.

The Nonproliferation Technology Section (NTS), formerly 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 2-9] but all activities have been orders of magnitude below the DOE guide values [ref 10] and EPA/CFR levels [ref 11]. In 1996, Vogtle effluents continued to contribute low activities to the river. The Vogtle release data and the NTS measurements have tracked well over the past ten years.

NTS ultra low-level radiometric measurement techniques are used in this work. In general, river samples are collected on ion exchange resins, concentrated further in the lab, and then counted in the Underground Counting Facility at 735-A [ref 12]. Beginning in 1995, this study has only reported gamma

spectrometry measurements, as tritium analyses are now being conducted in another NTS facility, whereby very sensitive tritium gas proportional counting is used [ref 13]. The overall sampling/counting technique for gamma-ray analysis provides detection limits that are thousands of times lower than those routinely achievable. An underwater NaI(Tl) detector at Hwy 301 Bridge, which normally provides continuous gamma monitoring of the Savannah River, was redeployed in August, following refurbishing that was needed due to electrical surge damage.

Summary

During 1996, the radioactive effluents in the Savannah River were generally comparable to (or lower than) those observed during the earlier years of these studies, being orders of magnitude below DOE and EPA/CFR guide levels. Relative to SRS and Plant Vogtle, the upstream site at Shell Bluff and the downstream site at Hwy 301 Bridge are the only resin sampler sites still in service.

Vogtle associated activities were largest during June to August, and they are dominated by ^{60}Co as was the case in 1995. In earlier years, Vogtle effluents had been dominated by ^{58}Co. The maximum observed ^{58}Co and ^{60}Co were 52 fCi/L and 162 fCi/L; however, values an order of magnitude greater are projected just downstream of Plant Vogtle, as noted earlier [refs 9]. In addition to ^{58}Co and ^{60}Co, Vogtle activity for ^{54}Mn was correlated.

SRS associated gamma activities were for ^{137}Cs, which were observed at levels consistent with known SRS sources. In 1996, a isotope-specific resin was used for cesium collection, and this resulted in a maximum observed ^{137}Cs of 85 fCi/L at Hwy 301 Bridge. The standard resin yielded a maximum of 54 fCi/L, which is comparable to the 1995 result. Although the isotopic-specific resin generally yielded the higher ^{137}Cs concentration, the larger of the two resin values was adopted for conservatism.

River Sampling

Samples were collected from the Savannah River at Shell Bluff, near the Vogtle outfall, and at Hwy 301 bridge. Bi-weekly resin sampler for river water concentrations were only located at Shell Bluff and Hwy 301 Bridge. A map of the sampling sites is given in Appendix A. Quarterly sediment samples were taken near the Vogtle outfall and at Hwy 301 Bridge.

The current sampling philosophy relies on the data obtained from the earlier studies [refs 1-9] and the fact that no large-scale SRS reactor operations have occurred since 1988. Accordingly, Vogtle releases have been primarily dominated by

reactor produced neutron activation products (^{54}Mn, ^{58}Co, etc), which are unlikely to have a current source from SRS. Most of the releases attributed to SRS are from earlier release sources (primarily ^{137}Cs) that continue to contribute to the river. Earlier sampling [refs 1-9] had deployed resin samplers just above and below the Vogtle outfall to assure that the above distinction between Vogtle and SRS releases could be made. Should Plant Vogtle experience significant fuel failures incurring noticeable fission product releases (particularly ^{137}Cs), resumption of such sampling in the Vogtle vicinity would be strongly advised.

Resin and sediment samples were collected using methods detailed in the Vogtle pre-start study [ref 1]. Each resin concentrator sampler consists of ≈ 25 g of resin in a collector. Starting this year, the collections of both the standard resin sampler and a ^{137}Cs-specific resin sampler are now being incorporated into the analyses. The samplers were in the river for two weeks, after which they were retrieved and returned to the lab. 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 counting 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, larger detectors with ^{60}Co standard efficiencies of 90% and 160% have been calibrated to examine these samples. (The 90% HPGe includes an active/passive shield). 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 using the GRABGAM code [ref 12] 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).

Sediment samples were dried and transferred to 1-L Marinelli beakers for counting on the 20% and 25% HPGe detectors. 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 floating platform anchored near Hwy 301 bridge. The unit 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 with 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 14,15].

The performance of the underwater NaI detector during 1987-1994 illustrates that it has tracked the notable Vogtle releases quite reliably by its detection of ^{58}Co [ref 14,15]. By contrast, the NaI detector did not readily observe SRS effluents during this period, as concentrations of the dominant ^{137}Cs of SRS river effluents were below the detection limit for the NaI detector.

During 1996, the underwater NaI was re-outfitted with replacement photo-multiplier tubes, as the detector had failed in October of 1995 due to a line surge following a power outage by Planters Electric Co. The available replacement tubes did not yield as good resolution, but the detector was appraised as adequate to detect releases that were a few orders of magnitude below legal guidelines (see Table 6). The detector was redeployed in August, but various outages and equipment failures delayed steady operations until October. A spurious peak near 1100 keV caused some further loss of sensitivity, but the detector was still adequate to monitor releases that were about two orders of magnitude below legal guidelines. (The peak was identified as spurious in early 1997 per replacement of the detector amplifier).

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 2-9]. The 1996 results for these isotopes are given in Tables 1-3, along with plots in Figures 1-3. In addition, Appendix B describes how an inconsistency in a small group of measurements was corrected. The Shell Bluff and Hwy 301 data in the tables are staggered relative to their collection dates, which were different but overlapping until July 16 when both collections were reinstituted on the same schedule. Table 3 includes ^{137}Cs as predicted by the standard resin, the ^{137}Cs-specific resin, and their conservative maxima; Figures 3A, 3B, and 3C are the corresponding plots.

Other measurements of ^{58}Co, ^{60}Co, and ^{137}Cs were also performed in 1996 by NTS [ref 16]. These measurements utilized calibrated flow-through resin collectors with particulate prefilters. The resin portions were counted in the Underground Counting Facility, but the particulate prefilters were unwieldy for sample preparation and were not counted. No ^{58}Co or ^{58}Co was detected on the resin fraction at MDAs ranging down to 10 fCi/L, suggesting that these isotopes were collected as particulates on the prefilters because the unfiltered resins of the present work frequently detected both ^{58}Co and ^{60}Co at levels above 10 fCi/L. On the other hand, the ^{137}Cs fraction on the filter gave numbers comparable to the present work, suggesting that a significant portion of the ^{137}Cs was solution. Indeed, the resin fraction for Hwy 301 Bridge ^{137}Cs was 41 fCi/L, which agrees will with a value of 48 fCi/L obtained in the present work. Other comparisons between the two sets of measurements are given in Appendix B.

Other detected manmade gamma-emitting radionuclides are given in Table 4, where they are compared with the ^{60}Co levels. The table corresponds to Hwy 301 Bridge, in contrast to similar earlier tables [Refs 2-9] for measurements below the Vogtle outfall. Consequently, Table 4 does not exhibit as many Vogtle isotopes as observed in earlier years due to the less optimum sampling location.

Sediments were analyzed for ^{58}Co, ^{60}Co, and ^{137}Cs to appraise whether significant deposition is occurring during the transport of these isotopes in river water. The corresponding results are shown in Table 5.

Data for the underwater NaI(Tl) detector are presented in Figure 4, which is an isometric plot of count rate vs gamma energy and date. As mentioned earlier, the peak near 1100 keV is spurious, as signified by its meandering nature.

Discussion

River Water Activity Levels

In 1996, the maximum reported manmade radioactivities in the Savannah River were at Hwy 301 Bridge, but these do not represent the highest levels in the river for each isotope. The earlier studies utilized resin samplers 0.1 mi downstream of the Vogtle outfall, indicating neutron-activated isotope (NI) levels that were over an order of magnitude larger than those observed at Hwy 301 Bridge [ref 9]. This is apparent from Table 6, which compares the maximum reported levels of 1996 with those of earlier years. A more realistic comparison is effected by increasing the 1996 NI levels by an order of magnitude (factor of 10). Such a comparison indicates that the 1996 maxima for NI levels of ^{54}Mn, ^{58}Co, and ^{60}Co are not significantly different from those of 1995; unfortunately, the 1996 resin measurements (Hwy 301 Bridge) were not sensitive enough to detect/compare gamma activities of ^{51}Cr, ^{57}Co, ^{59}Fe, ^{95}Nb, and ^{95}Zr observed in earlier resin measurements (0.1 mi below Vogtle outfall). The ^{137}Cs maxima occurred at Hwy 301 Bridge and thus may be compared directly.

The earlier studies imply that SRS effluents dominate the observed ^{137}Cs, and that Vogtle is the primary source of the other manmade gamma-emitting radionuclides as they are all neutron activation products. Although the 1996 results are consistent with this pattern, they do not provide proof-positive confirmation. Indeed, the 1995 report (ref 9) noted evidence of pinhole leaks in Vogtle fuels which yielded a ^{137}Cs concentration of 45 fCi/L in a resin sample just below Vogtle. Such Vogtle levels are comparable to the 1996 maximum of 85 fCi/L and should be distinguished from SRS sources. Proof-positive distinction between SRS and Vogtle contributions to the Savannah River can only be determined by reinstituting the resin samplers above and below the Vogtle outfall.

Sediment Activity Levels

The sediment samples frequently exhibited ^{137}Cs, but ^{58}Co and ^{58}Co were not observed in 1996, as indicated in Table 6. Overall activities observed in 1996 are comparable to those observed in earlier years [refs 2-9]. The largest ^{137}Cs activities continue to be observed at Hwy 301 Bridge, having an average of 71 pCi/kg sediment.

Underwater NaI

The underwater NaI(Tl) detector at Hwy 301 Bridge did not produce sufficient data to examine ^{58}Co as had been done in the past [refs 2-8,14,15]. Indeed, the isometric plot of Figure 4 only exhibits activities from natural backgrounds of ^{40}K and ^{214}Bi. Although the detector will need to be thoroughly refurbished to

achieve sufficient resolution for detecting ^{58}Co and other manmade isotopes at levels comparable to the typical background, these isotopes are still detectable at levels a few orders of magnitude below the guide values of Table 6.

Drinking Water Guides

Table 6 compares the maximum-detected river concentrations with the DOE guide limits for drinking water [ref 10] along with similar EPA/CFR guide limits [ref 11]. All concentrations are well below these guide limits. Furthermore, the table compares the maximum concentrations in 1996 with those of earlier years; however, as explained above, the 1996 values should be increased by an order of magnitude to better represent the actual (as opposed to measured) maxima. All radionuclide concentrations are well below DOE and EPA/CFR guides for drinking water, as shown in the table.

Continuation of Study

These studies have continuously monitored the Savannah River since their inception in 1986. However, in October of 1995 the scope of the studies was narrowed due to funding, whereby the resin samplers above and below the Vogtle outfall were discontinued, leaving only the samplers at Shell Bluff and Hwy 301 Bridge. As mentioned earlier, the resulting samplers only provide information on the collective releases of SRS and Plant Vogtle without proof-positive evidence that distinguishes which institution is responsible for individual releases.

Funding for resin samplers at the mouths of SRS effluent streams was also discontinued in October 1995. The results for the effluent streams have not been included in this series of reports [refs 2-9], as these measurements were conducted with the aim of characterizing any significant SRS effluent releases involving gamma-emitting radionuclide, and no such releases have occurred during these studies. These ultra-sensitive gamma measurements on the five SRS effluent streams have been archived in a recent report to formalize closure of this phase of the work and to provide guidance on future options [ref 16].

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Table 1. Co-58 Concentrations in 1996

(Values in fCi/L)[a]

Date	Plot X	Shell Bluff fCi/L	H301 Bridge fCi/L
12/19-01/09/96SB	*	-9.05	
01/02-01/16/96BR			-6.26
01/09-01/23/96SB	J	-2.75	
01/16-01/30/96BR			-5.59
01/23-02/13/96SB	*	-4.25	
01/30-02/20/96BR			-2.35
02/13-02/27/96SB	F	-4.30	
02/20-03/05/96BR			-5.95
02/27-03/12/96SB	*	-5.36	
03/05-03/19/96BR			8.61
03/12-03/26/96SB	M	-3.71	
03/19-04/02/96BR			5.56
03/26-04/09/96SB	*	-2.53	
04/02-04/16/96BR			6.15
04/09-04/23/96SB	A	-3.28	
04/16-04/30/96BR			-5.64
04/23-05/07/96SB	*	-8.62	
04/30-05/15/96BR			7.34
05/07-05/22/96SB	M	-6.67	
05/15-05/28/96BR			6.65
05/22-06/04/96SB	*	-7.54	
05/28-06/18/96BR			46.89
06/04-06/22/96SB	J	-7.09	
06/18-07/02/96BR			-9.31
06/22-07/09/96SB	*	-3.89	
07/02-07/16/96BR			43.15
07/09-07/16/96SB	-	-3.10	
07/16-07/30/96BR	J		26.25
07/16-07/30/96SB	-	-5.80	
07/30-08/13/96BR			23.27
07/30-08/13/96SB	*	-6.25	
08/13-08/27/96BR			52.37
08/13-08/27/96SB	A	-8.46	
08/27-09/10/96BR			38.31
08/27-09/10/96SB	*	-6.56	
09/10-09/24/96BR			44.29
09/10-09/24/96SB	S	-7.52	
09/24-10/08/96BR			43.37
09/24-10/08/96SB	*	-7.83	
10/08-10/22/96BR			23.30
10/08-10/22/96SB	O	-5.98	
10/22-11/05/96BR			25.70
10/22-11/05/96SB	*	-2.98	
11/05-11/19/96BR			32.22
11/05-11/19/96SB	N	-1.81	
11/19-12/03/96BR			27.36
11/19-12/03/96SB	*	-1.42	
12/03-12/17/96BR			11.58
12/03-12/17/96SB	D	-4.90	
12/17-01/07/97BR			-8.32
12/17-01/07/97SB	*	-5.85	

a) Counting error estimated at $\leq 0.82\ V^{1/2}$ where V is entry value. Values with minus(-) are minimum detectable amounts or MDAs.

Table 2. Co-60 Concentrations in 1996

(Values in fCi/L)[a]

Date	Plot X	qe	Shell Bluff fCi/L	H301 Bridge fCi/L
12/19-01/09/96SB	*		-7.30	
01/02-01/16/96BR				13.20
01/09-01/23/96SB	J		-2.70	
01/16-01/30/96BR				-5.60
01/23-02/13/96SB	*		-3.50	
01/30-02/20/96BR				4.00
02/13-02/27/96SB	F		-4.90	
02/20-03/05/96BR				14.20
02/27-03/12/96SB	*		-4.90	
03/05-03/19/96BR				19.00
03/12-03/26/96SB	M		-3.90	
03/19-04/02/96BR				2.40
03/26-04/09/96SB	*		-2.40	
04/02-04/16/96BR				10.00
04/09-04/23/96SB	A		-3.00	
04/16-04/30/96BR				9.00
04/23-05/07/96SB	*		-5.50	
04/30-05/15/96BR				10.10
05/07-05/22/96SB	M		-5.80	
05/15-05/28/96BR				8.60
05/22-06/04/96SB	*		-5.80	
05/28-06/18/96BR				41.30
06/04-06/22/96SB	J		-7.80	
06/18-07/02/96BR				-8.00
06/22-07/09/96SB	*		-3.40	
07/02-07/16/96BR				113.90
07/09-07/16/96SB	-		-3.10	
07/16-07/30/96BR	J			96.20
07/16-07/30/96SB	-		-5.50	
07/30-08/13/96BR				108.60
07/30-08/13/96SB	*		-6.60	
08/13-08/27/96BR				161.70
08/13-08/27/96SB	A		-6.00	
08/27-09/10/96BR				111.40
08/27-09/10/96SB	*		-4.80	
09/10-09/24/96BR				56.60
09/10-09/24/96SB	S		-6.20	
09/24-10/08/96BR				35.90
09/24-10/08/96SB	*		-3.20	
10/08-10/22/96BR				23.20
10/08-10/22/96SB	O		-2.70	
10/22-11/05/96BR				26.90
10/22-11/05/96SB	*		-1.40	
11/05-11/19/96BR				31.00
11/05-11/19/96SB	N		-0.90	
11/19-12/03/96BR				48.30
11/19-12/03/96SB	*		-0.50	
12/03-12/17/96BR				17.40
12/03-12/17/96SB	D		-3.40	
12/17-01/07/97BR				9.90
12/17-01/07/97SB	*		-4.40	

a) Counting error estimated at $\leq 0.75\ V^{1/2}$ where V is entry value. Values with minus(-) are minimum detectable amounts or MDAs.

Table 3. Cs-137 Concentrations in 1996

(Values in fCi/L)[a]

Date	Plot X	Standard Resin		Isotope Specific Resin		Maximum of Resins	
		Shell Bluff fCi/L	H301 Bridge fCi/L	Shell Bluff fCi/L	H301 Bridge fCi/L	Shell Bluff fCi/L	H301 Bridge fCi/L
		Cs137 Rev		Cs-137 Rev			
12/19-01/09/96SB	*	12.13		21.98		21.98	
01/02-01/16/96BR			20.90		60.88		60.88
01/09-01/23/96SB	J	7.23		23.45		23.45	
01/16-01/30/96BR			18.29		68.81		68.81
01/23-02/13/96SB	*	-2.49		23.43		23.43	
01/30-02/20/96BR			5.69		84.90		84.90
02/13-02/27/96SB	F	6.71		18.03		18.03	
02/20-03/05/96BR			18.43		47.94		47.94
02/27-03/12/96SB	*	-2.96		15.98		15.98	
03/05-03/19/96BR			7.28		40.67		40.67
03/12-03/26/96SB	M	2.56		8.66		8.66	
03/19-04/02/96BR			4.76		57.90		57.90
03/26-04/09/96SB	*	1.99		11.34		11.34	
04/02-04/16/96BR			10.69		59.65		59.65
04/09-04/23/96SB	A	9.44		18.47		18.47	
04/16-04/30/96BR			29.75		64.16		64.16
04/23-05/07/96SB	*	9.71		14.73		14.73	
04/30-05/15/96BR			35.85		55.28		55.28
05/07-05/22/96SB	M	8.46		16.03		16.03	
05/15-05/28/96BR			30.82		46.99		46.99
05/22-06/04/96SB	*	8.27		13.22		13.22	
05/28-06/18/96BR			30.05		20.60		30.05
06/04-06/22/96SB	J	14.82		12.74		14.82	
06/18-07/02/96BR			32.23		24.40		32.23
06/22-07/09/96SB	*	12.17		3.76		12.17	
07/02-07/16/96BR			53.80		37.48		53.80
07/09-07/16/96SB	-	5.14		8.14		8.14	
07/16-07/30/96BR	J		34.76		23.59		34.76
07/16-07/30/96SB	-	13.02		11.03		13.02	
07/30-08/13/96BR			48.61		22.26		48.61
07/30-08/13/96SB	*	16.30		8.14		16.30	
08/13-08/27/96BR			32.39		40.64		40.64
08/13-08/27/96SB	A	10.70		12.71		12.71	
08/27-09/10/96BR			37.01		33.93		37.01
08/27-09/10/96SB	*	9.37		11.88		11.88	
09/10-09/24/96BR			38.15		44.08		44.08
09/10-09/24/96SB	S	13.39		15.18		15.18	
09/24-10/08/96BR			17.09		13.70		17.09
09/24-10/08/96SB	*	11.58		12.12		12.12	
10/08-10/22/96BR			11.41		32.88		32.88
10/08-10/22/96SB	D	9.53		10.96		10.96	
10/22-11/05/96BR			22.47		40.21		40.21
10/22-11/05/96SB	*	6.24		17.64		17.64	
11/05-11/19/96BR			20.42		55.45		55.45
11/05-11/19/96SB	N	2.45		10.27		10.27	
11/19-12/03/96BR			28.90		53.65		53.65
11/19-12/03/96SB	*	2.66		11.39		11.39	
12/03-12/17/96BR			16.35		49.25		49.25
12/03-12/17/96SB	D	4.93		12.44		12.44	
12/17-01/07/97BR			23.58		45.52		45.52
12/17-01/07/97SB	*	5.67		1.55		5.67	

a) Counting error estimated at $\leq 0.58\ V^{1/2}$ where V is entry value. Values with minus(-) are minimum detectable amounts or MDAs.

Table 4. Relative Isotopics in Savannah River During 1996[a,b]

(Sample site at Hwy 301 Bridge)

Date	Plot X	Co-60	Isotopics % of Co-60 Activity at Hwy 301 Bridge								
		fCi/L	Cr-51	Mn-54	Co-57	Co-58	Fe-59	Co-60	Nb-95	Zr-95	Cs-137
12/19-01/09/96SB	*										
01/02-01/16/96BR		13.20	--	--	--	--	--	100.00	--	--	461.21
01/09-01/23/96SB	J										
01/16-01/30/96BR		-5.60	--	--	--	--	--	-100.00	--	--	1228.75
01/23-02/13/96SB	*										
01/30-02/20/96BR		4.00	--	--	--	--	--	100.00	--	--	2122.50
02/13-02/27/96SB	F										
02/20-03/05/96BR		14.20	--	--	--	--	--	100.00	--	--	337.61
02/27-03/12/96SB	*										
03/05-03/19/96BR		19.00	--	--	--	45.31	--	100.00	--	--	214.05
03/12-03/26/96SB	M										
03/19-04/02/96BR		2.40	--	--	--	230.77	--	100.00	--	--	2412.50
03/26-04/09/96SB	*										
04/02-04/16/96BR		10.00	--	--	--	61.54	--	100.00	--	--	596.50
04/09-04/23/96SB	A										
04/16-04/30/96BR		9.00	--	--	--	--	--	100.00	--	--	712.89
04/23-05/07/96SB	*										
04/30-05/15/96BR		10.10	--	--	--	72.47	--	100.00	--	--	547.33
05/07-05/22/96SB	M										
05/15-05/28/96BR		8.60	--	--	--	77.08	--	100.00	--	--	546.40
05/22-06/04/96SB	*										
05/28-06/18/96BR		41.30	--	33.24	--	113.51	--	100.00	--	--	72.76
06/04-06/22/96SB	J										
06/18-07/02/96BR		-8.00	--	--	--	--	--	-100.00	--	--	402.87
06/22-07/09/96SB	*										
07/02-07/16/96BR		113.90	--	17.18	--	37.88	--	100.00	--	--	47.23
07/09-07/16/96SB	-										
07/16-07/30/96BR	J	96.20	--	18.48	--	27.28	--	100.00	--	--	36.13
07/16-07/30/96SB	-										
07/30-08/13/96BR		108.60	--	15.59	--	21.42	--	100.00	--	--	44.76
07/30-08/13/96SB	*										
08/13-08/27/96BR		161.70	--	14.11	--	32.39	--	100.00	--	--	25.13
08/13-08/27/96SB	A										
08/27-09/10/96BR		111.40	--	20.03	--	34.39	--	100.00	--	--	33.22
08/27-09/10/96SB	*										
09/10-09/24/96BR		56.60	--	27.43	--	78.21	--	100.00	--	--	77.88
09/10-09/24/96SB	S										
09/24-10/08/96BR		35.90	--	--	--	120.69	--	100.00	--	--	47.60
09/24-10/08/96SB	*										
10/08-10/22/96BR		23.20	--	29.56	--	100.54	--	100.00	--	--	141.72
10/08-10/22/96SB	D										
10/22-11/05/96BR		26.90	--	26.42	--	95.62	--	100.00	--	--	149.48
10/22-11/05/96SB	*										
11/05-11/19/96BR		31.00	--	28.70	--	104.00	--	100.00	--	--	178.87
11/05-11/19/96SB	N										
11/19-12/03/96BR		48.30	--	21.46	--	56.65	--	100.00	--	--	111.08
11/19-12/03/96SB	*										
12/03-12/17/96BR		17.40	--	37.87	--	66.60	--	100.00	--	--	283.05
12/03-12/17/96SB	D										
12/17-01/07/97BR		9.90	--	--	--	--	--	100.00	--	--	459.80
12/17-01/07/97SB	*										

a) All values are relative activities on resin sample, except for ^{137}Cs, which is uses conservative maximum of Table 3.

b) MDA values are denoted with a minus(-) sign for all entries.

Table 5. Sediment Concentrations in 1996

(Values in fCi/g = pCi/kg)

Isotope	Date	Vogtle Vicinity[a]			Hwy 301[a]
		+0.3 mi	0.0 mi	-0.1 mi	-32.0 mi
^{58}Co	03/26/96	<5.9	<10.o	<8.2	<5.0
	07/09/96	<10.o	<5.6	<3.1	<4.1
	09/03/96	<8.2	<5.3	<5.1	<8.1
	10/15/96	<5.8	<3.5	<2.9	<7.8
^{60}Co	03/26/96	<4.8	<8.2	<6.7	<3.9
	07/09/96	<8.7	<6.6	<3.5	<3.5
	09/03/96	<7.7	<5.4	<5.0	<7.5
	10/15/96	<5.3	<4.0	<2.6	<7.4
^{137}Cs	03/26/96	4.6±1.4	9.9±2.7	<6.2	63.4±1.8
	07/09/96	13.7±2.9	7.8±1.4	12.5±1.1	43.2±1.4
	09/03/96	15.3±2.8	12.9±1.6	11.5±1.9	81.0±3.2
	10/15/96	10.7±2.0	10.0±1.5	4.4±0.8	97.2±3.3

(a) Miles are measured upstream of Vogtle outfall.

Table 6. Comparison of Maximum 1987-1996 Levels with 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)					
	1987-92	1993-94	1995[a]	1996	DOE Guide[b]	EPA/CFR[c]
^{3}H	47,300[d]	64,000[d]	2300[e]	1840[e]	2,000,000	20,000
^{51}Cr	3.7	1.0	<0.01	---[e]	1,000,000	6000
^{54}Mn	0.61	0.17	0.20	0.02[e]	50,000	300
^{57}Co	0.02	0.03	0.006	---[e]	100,000	---
^{58}Co	16.8	1.81	0.46	0.052[e]	40,000	9000
^{59}Fe	0.49	0.06	<0.01	---[e]	20,000	200
^{60}Co	0.49	0.42	1.31	0.16[e]	5,000	100
^{95}Nb	0.50	0.10	0.02	---[e]	40,000	300
^{95}Zr	0.23	0.05	0.01	---[e]	60,000	200
^{137}Cs	0.39[e]	0.07[e]	0.05[e]	0.08[e]	3,000	200

a) Below Vogtle data from January to September of 1995.

b) DOE 5400.5 (details per reference 8).

c) See reference 10, which shows that higher levels are being proposed for some of the above values.

d) Maximum value at Vogtle outfall is high relative to EPA/CFR level based on 4 annual mrem/yr dose, but the overall annual average at this location is well below EPA/CFR level. Also the river significantly dilutes these outfall levels.

e) Value at Highway 301 Bridge. For ^{54}Mn, ^{58}Co, and ^{60}Co, projected actual maxima are ≥ 10X higher. (^{3}H from Ref 13).

FIGURE 1. Co-58 in Savannah River in 1996

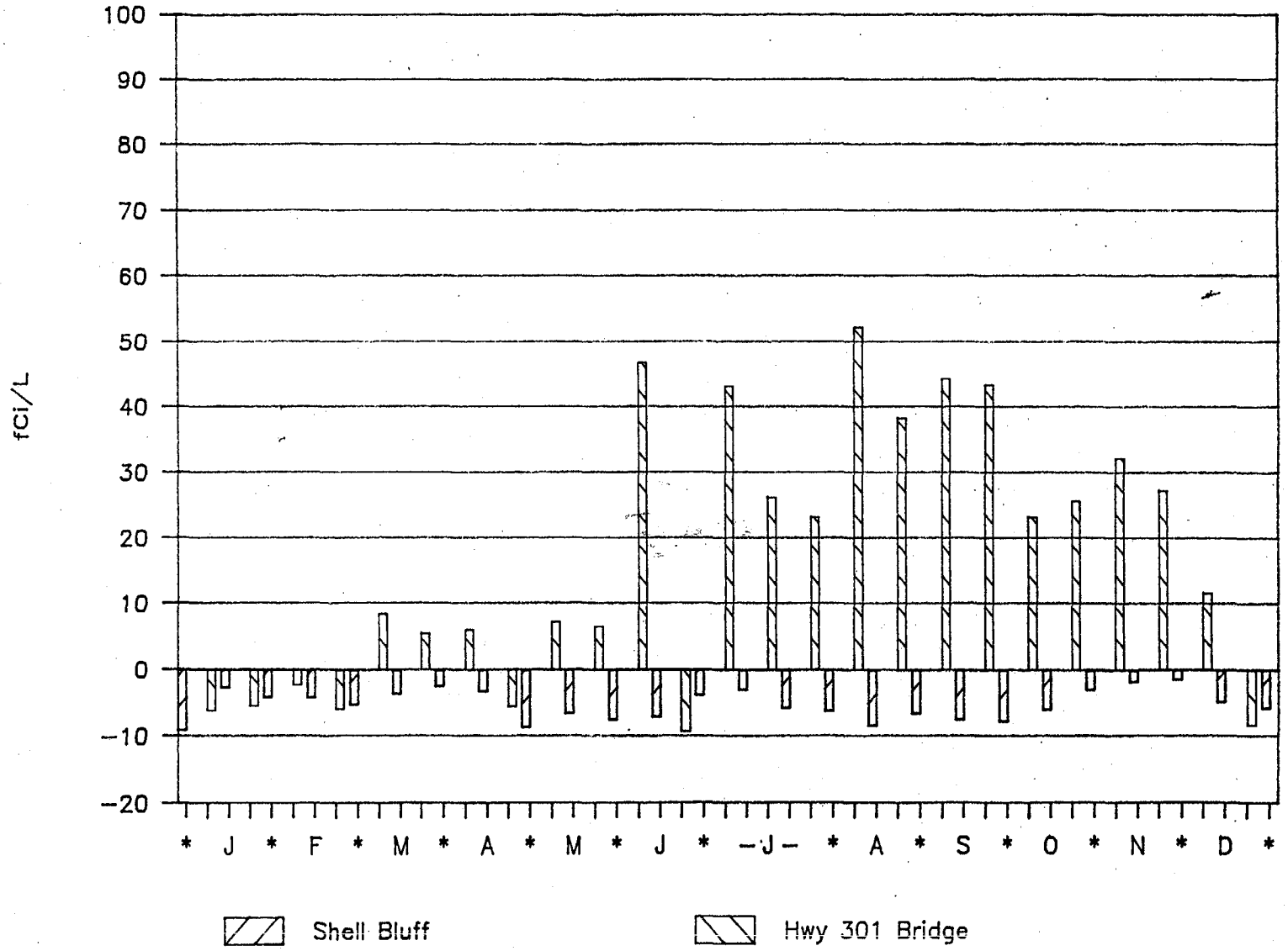


FIGURE 2. Co-60 in Savannah River in 1996

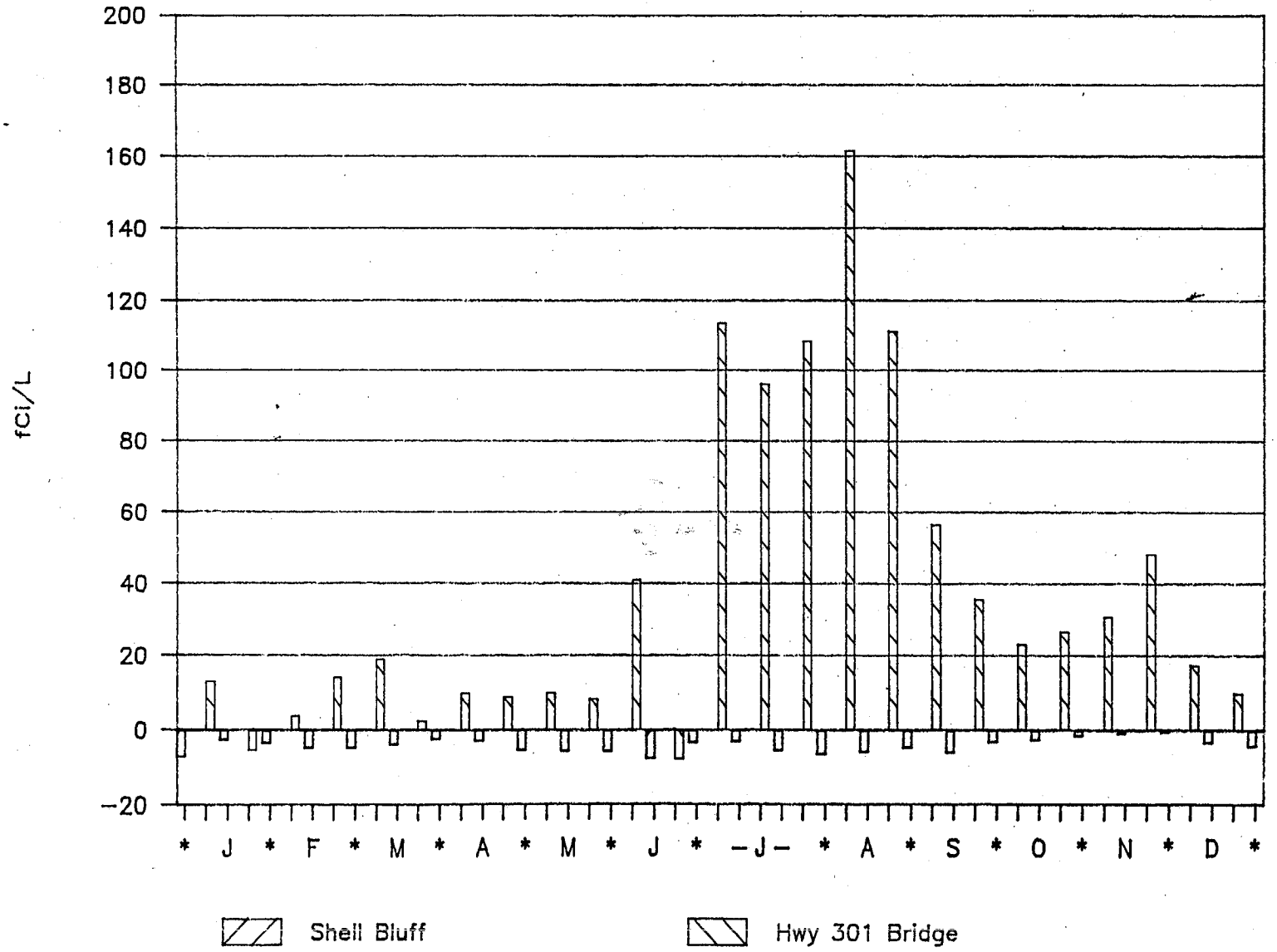


FIGURE 3A. Cs-137 in Savannah River in 1996

Standard Resin

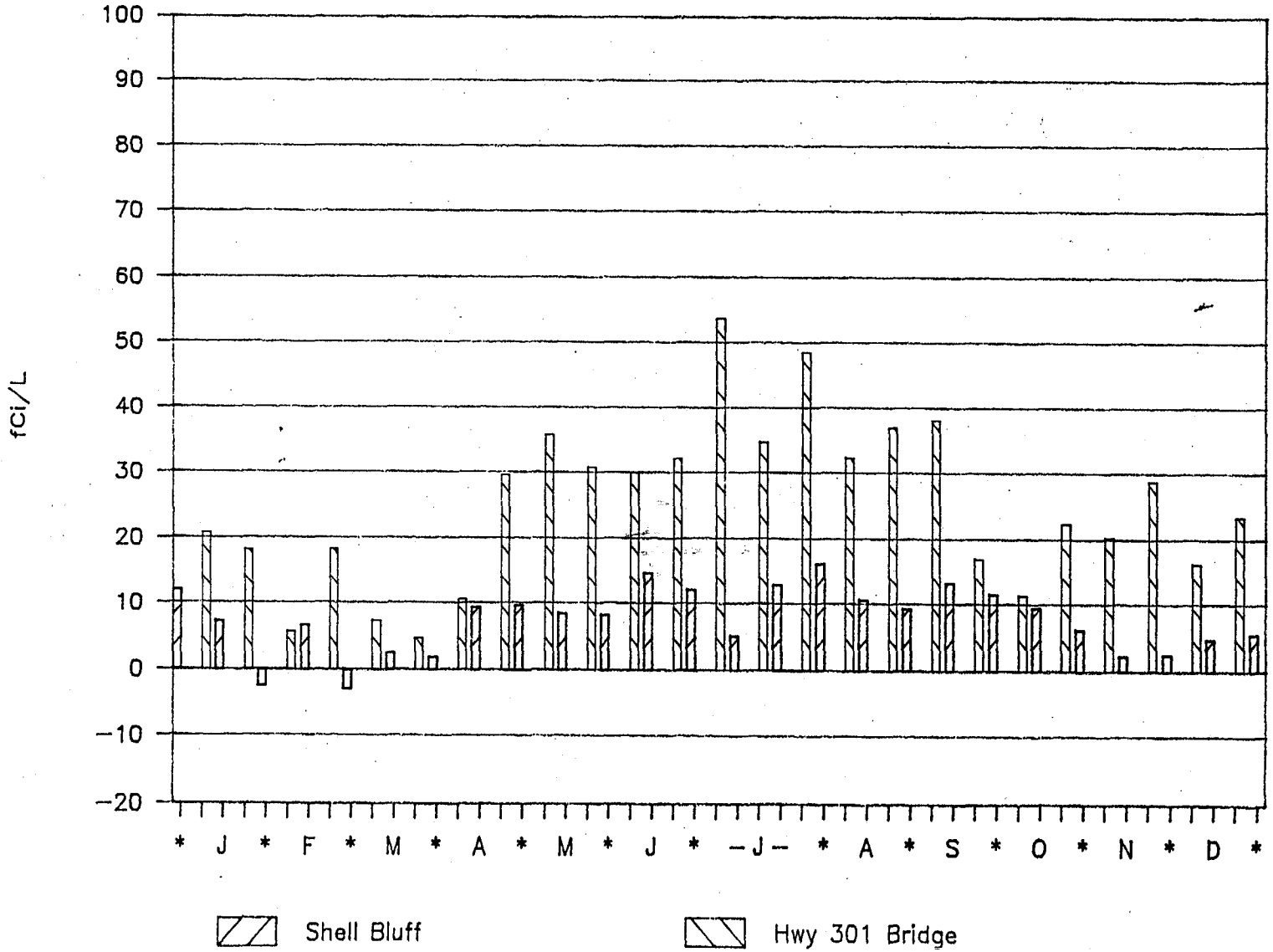


FIGURE 3B. Cs-137 in Savannah River in 1996

Isotope-Specific Resin

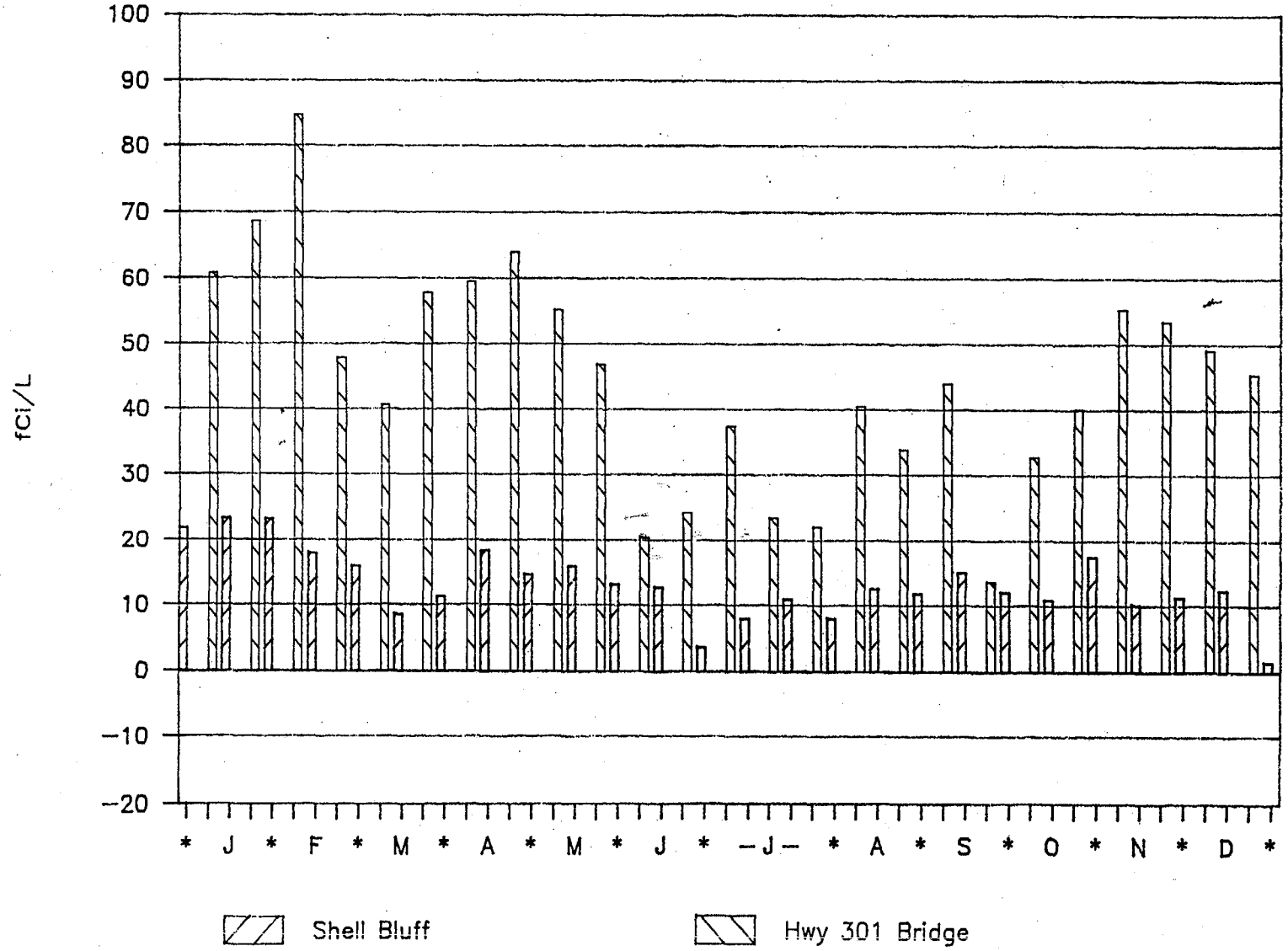
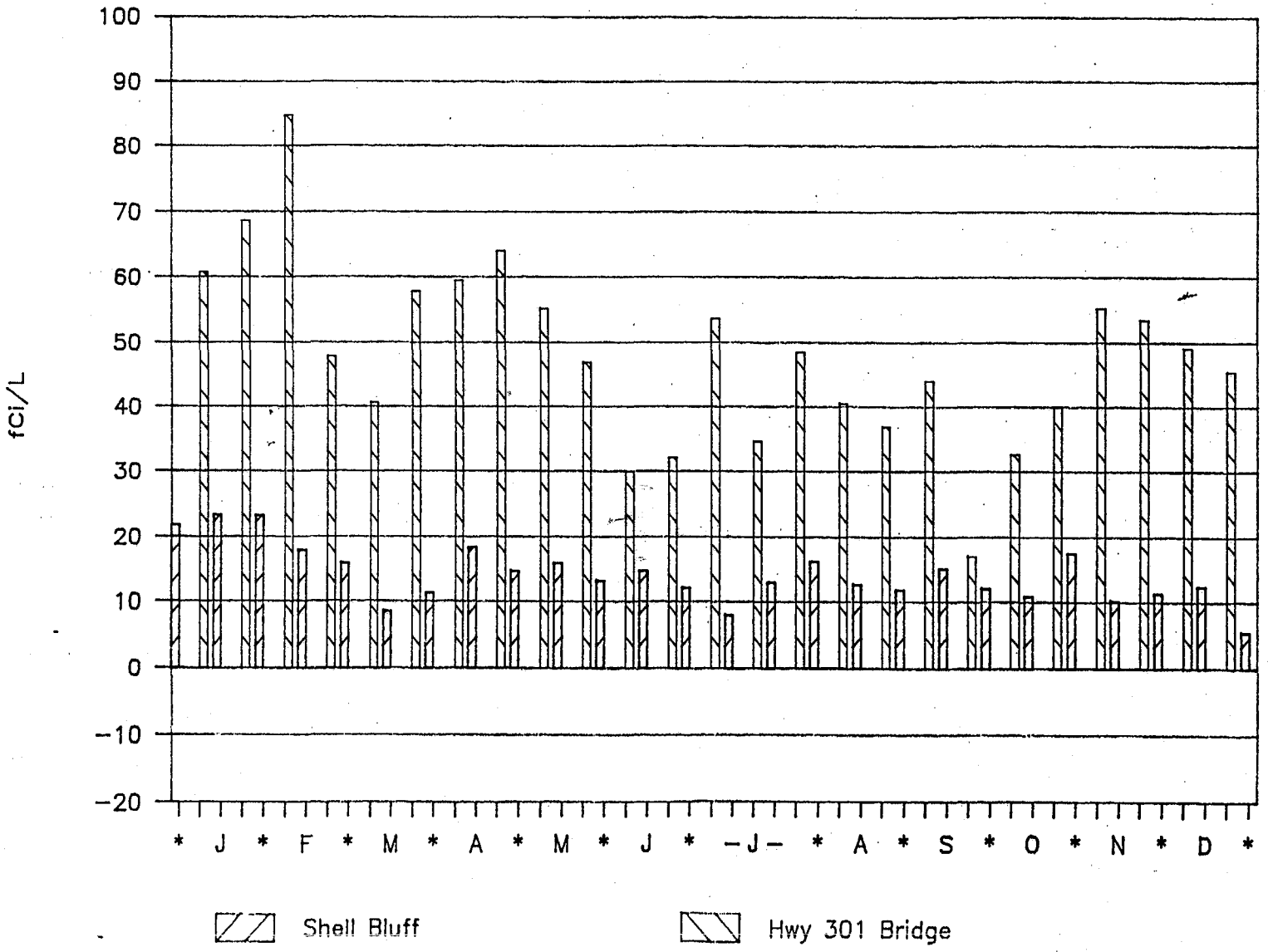


FIGURE 3C. Cs-137 in Savannah River in 1996

Maximum for Two Resins



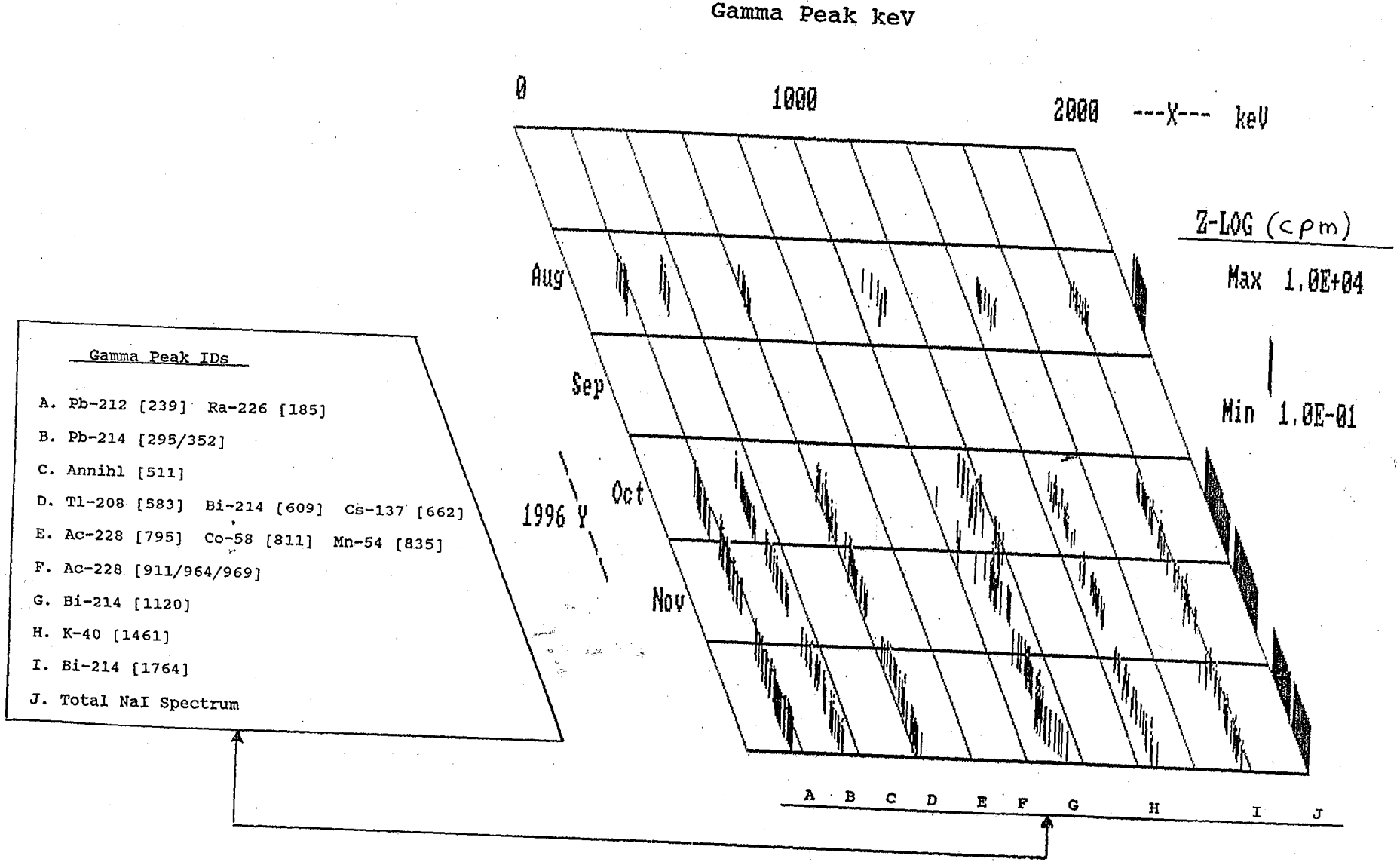
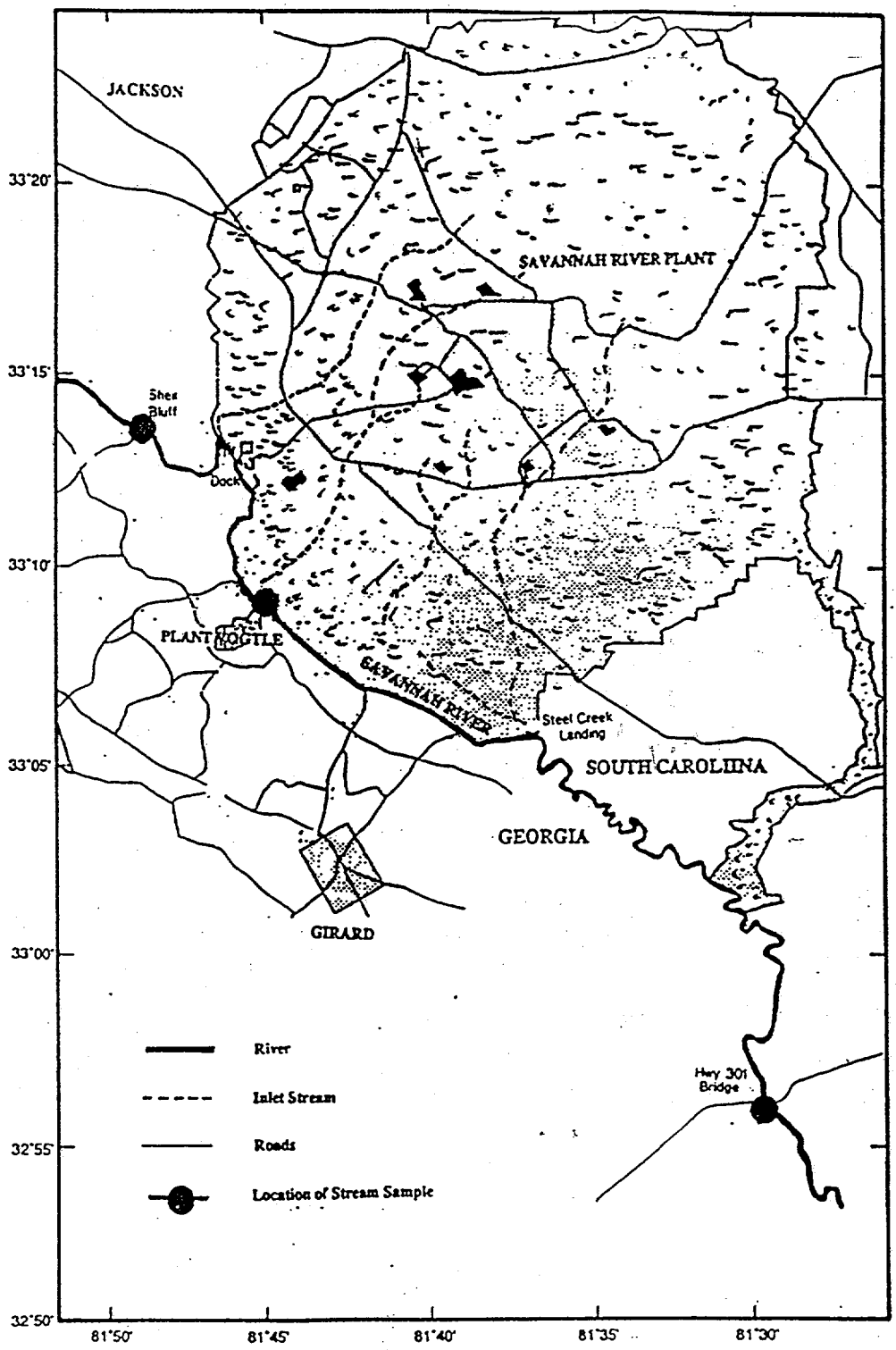


FIGURE 4. Results for Underwater NaI Detector at Hwy 301 Bridge

Appendix A. Map of Sample Locations



Appendix B. Consistency of NPT Resin Measurements

Introduction

NPT has conducted resin measurements on the Savannah River since 1986 prior to Plant Vogtle startup. Until 1995, all reported resin samplers were passive in nature, whereby the sampler units were submerged in the river for 2-3 weeks, during which they collected radionuclides by both cation absorption and particulate filtering as the river flowed by. The quantification of the radionclide concentrations were based on parallel studies with measured/controlled flow-though resin collections during 1986-1987 [ref 1]. W.G. Winn has coordinated these studies.

In 1995, flow-through resin samplers were incorporated to supplement the river studies. These samplers pass about 30 L of river water before retrieval [ref 13]. To date, only the resin portions of these samplers have been analyzed by low-level gamma spectrometry, as analysis of the particulate prefilters require some development to achieve appropriate volume reduction for suitable counting samples. This work has been coordinated by S.H. Reboul.

The resin samples analyzed in both the Winn and Reboul programs have utilized the same HPGe detectors of the Underground Counting Facility. The Winn measurements have better sensitivity for detection, but the Reboul measurements are considered more accurate because the flow-through is directly monitored. Thus, a worthwhile goal would be to couple the sensitivity and accuracy of the methods.

Comparison of Winn and Reboul Measurements

Measurements for river concentrations of ^{58}Co, ^{60}Co, and ^{137}Cs were conducted by both Winn and Reboul in 1996. Sampler collections were operated during the same time intervals and at the same locations (Shell Bluff and Hwy 301 Bridge).

The results for ^{58}Co and ^{60}Co are compared in Figures B-1 and B-2, where less-than values or MDAs are given as negative numbers. All the Reboul measurements are MDAs; thus, if the data are consistent, all the positive measurements of Winn should be lower than their corresponding Reboul MDA measurements. Relative to the Figures, this consistency is equivalent to having all the points lie below the equivalence line. However, Figure B-1 shows that ^{58}Co has eight points above the line, and Figure B-2 has 13 ^{60}Co points above the line. Accordingly, the Reboul resin sampler is not picking up the Co isotopes, suggesting that either the resin is inefficient for Co or that the Co is primarily on absorbed particulates removed by the prefilter.

The results for ^{137}Cs are compared in Figure B-3. The Winn measurements all yielded positive detection for ^{137}Cs, whereas some of the Reboul measurements were reported as MDAs. Of the Reboul MDA cases, only one corresponding Winn detection was significantly above the equivalence line, suggesting some ^{137}Cs absorbed on particulates. Comparison of the positive detections in the Figure shows that the points do display clustering about the equivalence line; however, a few Winn measurements are significantly above the line, again suggesting activity on the particulate fractions.

The ^{137}Cs agreement between the measurements seems fairly reasonable. As the main text implied, the Winn measurements were probably conservatively high because they used the maximum values between the standard resin and the isotope-specific resin; as mentioned above, the Winn measurements might also be expected to be high due to the effect of particulate collections. Indeed, a Winn mean of 48.1 ± 2.8 fCi/L is greater than the corresponding Reboul mean of 40.0 ± 2.4 fCi/L, where the averages are for the Hwy 301 samples, and the errors are the standard deviations of the mean. For comparison, the corresponding mean for the Winn isotope-specific resin was 45.0 ± 3.3 fCi/L, and the mean for the Winn standard resin was 25.2 ± 2.5 fCi/L.

Correction for Data Inconsistency

The overall agreement for the ^{137}Cs results provided a method for correcting an inconsistency in the original Winn data. The data in question are boxed in Table B-1, which gives the uncorrected ^{137}Cs values (fCi/L). Looking at the "Maximum of Resins" data, it appears that the consecutive Shell Bluff and Hwy 301 Bridge results have been swapped, as the Shell Bluff value (72.16) is much larger than the Hwy 301 value (12.16), exactly opposite of what would be expected. In addition, the Shell Bluff "Standard Resin" value (72.16) is much larger than its "Isotope Specific Resin" value (10.90), and this is also unlikely.

If we assume that the Shell Bluff resins were swapped in identity so that their detector assays (pCi) are opposite, correction yields a standard resin value of 32.23 fCi/L and a specific resin value of 24.40 fCi/L. The agreement is much improved, but the values are still significantly larger than the preceding Hwy 301 Bridge values. Thus, it is posited that the corrected Shell Bluff values should be swapped with the Hwy 301 Bridge values. With this done, the values are corrected to those shown in Table 3 of the main text. The final ^{137}Cs value (maximum of resins) at Hwy 301 Bridge is 32.23 fCi/L, which compares favorably with the 37 ± 4 fCi/L of the Reboul measurement. Also, the resulting Shell Bluff value of 12.17 fCi/L is in reasonable agreement with the Reboul measurement of 16 ± 2 fCi/L. Without

these corrections, the agreement between these Winn and Reboul values would be very poor, and the Winn data would imply very unlikely phenomena. Indeed, having two independent measurement efforts for comparison has provided good quality assurance and should not be construed as merely "needless duplication".

The difficulty with the misidentifications occurred for samples during the confusing June/July period when the sampling schedule was being realigned so that samples from both sites would be collected during the same time intervals. Replacement of the former staggered-interval collections at Shell Bluff and Hwy 301 Bridge with simultaneous collection intervals has now allowed more orderly sample processing with less chance for sample misidentification. The scheme for staggered collections had been inadvertently and unwisely incorporated to replace an earlier scheme of simultaneous collections in late 1995, without approval from the principal researcher.

Future Development

These data comparisons for consistency of NPT resin measurements identify two areas for future development, as discussed below:

Optimization of Winn and Reboul Measurements. The comparison of the results of the two methods should continue to explore prospects for refinement. A suitable method for counting the particulate collections of the Reboul prefilters should be developed to help explain why ^{58}Co and ^{60}Co have not been detected in the resin fractions. A prefilter correction for the ^{137}Cs results should also be applied, to see whether this would provide better agreement with the higher ^{137}Cs excursions in the Winn measurements. The ultimate goal of these efforts is to allow the direct accuracy of the Reboul results to be enhanced by the higher sensitivity of the Winn results.

Refinement of Earlier Winn ^{137}Cs Results. Earlier Winn ^{137}Cs resin concentrations [refs 1-9, 16] utilized the values of the standard resin as opposed to the isotope-specific resin, because the standard resin displayed better collection for the isotopes released by Plant Vogtle, which was the earlier focus of this work. The data comparisons above show that the standard resin yields ^{137}Cs values that are about 40% lower than the average of the Reboul and Winn results of the present work. Thus, the earlier ^{137}Cs Winn values could be corrected upward to address this discrepancy, using the isotope-specific data that was archived for these measurements. (Al Boni had commented earlier that these ^{137}Cs river values appeared somewhat low). A reissue of a recent comprehensive 1987-1995 compilation [ref 16] would correct the record.

Table B-1. Cs-137 Concentrations in 1996

(Original Values in fCi/L)[a]

Date	Plot	X	Standard Resin Shell Bluff fCi/L Cs137	Standard Resin H301 Bridge fCi/L Cs137	Isotope Specific Resin Shell Bluff fCi/L Cs-137	Isotope Specific Resin H301 Bridge fCi/L Cs-137	Maximum of Resins Shell Bluff fCi/L	Maximum of Resins H301 Bridge fCi/L
12/19-01/09/96SB	*		12.13		21.98		21.98	
01/02-01/16/96BR				20.90		60.88		60.88
01/09-01/23/96SB	J		7.23		23.45		23.45	
01/16-01/30/96BR				18.29		68.81		68.81
01/23-02/13/96SB	*		-2.49		23.43		23.43	
01/30-02/20/96BR				5.69		84.90		84.90
02/13-02/27/96SB	F		6.71		18.03		18.03	
02/20-03/05/96BR				18.43		47.94		47.94
02/27-03/12/96SB	*		-2.96		15.98		15.98	
03/05-03/19/96BR				7.28		40.67		40.67
03/12-03/26/96SB	M		2.56		8.66		8.66	
03/19-04/02/96BR				4.76		57.90		57.90
03/26-04/09/96SB	*		1.99		11.34		11.34	
04/02-04/16/96BR				10.69		59.65		59.65
04/09-04/23/96SB	A		9.44		18.47		18.47	
04/16-04/30/96BR				29.75		64.16		64.16
04/23-05/07/96SB	*		9.71		14.73		14.73	
04/30-05/15/96BR				35.85		55.28		55.28
05/07-05/22/96SB	M		8.46		16.03		16.03	
05/15-05/28/96BR				30.82		46.99		46.99
05/22-06/04/96SB	*		8.27		13.22		13.22	
05/28-06/18/96BR				30.05		20.60		30.05
06/04-06/22/96SB	J		14.82		12.74		14.82	
06/18-07/02/96BR				12.17		3.76		12.17
06/22-07/09/96SB	*		72.16		10.90		72.16	
07/02-07/16/96BR				53.80		37.48		53.80
07/09-07/16/96SB	-		5.14		8.14		8.14	
07/16-07/30/96BR	J			34.76		23.59		34.76
07/16-07/30/96SB	-		13.02		11.03		13.02	
07/30-08/13/96BR				48.61		22.26		48.61
07/30-08/13/96SB	*		16.30		8.14		16.30	
08/13-08/27/96BR				32.39		40.64		40.64
08/13-08/27/96SB	A		10.70		12.71		12.71	
08/27-09/10/96BR				37.01		33.93		37.01
08/27-09/10/96SB	*		9.37		11.88		11.88	
09/10-09/24/96BR				38.15		44.08		44.08
09/10-09/24/96SB	S		13.39		15.18		15.18	
09/24-10/08/96BR				17.09		13.70		17.09
09/24-10/08/96SB	*		11.58		12.12		12.12	
10/08-10/22/96BR				11.41		32.88		32.88
10/08-10/22/96SB	D		9.53		10.96		10.96	
10/22-11/05/96BR				22.47		40.21		40.21
10/22-11/05/96SB	*		6.24		17.64		17.64	
11/05-11/19/96BR				20.42		55.45		55.45
11/05-11/19/96SB	N		2.45		10.27		10.27	
11/19-12/03/96BR				28.90		53.65		53.65
11/19-12/03/96SB	*		2.66		11.39		11.39	
12/03-12/17/96BR				16.35		49.25		49.25
12/03-12/17/96SB	D		4.93		12.44		12.44	
12/17-01/07/97BR				23.58		45.52		45.52
12/17-01/07/97SB	*		5.67		1.55		5.67	

a) Counting error estimated at $\leq 0.58\ V^{1/2}$ where V is entry value. Values with minus(-) are minimum detectable amounts or MDAs.

FIGURE B-1. Comparison of Co-58 Measurements in 1996 (Data for Shell Bluff and Hwy 301 Bridge)

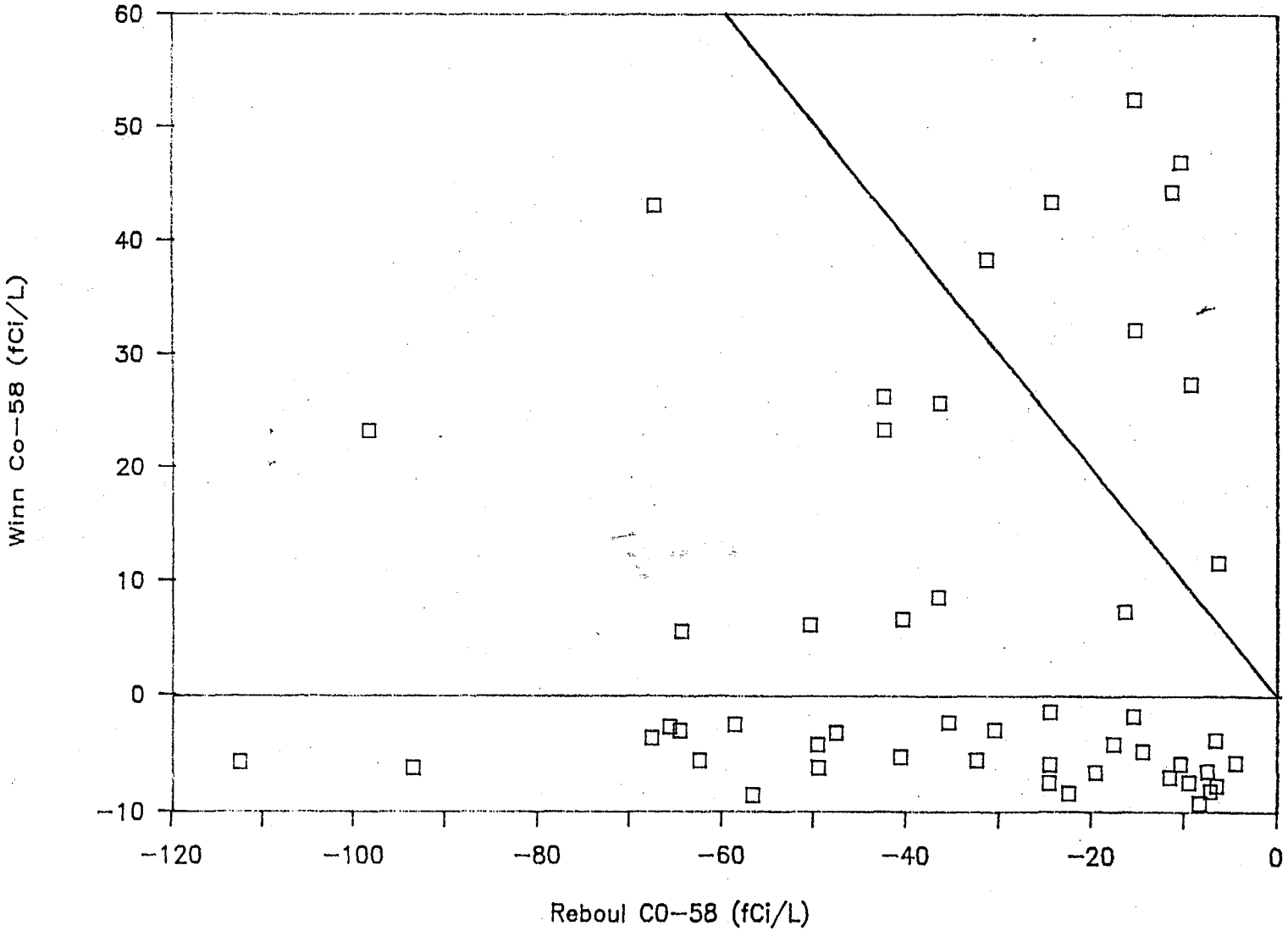


FIGURE B-2. Comparison of Co-60 Measurements in 1996 (Data for Shell Bluff and Hwy 301 Bridge)

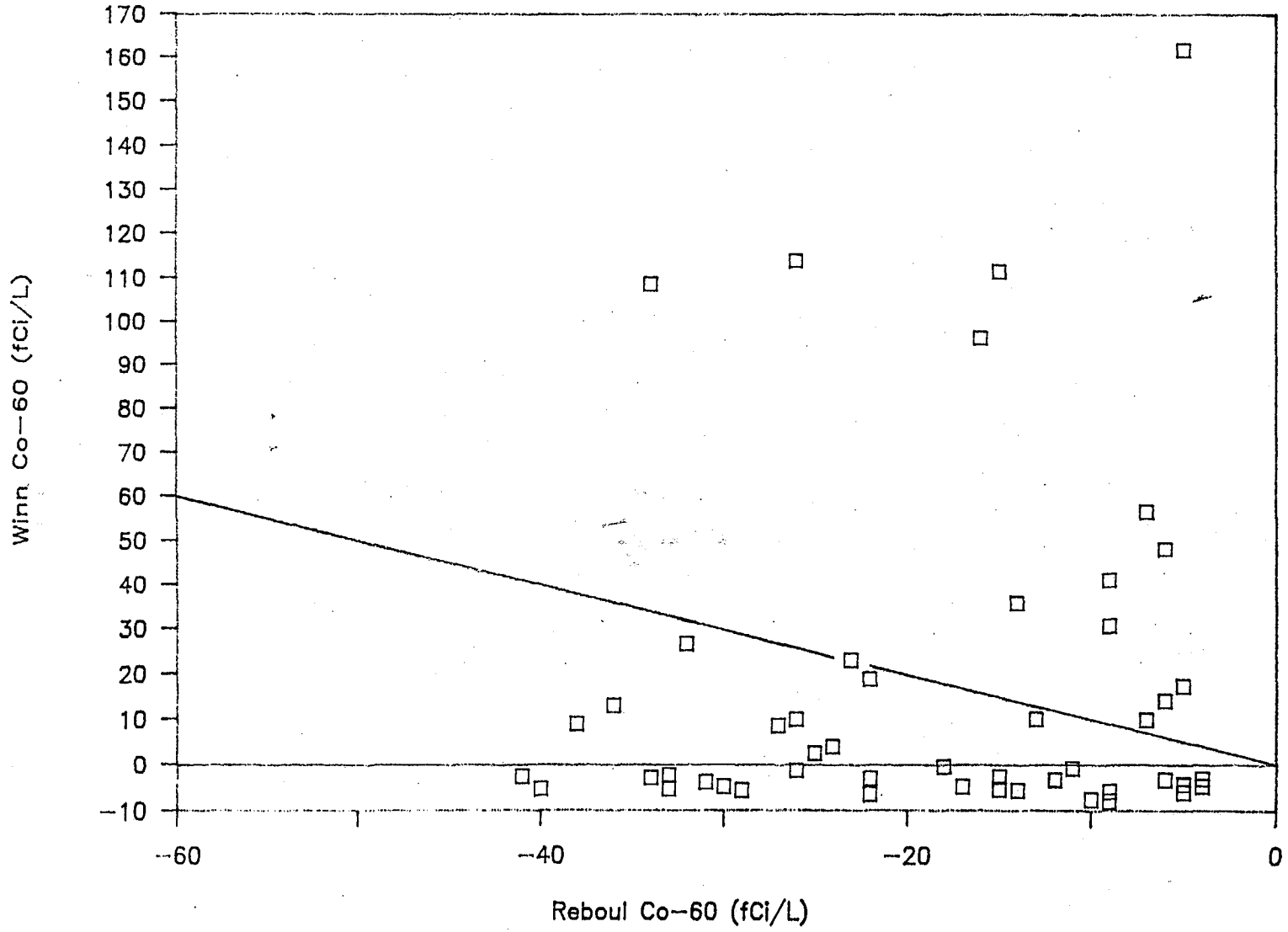


FIGURE B-3. Comparison of Cs-137 Measurements in 1996 (Data for Shell Bluff and Hwy 301 Bridge)