WSRC-TR-96-0188

# Radioactive Effluents in Savannah River-Summary Report for 1995

by

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DOE Contract No. **DE-AC09-89SR18035**

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WSRC-TR-96-0188

Derivative Classifier

A L Boni

CC: SR-DOE A. Doswell, 703-47A
E.C. Goodson, 703-46A
K. Hooker, 703-A

SRS L.M. Papouchado, 773-A
D.B. Moore-Shedrow, 773A
J.B. Gladden, 773-42A
A.L. Boni, 773-A
R.P. Addis, 773-A
W.H. Carlton, 773-A
W.A. Emel, 735-A
R.A. Sigg, 773-41A
K.J. Hofstetter, 735-A
K.W. MacMurdo, 735-A
M.M. Pendergast, 735-A
D.W. Hayes, 735-A
D.M. Beals, 735-A
J.R. Cadieux, 735-A
S.H. Reboul, 735-A
A.A. Simpkins, 773-A
J.S. Roberts, 742-A
M.D. Dukes, 742-A
C.S. Hetrick, 735-A
J.D. Heffner, 735-15A
R.H. Young, 735-A
P.D. Fledderman, 735-A
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Keywords
Plant Vogtle
Savannah River
Effluent Releases
Isotopic Activities
River Samples
Gamma Spectrometry
HPGe Detectors
NaI(Tl) Detectors

Lifetime Retention

TO: J.E. HALVERSON

FROM: W.G. WINN WGW

June 27, 1996

**Radioactive Effluents in Savannah River**
**Summary Report for 1995 (U)**

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June 27, 1996

TO: J.E. HALVERSON

FROM: W.G. WINN

**Radioactive Effluents in Savannah River**
**Summary Report for 1995 (U)**

**Introduction**

During 1995, low-level radiometric studies of the Savannah River continued to distinguish between 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 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 2-8] but all activities have been orders of magnitude below the DOE guide values [ref 9] and EPA/CFR levels [ref 10]. In 1995, Vogtle effluents continued to contribute low activities to the river, although the scope for such determinations has been reduced since the beginning of FY96 (October 1995). The Vogtle release data and the ETS measurements have tracked well over the past nine years.

ETS ultra low-level radiometric measurement techniques are used in this work. In general, river samples are collected on ion excahnge resins, concentrated further in the lab, and then counted in the Underground Counting Facility at 735-A [ref 11]. For 1995, only gamma spectrometry results are given, as tritium analyses are now being conducted in another ETS facility, whereby very sensitive tritium gas proportional counting is used [ref 12]. 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 October for a few weeks, but was removed for repair following an electrical surge.

**Summary**

During 1995, the radioactive effluents in the Savannah River were generally lower but comparable to those observed during the earlier years of these studies, being orders of magnitude below DOE and EPA/CFR guide levels. Vogtle had only one notable effluent release in 1995. In earlier years, Vogtle effluents had been dominated by $^{58}$Co; however, in 1995 $^{60}$Co exhibited the overall maximum at 1.31 pCi/L, which is almost three times larger that the previous $^{60}$Co maximum of 0.49 pCi/L observed in 1988. By comparison, the $^{58}$Co maximum was 0.46 pCi/L, which was lower than its maxima in earlier years. In addition to $^{58}$Co and $^{60}$Co, Vogtle activities of $^{54}$Mn, $^{57}$Co, $^{95}$Nb, and $^{95}$Zr were observed. The above activities were observed from samples just downstream of Vogtle, but these samples were discontinued in October due to funding priorities. In addition, $^{137}$Cs was detected, but its levels are consistent with known SRS sources. The maximum for $^{137}$Cs was 49 fCi/L at Hwy 301 Bridge.

**River Sampling**

Samples were collected from the Savannah River at Shell Bluff, near the Vogtle outfall, and at Hwy 301 bridge. Activities measured just upstream and downstream of the Vogtle outfall have been used to identify contributions from that plant alone. Specifically, samples were taken 0.3 mi above, 0.1 mi below, and at the Vogtle outfall. By October, all samples in the Vogtle vicinity were discontinued except for the quarterly sediment samples. The SRS effluents had been deduced using the Vogtle results and the activities upstream/downstream of SRS at Shell Bluff/Hwy 301 bridge, which continue to be monitored. A map of the sampling sites is given in the appendix.

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. 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 166% 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 11] 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 to constant weight 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 13,14].

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 13,14]. 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 1995, the underwater NaI was only in limited service. The pontoon platform was removed from the river in May of 1994, and it was not replaced with a new one until September of 1995. Upon deploying the detector in late September, difficulties resulting from pontoon platform movement/instabilities hindered smooth operations, and in mid-October the detector failed due to an apparent line surge following a power outage by Planters Electric Co. As a result, only about three weeks of data were collected.

## 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 2-8]. The 1995 results for these isotopes are given in Tables 1-3, along with plots in Figures 1-3. Other detected manmade gamma-emitting radionuclides are given in Table 4, where they are compared with the $^{58}$Co levels.

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 Figures 4 and 5. Figure 4 is an isometric plot of count rate vs gamma energy and date. As explained earlier, the measurements yielded only sparse data during September and October of 1995.

## Discussion

### River Water Activity Levels

In 1995, some of manmade radioactivities in the Savannah River decreased while others increased, as shown in Table 7. For example, the maximum $^{58}$Co of 0.46 pCi/L was about 1/4 of the 1993-1994 maximum, but the now-dominant $^{60}$Co had a maximum of 1.31 pCi/L, almost 3 times larger than its earlier maximum which occurred in 1988. $^{54}$Mn also indicates an increase in 1995, while $^{51}$Cr, $^{57}$Co, $^{59}$Fe, $^{95}$Nb, and $^{95}$Zr all display decreases. Because all of the above Vogtle isotopes are neutron activation products from the moderator/coolant piping, it is apparent that the longerlived $^{54}$Mn and $^{60}$Co experience more buildup over the years than the other shorter-lived isotopes. The improved effluent cleanup techniques invoked by Vogtle over the years account for some of the decrease in the levels for the shorter-lived isotopes.

SRS radionuclides $^{60}$Co and $^{137}$Cs accounted for the other manmade radionuclides observed in the river water, but their concentrations have remained essentially consistent with those measured prior to Vogtle startup in 1987. SRS $^{60}$Co was not positively isolated in the 1995 measurements but had been detected in pre-Vogtle studies [ref 1]; it can be only a fraction of the Vogtle $^{60}$Co, as noted by the largest $^{60}$Co levels, which were measured immediately down stream of the Vogtle outfall. The $^{137}$Cs concentrations in the river are primarily due to SRS sources. At Hwy 301 Bridge, $^{137}$Cs averaged about 20fCi/L, which remains consistent with SRS being the dominant source. However, it should be noted that a significantly higher $^{137}$Cs concentration of 45 fCi/L was detected below Vogtle during the time (8/1-22/95) of maximum release, suggesting that small pinhole leaks in Vogtle fuels are releasing some low-level fission products.

The 1995 release activities near Plant Vogtle were reduced by a factor of about 1/25 by the time they reached Hwy 301 Bridge. This reduction factor is between that of 1/10 during very earlier releases and the 1/100 denoted for 1993-1994 [ref 8]; the river conditions that impact this factor have not been examined quantitatively.

Sediment Activity Levels

The sediment samples frequently exhibited $^{137}$Cs, but only one occurrence of $^{60}$Co and none for $^{58}$Co [Table 6]. Overall activities observed in 1995 are comparable to those observed in earlier years [refs 2-8]. The largest $^{137}$Cs activities were observed at Hwy 301 Bridge, having an average of 164 pCi/kg sediment. Activity for $^{60}$Co was observed only in the 8/15/95 sample from Hwy 301 Bridge, having a concentration of about 14 pCi/kg. This detection occurred during the 8/1-22/95 interval for which the water-resin samples also showed high release activity. It is interesting that the companion sediment sample taken just below Vogtle indicated < 6.4 pCi/L $^{60}$Co, suggesting that much of the $^{60}$Co was carried downstream before depositing out. On the other hand, the long-lived $^{60}$Co detected at Hwy 301 Bridge could have resulted from at hot particle from earlier sources.

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 2-8,13,14]. Indeed, the isometric plot of Figure 4 only exhibits activities from natural backgrounds of $^{40}K$ and $^{214}Bi$. Upon detector repair, more meaningful studies with the underwater NaI will resume.

Drinking Water Guides

Table 6 compares the maximum-detected river concentrations with the DOE guide limits for drinking water [ref 9] along with similar EPA/CFR guide limits [ref 10]. All concentrations are well below these guide limits. Furthermore, the table compares the maximum concentrations in 1995 with those of earlier years. All measured 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. They continued on a routine basis until this year, when funding limitations, beginning in October, limited the scope of the studies. In particular, the resin samplers just above and below Vogtle were discontinued. In addition, the remaining samplers at Shell Bluff and Hwy 301 Bridge are now deployed and collected on staggered two-week intervals to facilitate sampling economy.

The above changes are having some impact on the ability to distinguish between Vogtle and SRS radioactive effluents in the Savannah River. The Shell Bluff and Hwy 301 resin samples alone only indicate what Vogtle and SRS have together contributed to the river, with no certification of which is responsible. Our sensitivity for detecting Vogtle effluent contributions by gamma spectrometry is decreased by at least an order of magnitude by not having resin samplers in the locations near Vogtle. As such we decrease by a factor of 10-100 our ability to detect/correct abnormal trends before actual health and compliance concerns evolve. These analyses are also unique in that they provide much more sensitivity than traditional methods offered on- or off-site, as has been demonstrated in data comparisons of SRS-EMS, GDNR, SCDHEC, and Georgia Power at REMP meetings [ref 15].

**Acknowledgements**

The author wishes to thank Shan Sundaram, H.T. Wilson, and Shirley Patterson for their support in this study. Shan Sundaram of Plant Vogtle has continued to provide useful information on their releases. H.T. Wilson coordinated the river sampling program and analyzed the bulk of the samples in the Underground Counting Facility until his retirement in July. Since that time, S.D. Patterson has taken over and continued performing these operations. Also, the sample collections group of R.R. Penix, R.J. Roseberry, and A.B. Antonicelli are thanked for their supporting role.

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## Table 1. Co-58 Concentrations in 1995

(Values in fCi/L)[a]

| Date | Plot X | | Shell Bluff fCi/L | Above Vogtle fCi/L | Below Vogtle fCi/L | H301 Bridge fCi/L |
|---|---|---|---|---|---|---|
| 01/03-01/17/95 | * | | -7.09 | -8.36 | | -6.07 |
| 01/17-01/31/95 | J | | -8.39 | -4.82 | 7.46 | -8.35 |
| 01/31-02/14/95 | * | | -6.18 | -5.60 | -8.37 | -6.29 |
| 02/14-02/28/95 | F | | -6.64 | -4.37 | 12.35 | -6.09 |
| 02/28-03/14/98 | * | | -2.78 | -4.06 | 12.97 | -6.37 |
| 03/14-03/28/95 | M | | -5.51 | -3.94 | 21.30 | -5.78 |
| 03/28-04/11/95 | * | | -4.59 | -6.33 | 27.37 | -8.25 |
| 04/11-04/25/95 | A | | -6.09 | -6.91 | 12.65 | -5.97 |
| 04/25-05/09/95 | * | | -4.68 | -3.52 | 23.71 | -7.06 |
| 05/09-05/23/95 | M | | -4.85 | -6.47 | -2.92 | -6.45 |
| 05/23-06/06/95 | * | | -5.92 | -8.47 | 49.36 | -8.09 |
| 06/06-06/19/95 | J | | -6.74 | | 30.85 | -10.65 |
| 06/19-07/05/95 | * | | -1.76 | -6.50 | 9.05 | -1.91 |
| 07/05-07/18/95 | J | | -2.55 | -4.70 | 7.08 | -2.56 |
| 07/18-08/01/95 | * | | -3.75 | -6.86 | 21.53 | -4.30 |
| 08/01-08/22/95 | A | | -2.88 | -7.70 | 462.42 | 14.44 |
| 08/22-09/05/95 | * | | -7.66 | -10.42 | 53.75 | -6.74 |
| 09/05-09/19/95 | S | | -9.86 | -13.05 | -9.53 | -2.47 |
| 09/19-10/03/95 | * | | -11.49 | -12.25 | 41.93 | -9.07 |
| 10/03-10/17/95 | O | | -6.19 | | | -10.63 |
| 10/17-10/31/95 | * | SITE | -5.56 | | | -4.11 |
| 10/31-11/14/95 | n | SB | -3.59 | | | |
| 10/31-11/21/95 | N | BR | | | | -3.66 |
| 11/14-12/05/95 | + | SB | -4.96 | | | |
| 11/21-12/12/95 | * | BR | | | | -4.31 |
| 12/05-12/19/95 | d | SB | -4.46 | | | |
| 12/12-01/02/96 | D | BR | | | | -6.81 |
| 12/19-01/09/96 | + | SB | -9.05 | | | |

a) Counting error estimated at ≤ 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 1995

(Values in fCi/L)[a]

| Date | Plot X | | Shell Bluff fCi/L | Above Vogtle fCi/L | Below Vogtle fCi/L | H301 Bridge fCi/L |
|---|---|---|---|---|---|---|
| 01/03-01/17/95 | * | | -6.90 | -7.10 | | -5.20 |
| 01/17-01/31/95 | J | | -8.20 | -4.30 | 28.70 | -7.10 |
| 01/31-02/14/95 | * | | -6.30 | -4.30 | -7.70 | -5.70 |
| 02/14-02/28/95 | F | | -6.40 | -4.50 | 155.90 | 10.40 |
| 02/28-03/14/98 | * | | -2.80 | -4.10 | 65.10 | 9.40 |
| 03/14-03/28/95 | M | | -5.20 | -3.60 | 45.30 | -4.50 |
| 03/28-04/11/95 | * | | -4.40 | -5.50 | 33.10 | 16.10 |
| 04/11-04/25/95 | A | | -5.40 | -5.40 | 18.10 | -6.20 |
| 04/25-05/09/95 | * | | -4.20 | -2.90 | 60.10 | -6.70 |
| 05/09-05/23/95 | M | | -3.90 | -5.10 | 3.10 | -5.50 |
| 05/23-06/06/95 | * | | -4.30 | -5.60 | 75.40 | 7.50 |
| 06/06-06/19/95 | J | | -5.10 | | 42.20 | -7.40 |
| 06/19-07/05/95 | * | | -1.20 | -4.80 | 14.50 | -1.40 |
| 07/05-07/18/95 | J | | -2.00 | -3.70 | 10.50 | -2.10 |
| 07/18-08/01/95 | * | | -2.70 | -4.70 | 22.30 | -3.70 |
| 08/01-08/22/95 | A | | -2.40 | -6.10 | 1312.50 | 45.80 |
| 08/22-09/05/95 | * | | -4.80 | -8.30 | 73.20 | 6.50 |
| 09/05-09/19/95 | S | | -6.70 | -8.40 | 29.90 | 2.60 |
| 09/19-10/03/95 | * | | -8.00 | -9.00 | 264.00 | 30.40 |
| 10/03-10/17/95 | O | | -3.90 | | | 13.00 |
| 10/17-10/31/95 | * | SITE | -4.70 | | | 25.20 |
| 10/31-11/14/95 | n | SB | -3.20 | | | |
| 10/31-11/21/95 | N | BR | | | | -3.20 |
| 11/14-12/05/95 | + | SB | -4.50 | | | |
| 11/21-12/12/95 | * | BR | | | | -4.10 |
| 12/05-12/19/95 | d | SB | -3.80 | | | |
| 12/12-01/02/96 | D | BR | | | | 18.90 |
| 12/19-01/09/96 | + | SB | -7.30 | | | |

a) Counting error estimated at ≤ 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 1995**

(Values in fCi/L)[a]

| Date | Plot X | | Shell Bluff fCi/L | Above Vogtle fCi/L | Below Vogtle fCi/L | H301 Bridge fCi/L |
|---|---|---|---|---|---|---|
| 01/03-01/17/95 | * | | 5.80 | 10.95 | | 11.01 |
| 01/17-01/31/95 | J | | 6.53 | 4.74 | 11.63 | 18.78 |
| 01/31-02/14/95 | * | | 4.52 | -3.16 | 10.30 | 13.26 |
| 02/14-02/28/95 | F | | 7.54 | 5.12 | 8.75 | 22.53 |
| 02/28-03/14/98 | * | | 5.08 | -2.69 | -2.88 | 19.53 |
| 03/14-03/28/95 | M | | 4.52 | 2.53 | 5.99 | 11.28 |
| 03/28-04/11/95 | * | | 3.75 | 6.12 | 4.93 | 26.17 |
| 04/11-04/25/95 | A | | -3.49 | 9.04 | 12.03 | 20.44 |
| 04/25-05/09/95 | * | | 3.46 | 5.45 | 8.73 | 23.09 |
| 05/09-05/23/95 | M | | -3.07 | 5.82 | 5.47 | 19.38 |
| 05/23-06/06/95 | * | | 6.14 | 9.74 | 12.89 | 23.25 |
| 06/06-06/19/95 | J | | 6.55 | | 13.62 | 36.47 |
| 06/19-07/05/95 | * | | 3.29 | 10.93 | 2.82 | 10.61 |
| 07/05-07/18/95 | J | | -1.18 | 10.49 | 2.25 | 3.26 |
| 07/18-08/01/95 | * | | 2.45 | 9.90 | 4.75 | 12.47 |
| 08/01-08/22/95 | A | | 1.42 | 10.35 | 45.14 | 48.70 |
| 08/22-09/05/95 | * | | 0.37 | 7.38 | 6.69 | 25.20 |
| 09/05-09/19/95 | S | | 11.27 | -5.24 | 8.25 | 11.11 |
| 09/19-10/03/95 | * | | 14.73 | 16.47 | 10.19 | 24.81 |
| 10/03-10/17/95 | O | | 16.25 | | | 34.06 |
| 10/17-10/31/95 | * | SITE | 8.57 | | | 16.77 |
| 10/31-11/14/95 | n | SB | 3.07 | | | |
| 10/31-11/21/95 | N | BR | | | | 7.34 |
| 11/14-12/05/95 | + | SB | 7.21 | | | |
| 11/21-12/12/95 | * | BR | | | | 14.03 |
| 12/05-12/19/95 | d | SB | 3.29 | | | |
| 12/12-01/02/96 | D | BR | | | | 12.91 |
| 12/19-01/09/96 | + | SB | 12.13 | | | |

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 Below Vogtle During 1995[a,b]**

(Sample site 0.1 mi downstream of Vogtle)

| Date | Plot X | | Co-58 fCi/L | Cr-51 | Mn-54 | Co-57 | Co-58 | Fe-59 | Co-60 | Nb-95 | Zr-95 | Cs-137 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Isotopics % of Co-58 Activity below Vogtle | | | | | | | | |
| 01/03-01/17/95 | * | | na | na | na | na | 100.00 | na | na | na | na | na |
| 01/17-01/31/95 | J | | 7.46 | 0.00 | 132.91 | 0.00 | 100.00 | 0.00 | 384.81 | 0.00 | 0.00 | 155.95 |
| 01/31-02/14/95 | * | | -8.37 | 0.00 | 0.00 | 0.00 | -100.00 | 0.00 | 92.05 | 0.00 | 0.00 | 123.09 |
| 02/14-02/28/95 | F | | 12.35 | 0.00 | 242.07 | 33.10 | 100.00 | 0.00 | 1758.62 | 0.00 | 0.00 | 70.85 |
| 02/28-03/14/98 | * | | 12.97 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 502.29 | 0.00 | 0.00 | -22.21 |
| 03/14-03/28/95 | M | | 21.30 | 0.00 | 28.33 | 0.00 | 100.00 | 0.00 | 225.00 | 0.00 | 33.75 | 28.12 |
| 03/28-04/11/95 | * | | 27.37 | 0.00 | 18.15 | 0.00 | 100.00 | 0.00 | 120.89 | 0.00 | 0.00 | 18.01 |
| 04/11-04/25/95 | A | | 12.65 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 143.08 | 0.00 | 0.00 | 95.11 |
| 04/25-05/09/95 | * | | 23.71 | 0.00 | 30.62 | 0.00 | 100.00 | 0.00 | 253.49 | 0.00 | 45.74 | 36.82 |
| 05/09-05/23/95 | M | | -2.92 | 0.00 | 0.00 | 0.00 | -100.00 | 0.00 | 106.06 | 190.91 | 0.00 | 187.52 |
| 05/23-06/06/95 | * | | 49.36 | 0.00 | 17.15 | 0.00 | 100.00 | 0.00 | 152.74 | 0.00 | 0.00 | 26.11 |
| 06/06-06/19/95 | J | | 30.85 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 136.73 | 76.53 | 0.00 | 44.15 |
| 06/19-07/05/95 | * | | 9.05 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 159.90 | -52.08 | 0.00 | 31.16 |
| 07/05-07/18/95 | J | | 7.08 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 148.55 | 0.00 | 0.00 | 31.80 |
| 07/18-08/01/95 | * | | 21.53 | 0.00 | -13.18 | 0.00 | 100.00 | 0.00 | 103.41 | 0.00 | 0.00 | 22.06 |
| 08/01-08/22/95 | A | | 462.42 | 0.00 | 44.10 | 1.30 | 100.00 | 0.00 | 283.84 | 0.00 | 0.00 | 9.76 |
| 08/22-09/05/95 | * | | 53.75 | 0.00 | 22.22 | 0.00 | 100.00 | 0.00 | 136.11 | 0.00 | 0.00 | 12.45 |
| 09/05-09/19/95 | S | | -9.53 | 0.00 | 0.00 | 0.00 | -100.00 | 0.00 | 314.09 | 0.00 | 0.00 | 86.60 |
| 09/19-10/03/95 | * | | 41.93 | 0.00 | 163.54 | 0.00 | 100.00 | 0.00 | 943.78 | 0.00 | 0.00 | 24.30 |
| 10/03-10/17/95 | O | | | | | | | | | | | |
| 10/17-10/31/95 | * | SITE | | | | | | | | | | |
| 10/31-11/14/95 | n | SB | | | | | | | | | | |
| 10/31-11/21/95 | N | BR | | | | | | | | | | |
| 11/14-12/05/95 | + | SB | | | | | | | | | | |
| 11/21-12/12/95 | * | BR | | | | | | | | | | |
| 12/05-12/19/95 | d | SB | | | | | | | | | | |
| 12/12-01/02/96 | D | BR | | | | | | | | | | |
| 12/19-01/09/96 | + | SB | | | | | | | | | | |

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 asterisk(*) for MDA cases. For zero values (0.00) no gamma peak or MDA was deduced.

**Table 5. Sediment Concentrations in 1993-94**

(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 |
| $^{58}Co$ | 03/14/95 | <24.0 | <6.6 | <11.0 | <9.0 |
| | 06/13/95 | <4.6 | <5.0 | <7.4 | <7.3 |
| | 08/15/95 | <5.0 | <3.2 | <7.4 | <7.6 |
| | 11/13-21/95[b] | <4.3 | <6.8 | <7.5 | <3.9 |
| $^{60}Co$ | 03/14/95 | <13.0 | <3.7 | <6.3 | <4.8 |
| | 06/13/95 | <4.4 | <4.6 | <6.7 | <6.9 |
| | 08/15/95 | <4.4 | <3.0 | <6.4 | 13.6±1.8 |
| | 11/13-21/95[b] | <4.1 | <6.3 | <6.8 | <4.2 |
| $^{137}Cs$ | 03/14/95 | <12.0 | 6.3±1.2 | 8.0±2.0 | 158.0±3.0 |
| | 06/13/95 | 11.8±1.7 | 9.7±1.8 | 14.5±2.6 | 81.8±3.4 |
| | 08/15/95 | 11.2±1.8 | 7.3±1.1 | 13.9±2.5 | 331.0±5.0 |
| | 11/13-21/95[b] | 8.9±1.5 | 8.8±2.3 | 21.1±2.7 | 85.1±2.3 |

(a) Miles are measured upstream of Vogtle outfall.

(b) Dates: Vogtle[+0.3mi] on 11/13, Vogtle [0.0 and -0.1mi] on 11/14 and Hwy 301 on 11/21.

**Table 6. Comparison of Maximum 1987-1994 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) | | | | | |
|---|---|---|---|---|---|---|
| | 1987-89 | 1990-92 | 1993-94 | 1995[a] | DOE Guide[b] | EPA/CFR[c] |
| $^{3}H$ | 47,300[d] | 42,600[d] | 64,000[d] | 2300[e] | 2,000,000 | 20,000 |
| $^{51}Cr$ | 3.7 | 0.08 | 1.0 | <0.01 | 1,000,000 | 6000 |
| $^{54}Mn$ | 0.61 | 0.03 | 0.17 | 0.20 | 50,000 | 300 |
| $^{57}Co$ | 0.02 | 0.005 | 0.03 | 0.006 | 100,000 | --- |
| $^{58}Co$ | 16.8 | 2.37 | 1.81 | 0.46 | 40,000 | 9000 |
| $^{59}Fe$ | 0.49 | 0.02 | 0.06 | <0.01 | 20,000 | 200 |
| $^{60}Co$ | 0.49 | 0.11 | 0.42 | 1.31 | 5,000 | 100 |
| $^{95}Nb$ | 0.50 | 0.12 | 0.10 | 0.02 | 40,000 | 300 |
| $^{95}Zr$ | 0.23 | 0.03 | 0.05 | 0.01 | 60,000 | 200 |
| $^{137}Cs$ | 0.39[e] | 0.09[e] | 0.07[e] | 0.05[e] | 3,000 | 200 |

a) Data for 1995 does not span entire year in some cases - see Tables 1-5.

b) DOE 5400.5 (details per reference 8).

c) See reference 9, 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 (Tritium - Reference 12).

**FIGURE 1. Co-58 in Savannah River in 1995**

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

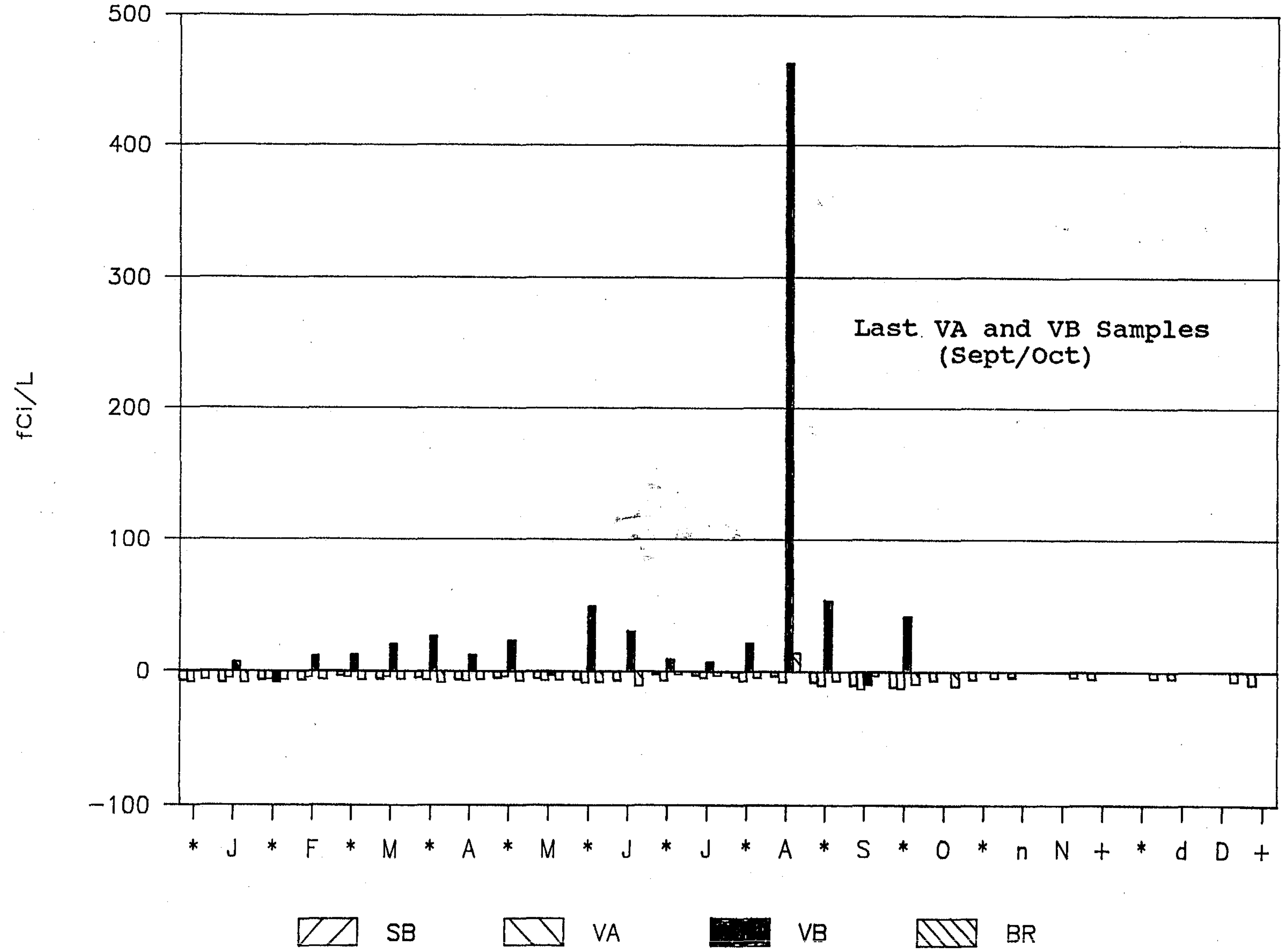


**FIGURE 2. Co-60 in Savannah River in 1995**

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

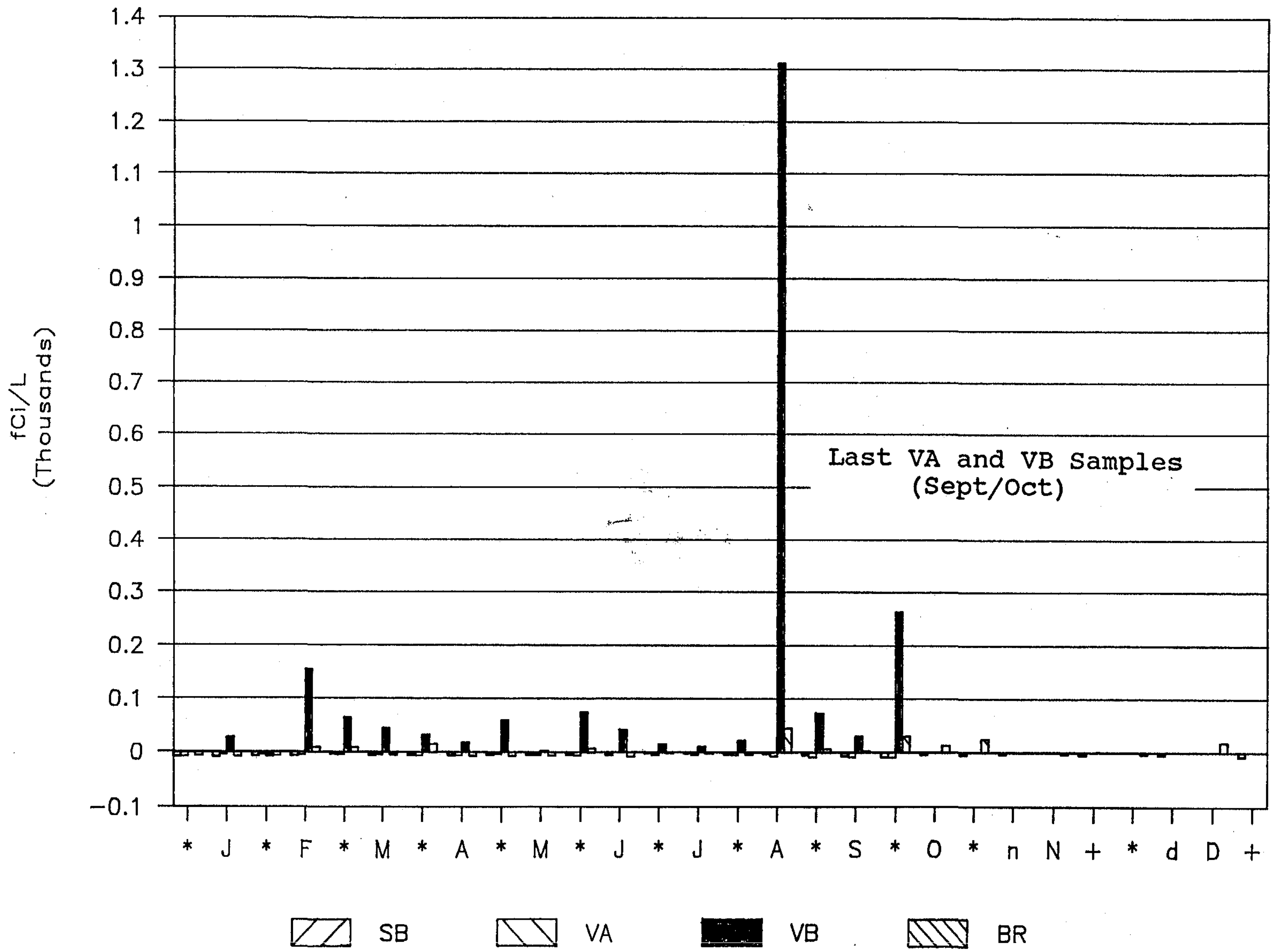
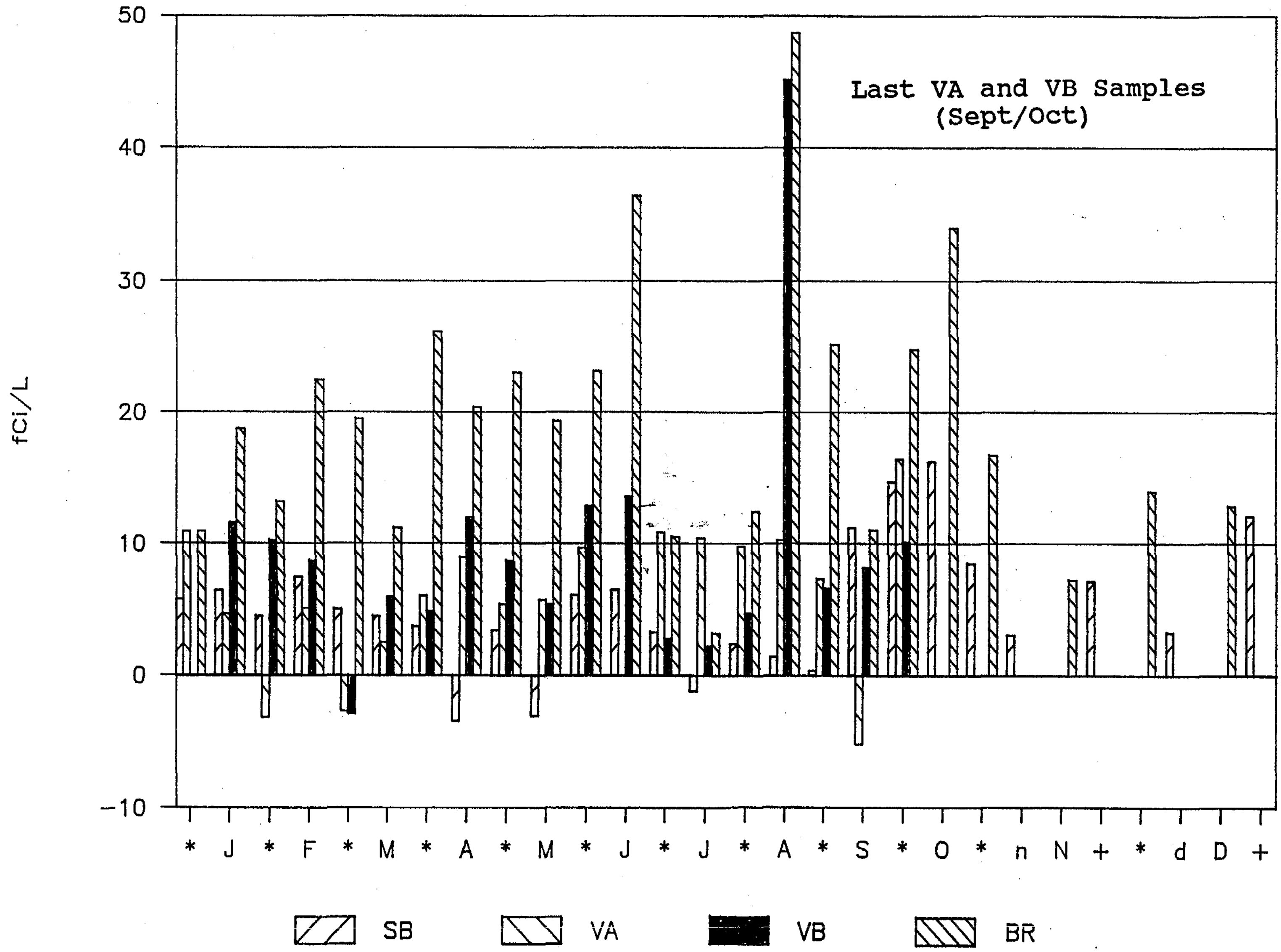


**FIGURE 3. Cs-137 in Savannah River in 1995**

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



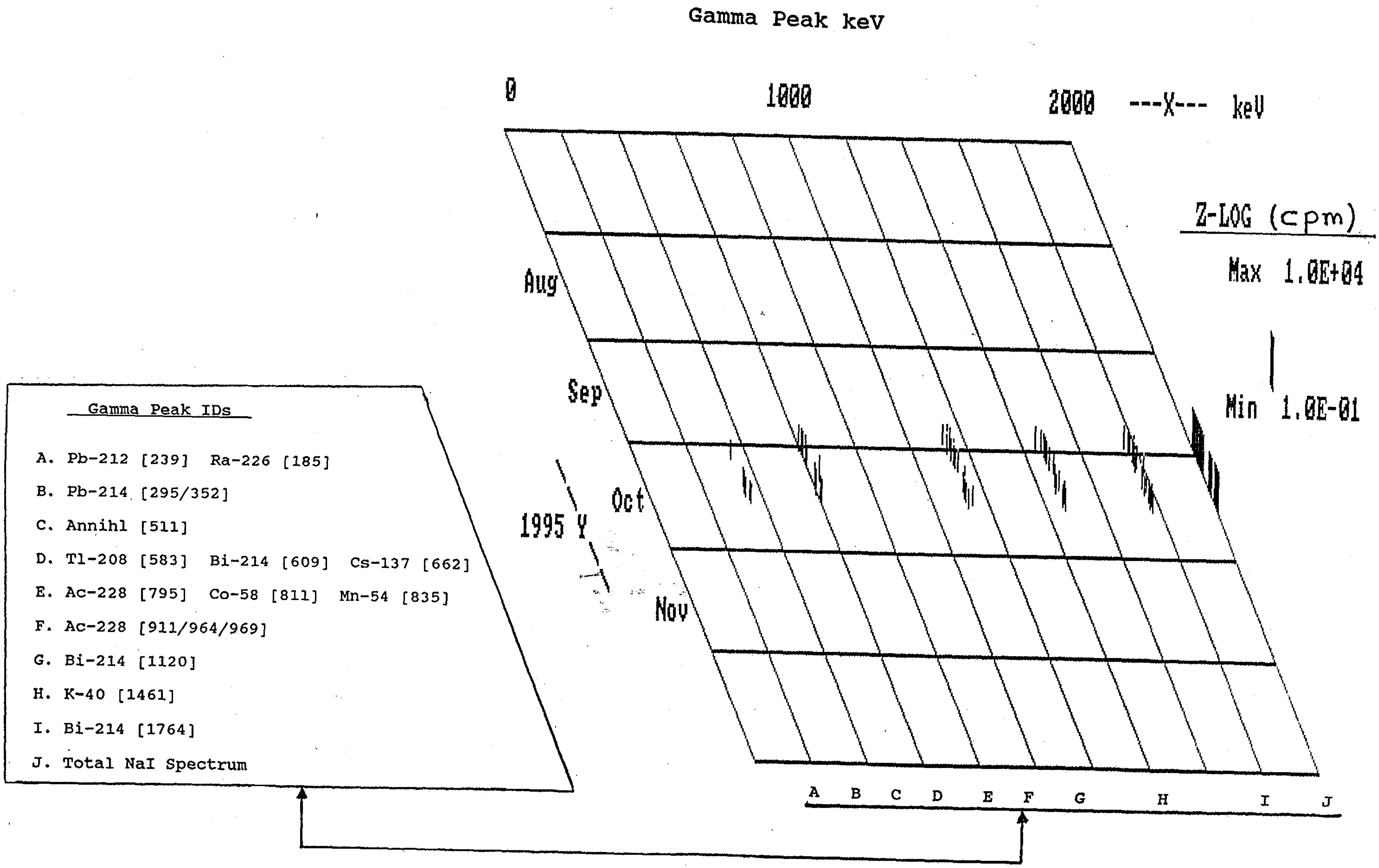



**FIGURE 4. Results for Underwater NaI Detector at Hwy 301 Bridge**

# Appendix - Map of Sample Locations