CHAPTER 9

RADIONUCLIDES IN VEGETATION AND AGRICULTURAL PRODUCTS

ABSTRACT

This chapter discusses radionuclide concentrations measured in vegetation and agricultural products collected on or in the vicinity of the Savannah River Site (SRS). We evaluated these data with regard to their potential usefulness for dose reconstruction. We also attempted to validate the reported concentrations by making comparisons among as many data sources as possible. These data included original, hand-written compilations for many years. We have found these original data to consistently correspond to the information reported in monthly, semiannual, and annual summary reports.

We compiled and examined vegetation data and other environmental data to determine their usefulness for source term verification, model validation, and direct exposure assessment. In general, the vegetation data are most valuable for source term verification and model validation. However, the potential usefulness of the data is limited in many cases by spatial or temporal resolution. Appendix K further discusses potential uses for environmental monitoring data.

INTRODUCTION

Since 1953, vegetation has been sampled at various locations on or in the vicinity of the Savannah River Site (SRS). Bermuda grass has been the preferred species for sampling because of its use as food for dairy cattle and its year-around availability. In May 1961, the SRS began collecting local agricultural products, including collards, plums, peaches, oats, wheat, soybeans, rye, corn, and meat (chicken and beef), at several vicinity locations. Radionuclide concentrations in vegetation and agricultural products are important to evaluate because they serve as sensitive indicators of aerial deposition resulting from plant operations and atmospheric weapons testing fallout. Examining concentrations measured in vegetation and agricultural products at various distances from the SRS can help to determine the source of atmospherically deposited radionuclides and may also be useful for source term and model validation.

This chapter summarizes reported information regarding radionuclide concentrations in vegetation and agricultural products on or in the vicinity of the SRS. We examined several sets of routine semiannual and annual environmental monitoring reports, prepared by the SRS contractor and spanning the years 1953 through 1992. See Chapter 7, Table 7-1 for a complete description of the various monitoring report series.

We reviewed several additional documents for information pertaining to vegetation monitoring at the SRS. These include monthly monitoring reports from 1962 through 1965, weekly monitoring reports from 1959 through 1962, and aperture cards (handwritten compilations of original environmental monitoring results that were photographed in a format similar to microfiche) from 1957 and 1959 through 1973.

Annual environmental monitoring reports provide only average annual results for all collection locations for each agricultural product and radionuclide. However, we reviewed aperture cards for 1966–1973 and 1982–1983 and these documents do provide concentrations

measured in agricultural products at individual collection locations for each collection period. In general, although sometimes illegible, the information reported in the aperture cards is consistent with information provided in the monitoring reports.

Data that are available for vegetation and agricultural products include gross alpha activity; nonvolatile beta activity; and concentrations of ^{7}Be, ^{144}Ce, ^{137}Cs, ^{40}K, ^{54}Mn, ^{106}Ru, $^{95}Zr/Nb$, $^{140}Ba/La$, ^{131}I, and ^{3}H. Appendix A details analytical and counting procedures for vegetation and agricultural products. We focussed the majority of our efforts on the evaluating vegetation data, rather than food or agricultural product data, because vegetation has been collected since the early days of plant operations. Atmospheric releases from SRS were generally the highest and the potential for offsite deposition was the greatest during these early years. Agricultural products, on the other hand, were not collected until May 1961. Most of the significant atmospheric releases at SRS occurred before this time. Additionally, there were fewer agricultural product collection locations, and concentrations were reported in the annual environmental monitoring reports as average annual concentrations for all locations. This precludes any spatial or temporal analysis of these data and limits their usefulness. The vegetation data are somewhat more adequate for spatial or temporal analyses and span a greater number of years. It can be assumed, however, that spatial deposition patterns inferred from vegetation monitoring would be similar to those based on agricultural product monitoring. We provide the summary results for the F-Area and H-Area, plant perimeter, 25-mi radius, and 100-mi radius locations in this chapter.

RADIONUCLIDE CONCENTRATIONS IN VEGETATION

Since 1953, vegetation has been sampled at various locations on or in the vicinity of the SRS. Before 1971, the environmental monitoring reports do not specify the type of vegetation that was sampled, and it appears likely that several different species were included in the sampling protocol. The monitoring reports give results for vegetation in general, but it is assumed that the majority of results since 1971 apply to Bermuda grass (Du Pont 1972a). Bermuda grass was indicated as the preferred species for sampling because of its importance as a pasture grass for dairy cattle and its year-around availability. Vegetation samples have been routinely collected from F-Area and H-Area, plant perimeter, 25-mi radius, and 100-mi radius locations.

Beginning in July 1955, radionuclide concentrations were reported for vegetation samples collected at 24 F-Area and at 24 H-Area locations. The number of locations was reduced to 10 at each area from 1957 through June 1964. Between July 1964 and 1971, vegetation was sampled at a total of four locations; two locations were approximately 1 mi distant from each of the areas. Two locations were positioned approximately 1 mi northwest and 1 mi west of the H-Area, and the other two were positioned approximately 1 mi southeast of the F-Area. In 1972, one location southeast of the F-Area was repositioned to approximately 1 mi west of the F-Area, and the location west of the H-Area was repositioned to approximately 1 mi southeast of the H-Area. From 1972 through 1991, the same four F-Area and H-Area locations were sampled. Samples were collected and composited for weekly analysis through 1972. Since 1972, the sampling frequency has been monthly. The monitoring reports provided semiannual averages through 1972 and annual averages from 1973 through 1991. Aperture cards provided weekly and monthly composite values for 1957 and 1959 through 1973.

There were 15 inner perimeter locations from 1953 through June 1955 and 14 from July 1955 through 1958, after which inner perimeter samples were no longer collected. There were 21

plant perimeter locations from 1953 through June 1954, 17 from July 1954 through June 1955, 14 from July 1955 through June 1964, 7 from July 1964 through 1981, 13 from 1982 through 1986, and 14 from 1987 through 1991. There were ten 25-mi radius locations from 1953 through June 1954, 11 from July 1954 through June 1955, 14 from July 1955 through June 1964, 7 from July 1964 through 1981, 12 from 1982 through 1985, 6 in 1986; and 4 from 1987 through 1991.

Samples from the plant perimeter and 25-mi radius locations were collected weekly and composited for analysis from 1954 through June 1965. Samples were collected monthly and composited for analysis from July 1965 through 1983. Samples were collected quarterly and composited for analysis from 1986 through 1991. The sampling frequency is unclear in 1984 and 1985. However, based on the reported number of samples, the sampling frequency has been quarterly since 1983. The monitoring reports provided semiannual averages through 1972 and annual averages from 1973 through 1976 and from 1983 through 1991. Aperture cards provided monthly and weekly composite values from 1957 and 1959 through 1973.

The monitoring reports began providing annual averages at four 100-mi radius locations in 1974, including Macon and Savannah in Georgia and Columbia and Greenville in South Carolina. The collection frequency was monthly through 1978 and quarterly from 1979 through 1991. Concentrations were reported rather sporadically in the aperture cards beginning in 1962. The reporting frequency varied from weekly to semiannually.

Figure 9-1 shows locations that were sampled at F-Area and H-Area, the plant perimeter, and the 25-mi radius distances from 1982 through 1985. The number of locations has varied somewhat historically, as discussed above, but Figure 9-1 provides a general representation of the various locations discussed in this chapter. The general reduction in sample numbers over time was an attempt to create a cost effective program without compromising its utility, and it permitted more duplicate analyses of certain “critical” samples (Marter and Johnson 1966). Table 9-1 provides a general summary of the routine sampling and analyses that have been completed for vegetation since the inception of the monitoring program.

Tritium

Because tritium concentrations were reported for individual vegetation samples collected at the plant perimeter, 25-mi radius, and 100-mi radius locations, spatial trend analysis is possible. Table 9-2 compiles mean reported concentrations since 1976 at all locations, along with the approximate direction from the center of the SRS. There were no apparent trends for any direction although concentrations decreased as a function of distance in all directions. This was expected given the lack of a dominant prevailing wind direction at the SRS. However, only annual average concentrations were reported for each location, which precluded examining temporal trends throughout the year and, consequently, during episodic releases.

According to the reports reviewed, tritium has been the only radionuclide of SRS origin to be detected offsite or beyond the plant perimeter in vegetation. Figure 9-2 shows the annual average tritium concentrations for the years 1974 through 1991. Concentrations measured at the F-Area and H-Area are clearly greater than those measured at the plant perimeter, 25-mi, and 100-mi locations. The plant perimeter concentrations are consistently higher than 25-mi radius concentrations, which are slightly higher than 100-mi radius concentrations. Concentrations for all locations decreased significantly from 1974 through 1977 and have fluctuated since that time.

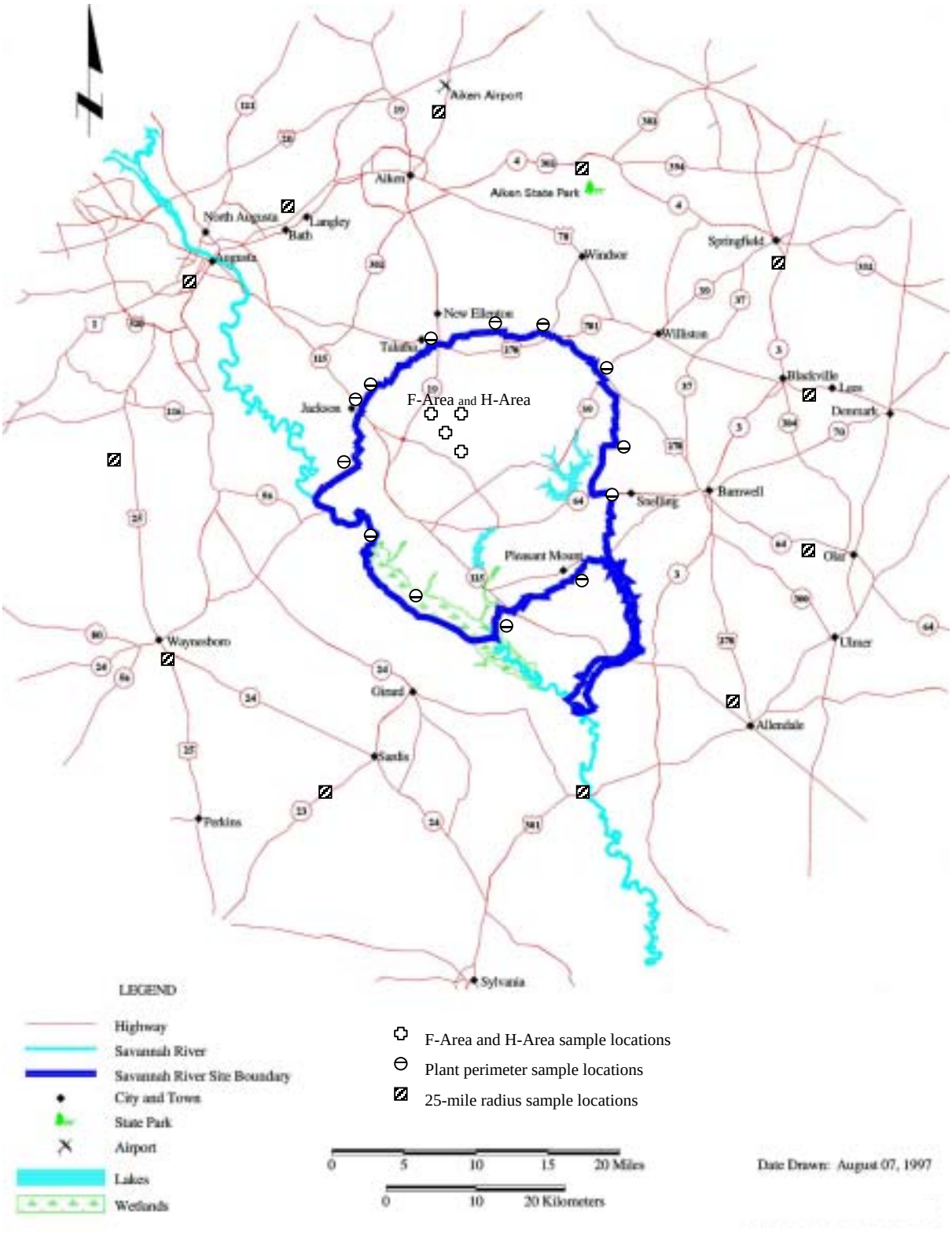

Figure 9-1. Map showing vegetation sampling locations during 1985.

Table 9-1. Summary of Routine SRS Radiological Monitoring for Vegetation[a]

	Number of routine locations					Radiological analyses				
Year	F- and H-Area	Inner perimeter	Plant perimeter	25-mile radius	100-mile radius	Gross alpha	Gross nonvolatile beta	Radioiodine	Tritium	Gamma spectroscopy
1953		15	21	10		x	x			
June 1954		15	21	10		x	x			
July 1954		15	17	11		x	x			
June 1955		15	17	11		x	x	x		
July 1955	48	14	14	14		x	x	x		
1956	48	14	14	14		x	x	x		
1957	20	14	14	14		x	x	x		
1958	20	14	14	14		x	x	x		
1959	20	b	14	14		x	x	x		
1960	20		14	14		x	x	x		
June 1961	20		14	14		x	x	x		
July 1961	20		14	14		x	x	x		x
1962	20		14	14	4	x	x	x		x
1963	20		14	14	4	x	x	x		x
June 1964	20		14	14	4	x	x	x		x
July 1964	4		7	7	4	x	x	x		x
1965 - 1973	4		7	7	4	x	x	x		x
1974	4		7	7	4	x	x	x	x	x
1975	4		7	7	4	x	x		x	x
1976	4		7	7	4	x	x		x	x
1977	4		7	7	4	x	x		x	x
1978	4		7	7	4	x	x	x	x	x
1979	4		7	7	4	x	x	x	x	x
1980	4		7	7	4	x	x	x	x	x
1981	4		7	7	4	x	x	x	x	x
1982	4		13	12	4	x	x	x	x	x
1983	4		13	12	4	x	x	x	x	x
1984	4		13	12	4	x	x		x	x
1985	4		13	12	4	x	x	x	x	x
1986	4		13	6	4	x	x		x	x
1987	4		14	4	4	x	x	x	x	x
1988	4		14	4	4	x	x	x	x	x
1989	4		14	4	4	x	x	x	x	x
1990	4		14	4	4	x	x		x	x
1991	4		14	4	4	x	x		x	x

[a] This table is intended to provide the reader with general time periods only for collection and analysis of samples at routine locations and is not an exact representation of all collected data

[b] sampling was discontinued

Table 9-2. Median, Maximum, and Minimum Annual Average Tritium Concentrations Measured in Vegetation Samples Collected at Individual Plant Perimeter, 25-Mi Radius, and 100-Mi Radius Locations Since 1976[a]

Location (years reported)	Direction[b]	Concentration (pCi mL^{-1})		
		Median	Maximum	Minimum
Plant perimeter				
East Talatha (1982–1991)	N	4.7	12	1
Windsor Road (1982–1991)	NNE	3.1	8	1.7
Darkhorse (1976—1991)	NE	4.4	15	0.8
Highway 21/167 (1982–1991)	ENE	3.4	36	0.8
Barnwell Gate (1982–1991)	E	1.9	13	0.6
Pattersons Mill (1976–1991)	ESE	3.0	18	0.4
Allendale Gate (1976–1991)	SSE	2.0	6.9	0.3
A/14 (1976–1991)	SSW	6.6	13	1.4
D area (1976–1991)	WSW	6.8	30	2.1
West Jackson (1982–1991)	WNW	3.1	27	1
Jackson (1982—1991)	NW	3.8	24	0.8
Greenpond (1976—1991)	NW	4.2	19	0.8
Talatha Gate (1976–1991)	NNW	4.2	15	0.6
Plant perimeter mean		*3.9*	*10.6*	*1.3*
25-mi radius				
Aiken Airport (1976–1985)	N	3.5	5	1.2
Aiken State Park (1976–1985)	NNE	1.8	4.9	0.6
Springfield (1976–1991)	NE	1.5	4.5	0.2
Lees (1976–1985)	ENE	2.3	3.1	1.5
Olar (1976–1985)	E	1.9	4.2	0.01
Allendale (1976–1991)	SE	1.1	4	0.2
Highway 301 (1976–1987)	SSE	1.6	2.9	0.7
Perkins (1976–1987)	SSW	1.4	4.6	0.7
Waynesboro (1976–1991)	WSW	1.6	4.8	0.3
South Richmond (1976–1986)	W	1.8	3.7	0.4
Augusta (1976–1986)	NW	1.7	4.1	0.8
Langley (1976–1991)	NNW	1.5	3.3	0.1
25-mi radius mean		*1.6*	*3.2*	*0.4*
100-mi radius				
Columbia	NNE	0.4	2.4	0.09
Greenville	NNW	0.4	2.9	0.03
Macon	WSW	0.4	8	0.04
Savannah	SSE	0.4	2.3	0.01
100-mi radius mean		*0.4*	*2.8*	*0.09*

[a] Data are from Du Pont (1977, 1978, 1979, 1980, 1981, 1982, 1983, 1984), Zeigler et al. (1985), Zeigler et al. (1986b, 1987b), Mikol et al. (1988b), Davis et al. (1989b), Cummins et al. (1990, 1991), and Arnett et al. (1992).

[b] Approximate direction relative to the center of the SRS.

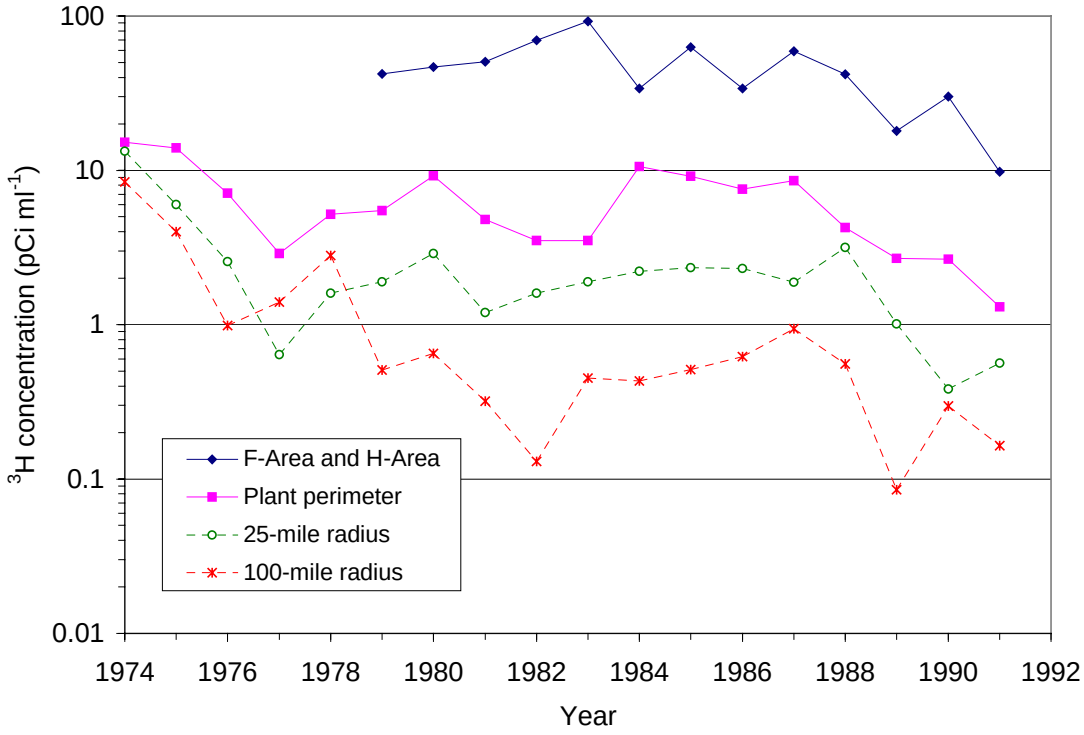

Figure 9-2. Tritium concentrations measured in water extracted from vegetation at the F-Area and H-Area, plant perimeter, 25-mi radius, and 100-mi radius locations. Link to tabulated figure data.

Because tritium concentrations were reported for 1-mi distant locations surrounding the F-Area and H-Area and many tritium releases originated from F-Area and H-Area stacks, it is instructive to look at concentrations as a function of distance from the F-Area and H-Areas (Figure 9-3). While the distance estimates are not precise, they do provide a good approximation. Average concentrations for 1979 through 1991 were calculated for approximately 1-, 10-, 25-, and 100-mi distances. Concentrations decreased as a power function of distance for the four locations, and regression analysis of the log-transformed data yielded a very good fit (R^2 = 0.997). This is consistent with information reported on special studies in 1973 and 1974 for tritium in vegetation at distances up to 8 mi in four directions around H-Stack (see special studies section).

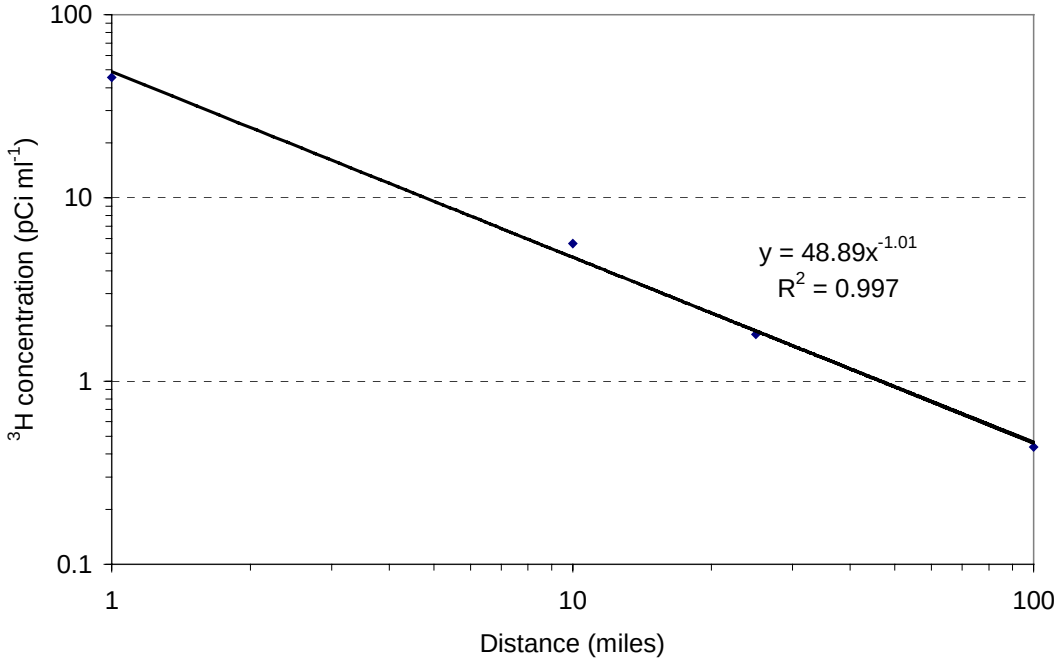

Figure 9-3. Average tritium concentration as a function of distance from the center of the SRS for 1979 through 1991. Link to tabulated figure data.

Figures 9A-1–9A-4 (Addendum 9A) show tritium concentrations for the individual plant perimeter, 25-mi radius, and 100-mi radius locations as a function of time since 1976. There are no apparent temporal or spatial trends for any of the locations at the 25-mi and 100-mi radius locations. The high concentration reported for the west-southwest direction at the 100-mi radius location in 1978 was due to a reported concentration of 30 pCi mL^{-1} in one sample collected at Macon, Georgia. At the plant perimeter, concentrations appear somewhat elevated in a westerly direction from 1983 through 1986. The wind was blowing in a northeast direction for most of the reported releases during this time period (see Table 9-3). An abnormally high concentration (36 pCi mL^{-1}) was reported at the Highway 21/167 perimeter location (east-northeast direction) in 1987. The wind was blowing in a northeast direction during a June 31, 1987 reported release (see Table 9-3). Comparisons based on annual average concentrations are of limited usefulness, however, because it is not possible to examine spatial or temporal trends during episodic releases.

Radioiodine, Gross Alpha, Nonvolatile Beta, and Gamma-Emitting Radionuclides

The environmental monitoring reports maintained that the remaining radionuclides for which concentrations have been reported are either naturally occurring or the result of atmospheric fallout from weapons testing. The following four sections examine these claims for radioiodine, gross alpha, nonvolatile beta, and gamma-emitting radionuclides. Naturally occurring radionuclide concentrations, including ^{7}Be and ^{40}K, are also examined.

Before the Test Ban Treaty of 1963 was signed by the U.S., United Kingdom, and Soviet Union, extensive atmospheric weapons testing was conducted. In addition, the Chinese conducted

atmospheric weapons tests on May 13, 1965; May 9 and October 27, 1966; September 26 and November 17, 1976; September 17, 1977; March 14 and December 14, 1978; and October 16, 1980 (Du Pont 1965b, 1966b, 1967a; Ashley and Zeigler 1978a, 1978b, 1981, and 1983). Carter and Moghissi (1977) provides a comprehensive discussion of all nuclear detonations occurring between July 1945 and June 1975.

Several radionuclides associated with atmospheric testing as well as reactor and dissolution facility operations have been periodically detected in vegetation (e.g., ^{103,106}Ru, ^{95}Zr/Nb, ^{140}Ba/La, and ^{131}I). However, with the exception of the longer-lived radionuclides (including ^{141,144}Ce and ^{134,137}Cs) and nonvolatile beta activity, concentrations have in most cases been near the lower limit of detection (LLD)[1]. In general, reported concentrations for all fallout radionuclides have been indistinguishable at the plant perimeter, 25-mi radius, and 100-mi radius locations. Based on the data that have been reviewed, there is little evidence to suggest that SRS operations have resulted in elevated perimeter or offsite concentrations of any fission products, with the exception of radioiodine. There is some indication that concentrations have historically been higher at F-Area and H-Area locations, which is likely the result of F-Area and H-Area releases. With the exception of radioiodine, there is also evidence that suggests this pattern may partially be the result of variations in areal deposition rates. These topics are discussed in the following sections.

Radioiodine Concentrations

Vegetation was analyzed for ^{131}I from 1955 through 1991. Before 1961, radioiodine concentrations were determined using undried samples of vegetation, so concentrations reported in this chapter during that time period are in units of picocuries per gram wet weight. Beginning in 1961, vegetation samples were dried before analysis, so concentrations from 1961 through 1991 are in units of picocuries per gram dry weight. This should be noted when comparing concentrations measured during these two time periods.

The monitoring reports state that tritium is the only radionuclide of SRS origin to be detected in offsite vegetation. To examine the credibility of this claim, it is helpful to compare concentrations of other radionuclides measured in vegetation collected at the F-Area and H-Area (many of the radioiodine releases at the SRS originated from the F-Area and H-Area stacks), plant perimeter, and 25-mi radius locations (Figure 9-4). Concentrations measured before July 1961 were reported on a wet weight basis, and concentrations measured since July 1961 were reported on a dry weight basis. For comparison, activity reported on a wet weight basis is approximately 3 times lower than the same amount of activity reported on a dry weight basis. For the purpose of viewing the data in Figure 9-4, we have increased the wet weight data before July 1961 by a factor of 3 to allow for a more direct comparison to the dry weight data after July 1961. F-Area and H-Area concentrations were not reported before July 1955, so inner perimeter concentrations were substituted for analysis of iodine, gross alpha, and nonvolatile beta comparisons during that time period. The lower limit of detection (LLD) is also shown.

[1] The lower limit of detection (LLD) values are provided in various figures throughout this chapter whenever they were reported in the environmental monitoring reports. In many cases, however, the reports state "...the sensitivity of analysis varied due to differing sample size..." and no LLD values were provided.

Radioiodine concentrations measured in vegetation have generally been highest at the F-Area and H-Area locations, particularly during the 1950s. Elevated concentrations at all locations during 1961, 1962, 1965, 1966, and 1978 may be related to atmospheric weapons tests conducted by the Soviet Union, U.S., and China during those years. However, limited data were available for F-Area and H-Area locations from September 1960 through December 1961, and concentrations have been infrequently reported since 1974. A concentration of 245 pCi g^{-1} was reported for F-Area and H-Area locations in June 1961, compared to concentrations of 5.6 and 5.2 pCi g^{-1} at the plant perimeter and 25 mi-radius locations, respectively.

Figures 9-5 and 9-6 show ^{131}I concentrations at the F-Area and H-Area and plant perimeter locations, respectively, compared to concentrations measured at the 25-mi radius locations. This comparison is useful to establish whether concentrations at the F-Area and H-Area and plant perimeter locations are elevated compared to concentrations at the 25-mi radius locations. Ratio values consistently greater than 1 suggest higher concentrations than at the 25-mi radius locations, and ratio values averaging close to 1 suggest similar concentrations to the 25-mi radius locations. The values are plotted on a logarithmic scale in Figure 9-5, but it is clear that F-Area and H-Area concentrations are elevated relative to 25-mi radius locations, particularly through 1960. This reflects emissions from F-Area and H-Area stacks. Conversely, concentrations do not appear to be elevated at plant perimeter locations relative to 25-mi radius locations based on these data.

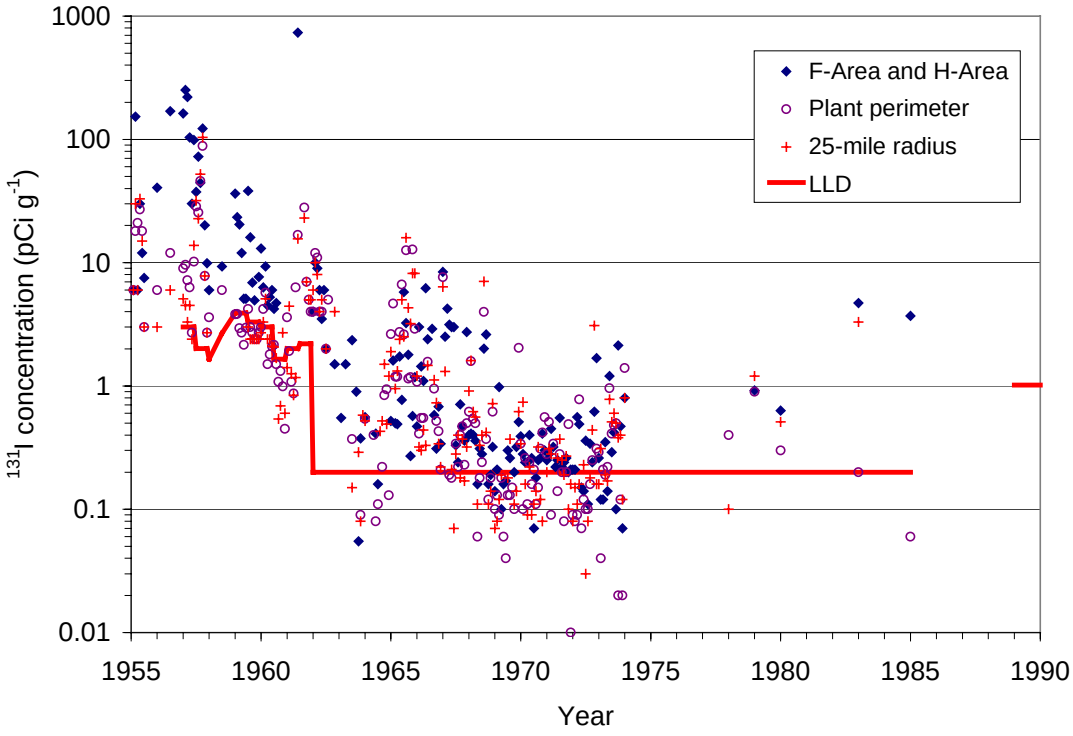

Figure 9-4. Iodine-131 concentrations measured in vegetation (dry weight) from the F-Area and H-Area, plant perimeter, and 25-mi radius locations since 1955 shown with the reported LLD. For the period before July 1961, we have increased the reported wet weight concentrations by a factor of 3 to allow for a more direct comparison to the dry weight data (see text for details). Link to tabulated figure data.

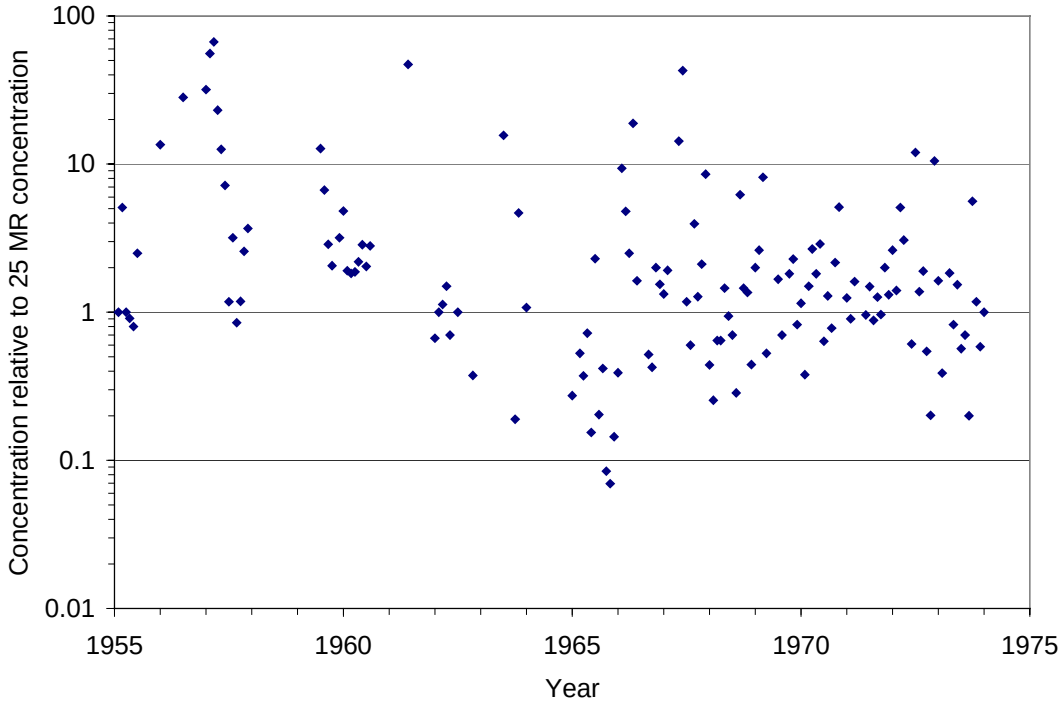

Figure 9-5. Ratio of ^{131}I concentrations measured in vegetation at the F-Area and H-Area to those measured at 25-mi radius locations. Link to tabulated figure data.

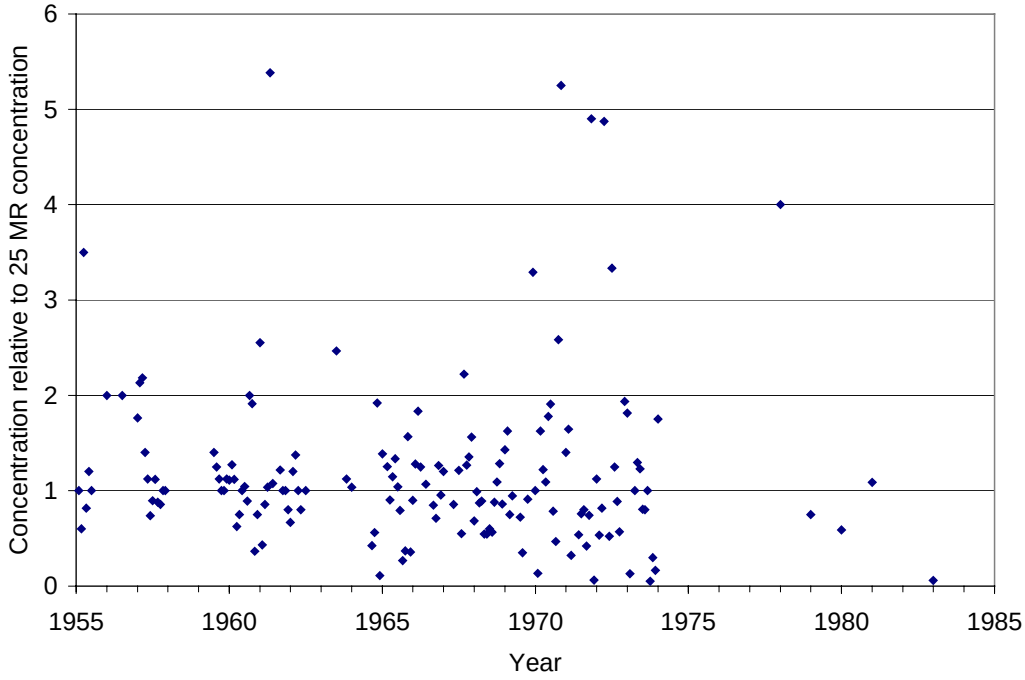

Figure 9-6. Ratio of ^{131}I concentrations measured in vegetation at the plant perimeter to those measured at 25-mi radius locations. Link to tabulated figure data.

Since 1970, no concentrations greater than 1 pCi g^{-1} have been reported for either of these locations. The higher ratio values since that time in Figure 9-6 are likely the result of comparing measured concentrations near or below the detection limit of 0.2 pCi g^{-1}. A higher ratio value (5.4) in May 1961 resulted from comparing reported concentrations of 2.1 and 0.39 pCi g^{-1} at the plant perimeter and 25-mi radius locations, respectively. The concentration for F-Area and H-Area locations was not reported. A higher ratio value (3.5) in April 1955 resulted from comparing reported concentrations of 7 and 2 pCi g^{-1} at the plant perimeter and 25-mi radius locations, respectively. For comparison, the inner perimeter concentration was 2 pCi g^{-1}.

Weekly average ^{131}I concentrations are available for 1957 and 1959 through 1961 in aperture card printouts for those years (Figures 9-7, 9-8, 9-9, and 9-10) (Du Pont 1957, 1959a, 1960c, and 1961b). Concentrations appear elevated at the plant perimeter locations compared to 25-mi radius locations through the first half of 1957. This suggests that SRS operations in 1957 may have impacted ^{131}I concentrations in vegetation to at least the plant perimeter. During the second half of 1957 and from January 1959 through June 1961, plant perimeter and 25-mi radius concentrations appear similar and/or near the LLD. This indicates that the majority of ^{131}I peaks detected in vegetation during these time periods resulted from atmospheric deposition. Similar peaks in concentration at the plant perimeter and 25-mi radius locations occurred in June 1961, following a substantial increase in the daily release rate of ^{131}I from the Building 291-F stack. It is difficult to determine if this increase resulted from weapons testing or plant releases, but similar concentrations at both distances suggest deposition related to weapons testing. Unfortunately, weekly or monthly data for 1958 or for years before 1957 are not available. Significant plant releases of ^{131}I occurred in 1956, but reported releases in 1958 were similar to reported releases in 1960, and elevated concentrations at the plant perimeter are not evident in 1960. Average monthly and semiannual concentrations in 1955 and 1956 suggest little SRS impact, but the temporal resolution is severely limited considering the relatively short half-life of ^{131}I (about 8 days).

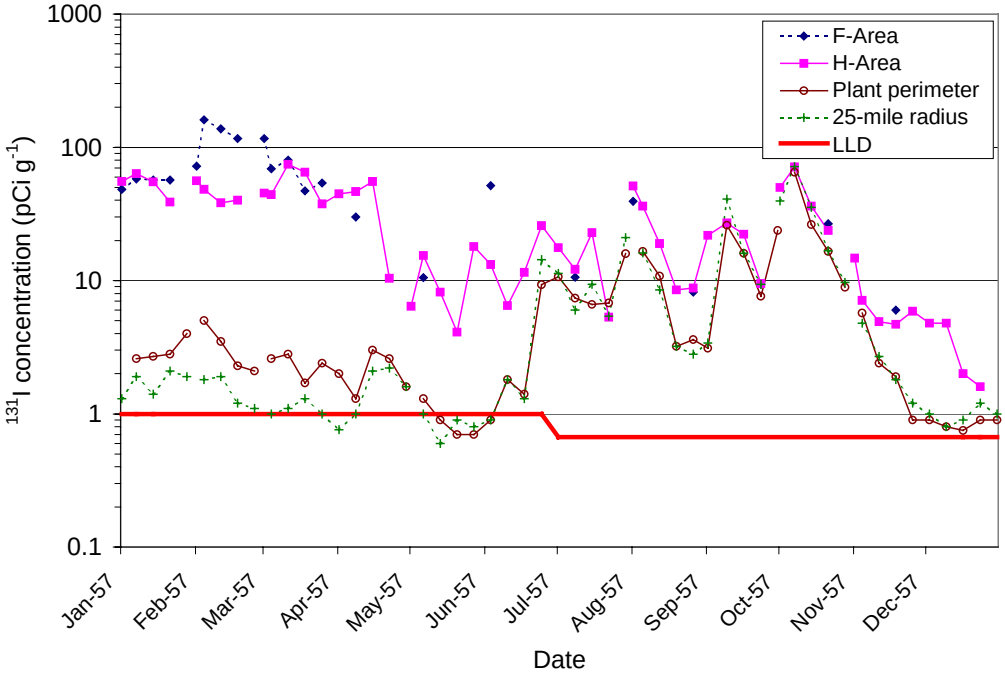

Figure 9-7. Weekly ^{131}I concentrations measured in vegetation (wet weight) at the F-Area and H-Area, plant perimeter, and 25-mi radius locations during 1957. Link to tabulated figure data.

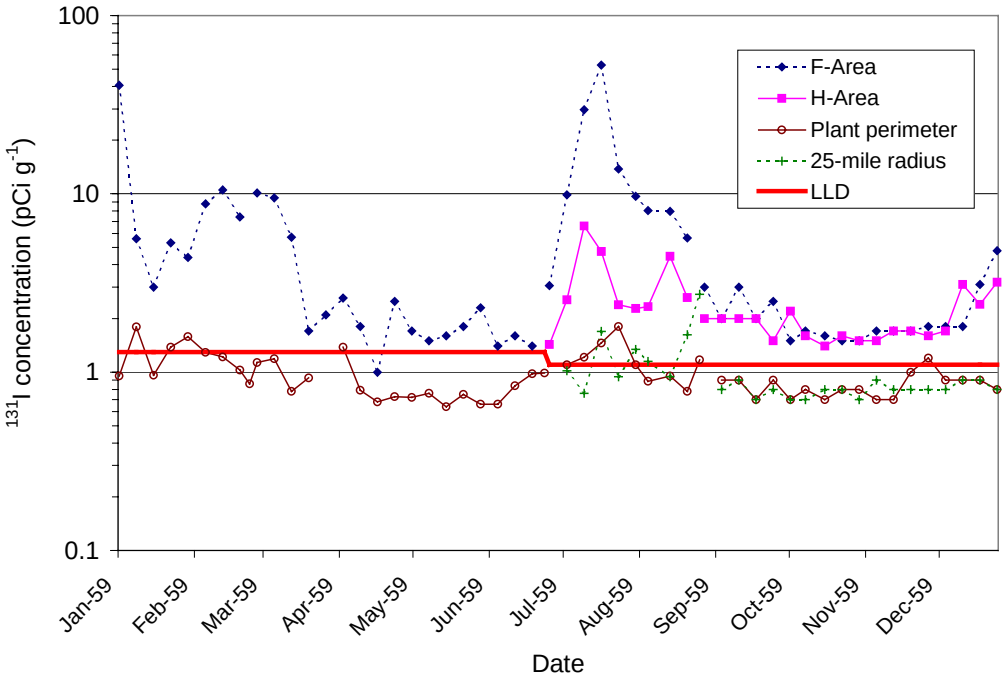

Figure 9-8. Weekly ^{131}I concentrations measured in vegetation (wet weight) at the F-Area and H-Area, plant perimeter, and 25-mi radius locations during 1959. Link to tabulated figure data.

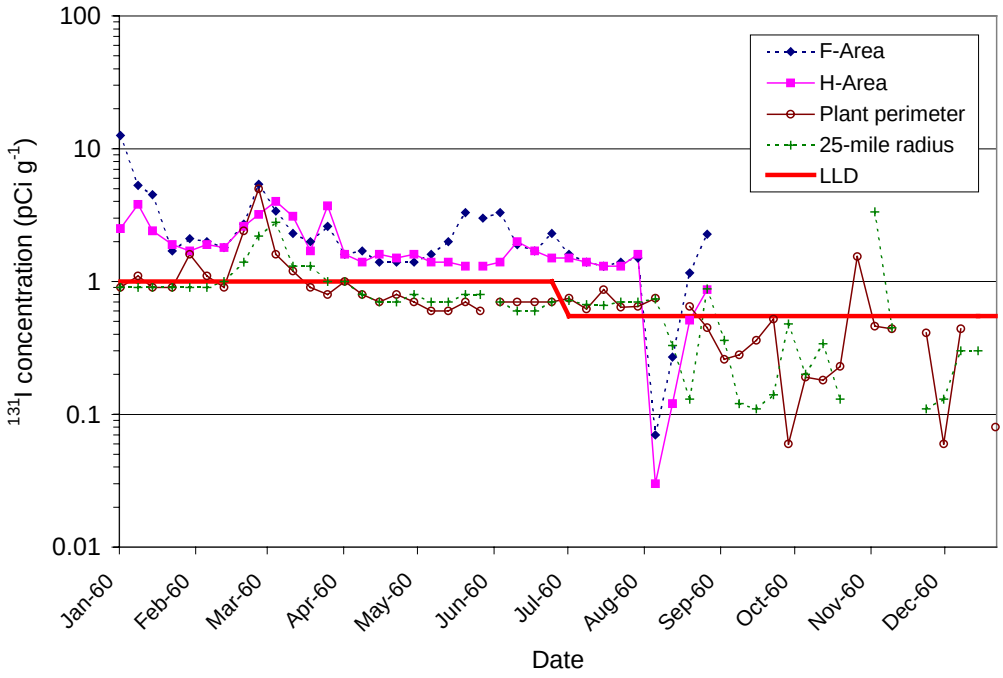

Figure 9-9. Weekly ^{131}I concentrations measured in vegetation (wet weight) at the F-Area and H-Area, plant perimeter, and 25-mi radius locations during 1960. Link to tabulated figure data.

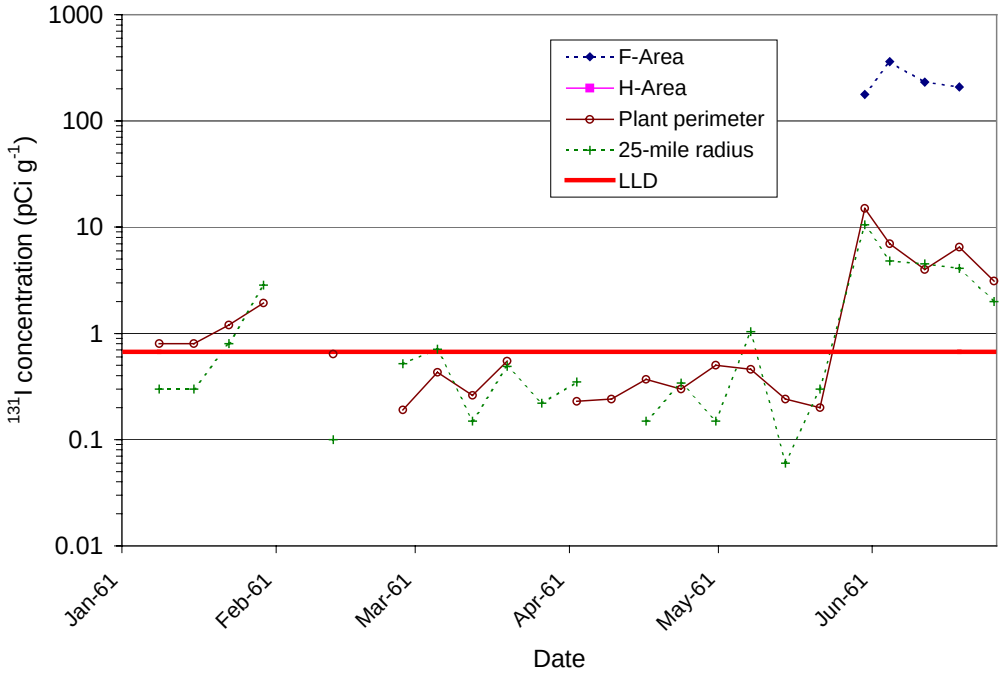

Figure 9-10. Weekly ^{131}I concentrations measured in vegetation (wet weight) at the F-Area and H-Area, plant perimeter, and 25-mi radius locations during the first half 1961. Link to tabulated figure data.

Comparing vegetation and air ^{131}I concentrations during 1959 and January through June of 1961 reveals generally close correlation between the two media, which would be expected (Figures 9-11 and 9-12). Vegetation concentrations do not appear to show the same increase seen for air concentrations during April, May, and June 1959. An explanation for this is not apparent, but trend differences between the two media could result from variations in wind rose, precipitation, and collection dates.

Based on the concentrations reported in the documents we reviewed, ^{131}I concentrations have clearly been elevated at the F-Area and H-Area locations compared to both the plant perimeter and 25-mi radius locations. However, it is difficult to distinguish between reported concentrations at the plant perimeter and 25-mi radius locations since the second half of 1957, and it is likely that the majority of ^{131}I detected at these locations was the result of atmospheric deposition. Plant operations appear to have impacted plant perimeter concentrations during at least the first half of 1957. Based on reported releases for 1955 and 1956, which were greater than for 1957, it is likely that ^{131}I concentrations in vegetation at the plant perimeter locations were also impacted by SRS operations during these years.

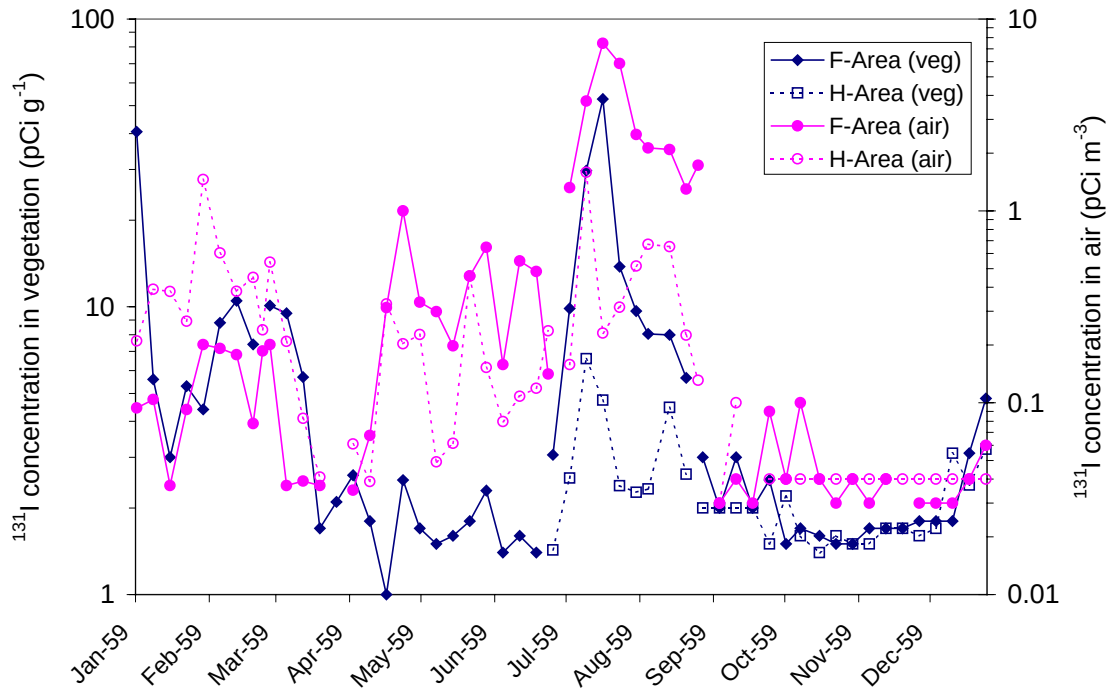

Figure 9-11. Comparison of ^{131}I concentrations measured in vegetation (wet weight) and air samples collected from the F-Area and H-Area locations during 1959. Link to tabulated figure data.

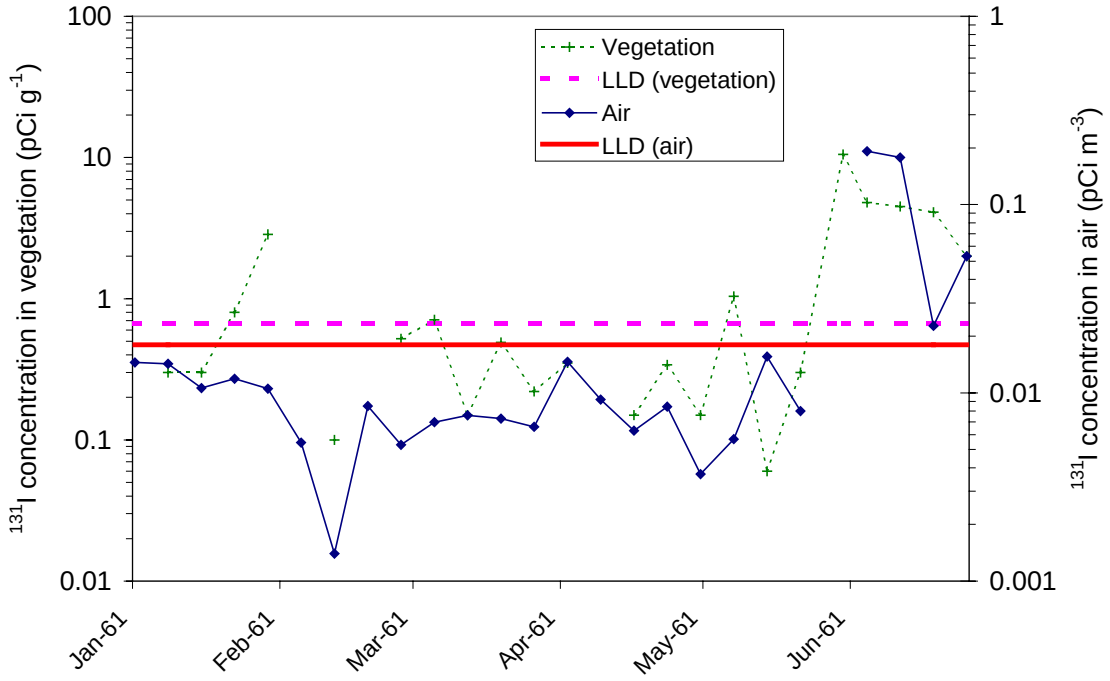

Figure 9-12. Comparison of ^{131}I concentrations measured in vegetation (wet weight) and air samples collected from the 25-mi radius locations during the first half of 1961. Link to tabulated figure data.

Gross Alpha Concentrations

Gross alpha concentrations were reported for vegetation from 1954 through 1991. It is again helpful to examine concentrations that have been reported for the F-Area and H-Area and plant perimeter locations to assess potential SRS impact (Figure 9-13). To present the data as clearly as possible, 25-mi radius concentrations are not included, but they have been generally indistinguishable from plant perimeter concentrations. Concentrations appear consistently higher at the F-Area and H-Area locations.

Comparing gross alpha concentrations at the F-Area and H-Area and plant perimeter locations to concentrations at 25-mi radius locations (Figures 9-14 and 9-15, respectively) confirmed consistently higher concentrations at F-Area and H-Area locations but generally indistinguishable concentrations at the plant perimeter and 25-mi radius locations.

A higher ratio value (5.5) in October 1961 (Figure 9-15) resulted from comparing reported concentrations of 0.22 and 0.04 pCi g^{-1} at the plant perimeter and 25-mi radius locations, respectively. For comparison, the concentration reported for F-Area and H-Area locations was 0.1 pCi g^{-1}. A higher ratio value (4.1) in 1991 (Figure 9-15) resulted from comparing reported concentrations of 0.29 and 0.07 pCi g^{-1} at the plant perimeter and 25-mi radius locations, respectively. For comparison, the concentration reported for the 100-mi radius locations was 0.22 pCi g^{-1}.

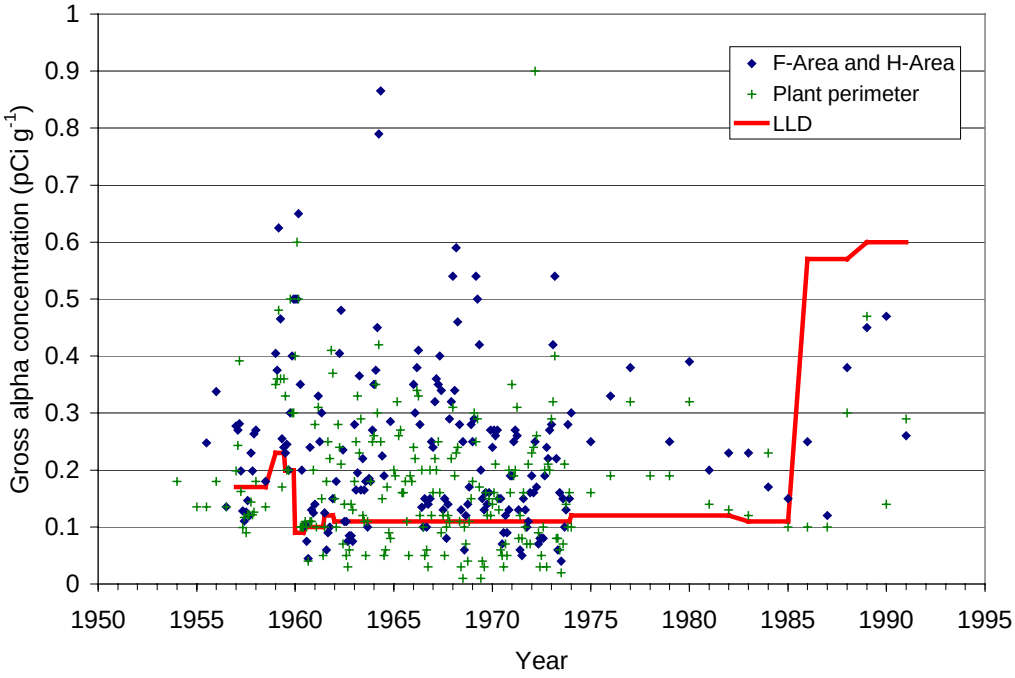

Figure 9-13. Gross alpha concentrations measured in vegetation (dry weight) at the F-Area and H-Area and plant perimeter locations shown with the reported LLD. Link to tabulated figure data.

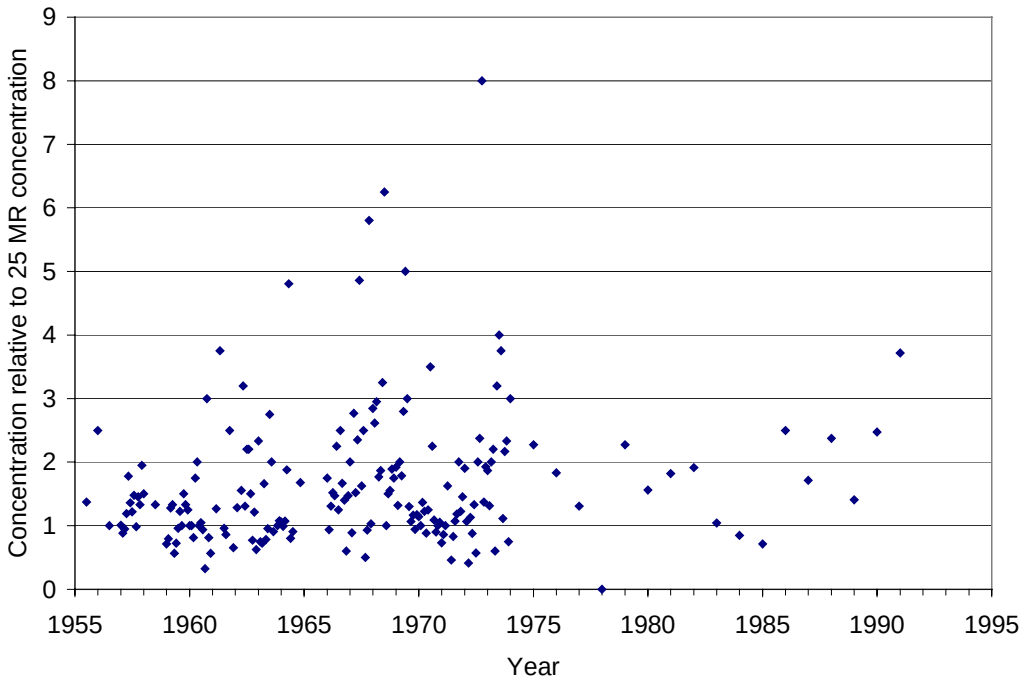

Figure 9-14. Ratio of gross alpha concentrations measured in vegetation (dry weight) at the F-Area and H-Area to those measured at 25-mi radius locations. Link to tabulated figure data.

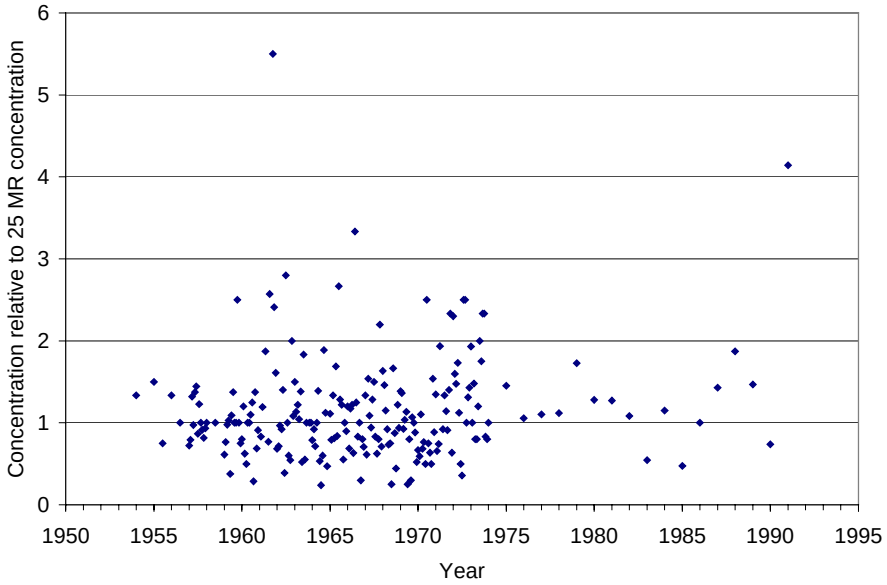

Figure 9-15. Ratio of gross alpha concentrations measured in vegetation (dry weight) at the plant perimeter to those measured at 25-mi radius locations. Link to tabulated figure data.

Based on the concentrations reported in the documents we reviewed, gross alpha concentrations appear to be elevated at the F-Area and H-Area locations compared to both the plant perimeter and 25-mi radius locations. However, it is difficult to distinguish between reported concentrations at the plant perimeter and 25-mi radius locations, and it is likely that the majority of gross alpha activity detected at these locations has been the result of atmospheric deposition.

Nonvolatile Beta Concentrations

Nonvolatile beta concentrations were reported for vegetation from 1954 through 1991. The primary radionuclides that could potentially contribute to nonvolatile beta activity at the SRS include ^{137}Cs, ^{65}Zn, ^{90}Sr, ^{32}P, and naturally occurring ^{40}K. It is again helpful to examine concentrations that have been reported for the F-Area and H-Area and plant perimeter locations to assess potential SRS impact (Figure 9-16). To present the data as clearly as possible, 25-mi radius concentrations are not included, but they have been generally indistinguishable from plant perimeter concentrations. Concentrations appear consistently higher at the F-Area and H-Area locations.

A significantly higher concentration (2600 pCi g^{-1}) was reported for the F-Area and H-Area locations (actually inner perimeter locations, see the iodine section) in March 1955. The high concentration was attributed to fallout from Nevada Test Site testing on March 12 (Teapot Hornet), which reportedly arrived on March 14 (Alexander and Horton 1956). Stack air filters indicated no unusual discharge, and constant air monitors showed that the material arrived at widely separated areas on the plant site between 2:00 and 2:30 p.m. A wind speed of 10 mph recorded at 200-F would likely not have been sufficient for such widespread contamination. Half-life determinations made by several Health Physics Area Survey Groups showed the half-life to

be between 30 and 40 hours, which is consistent with fission products that have had a few days to decay during atmospheric transport from the Nevada Test Site. The half-life for fission products released from the 200-Area would be significantly shorter since the shorter-lived radionuclides would not have had time to decay. The material appeared to be fallout, and lower concentrations measured at the plant perimeter and 25-mi radius locations were attributed to later sampling dates. The fallout reportedly arrived on March 14, and inner perimeter, outer (plant) perimeter, and 25-mi radius locations were sampled on March 15, 23, and 30, respectively. The reported concentrations for these locations were 2600, 220, and 700 pCi g^{-1}, respectively. It is not clear why the plant perimeter concentrations were lower than the 25-mi radius concentration. However, variations in precipitation patterns could be a factor. See Chapter 6 for a more detailed discussion regarding this event.

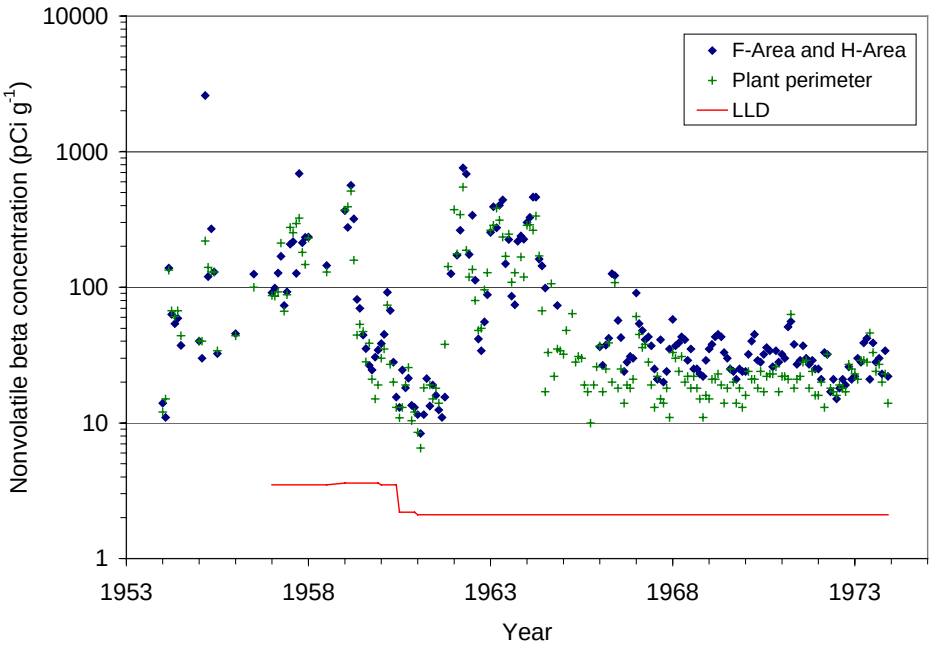

Figure 9-16. Nonvolatile beta concentrations measured in vegetation (dry weight) at the F-Area and H-Area and plant perimeter locations shown with the reported LLD. Link to tabulated figure data.

The nonvolatile beta concentrations at the F-Area and H-Area and plant perimeter locations compared to concentrations at the 25-mi radius locations (Figures 9-17 and 9-18) confirm consistently higher concentrations at the F-Area and H-Area locations but generally indistinguishable concentrations at the plant perimeter and 25-mi radius locations. A higher ratio value (3.4) in April 1957 (Figure 9-18) resulted from comparing reported concentrations of 212 and 62 pCi g^{-1} at the plant perimeter and 25-mi radius locations, respectively. For comparison, the concentration reported for the F-Area and H-Area locations was 169 pCi g^{-1}. A higher ratio value (3.3) in 1991 (Figure 9-18) resulted from comparing reported concentrations of 106 and 32 pCi g^{-1} at the plant perimeter and 25-mi radius locations, respectively. The concentration at the F-Area and H-Area locations was not reported.

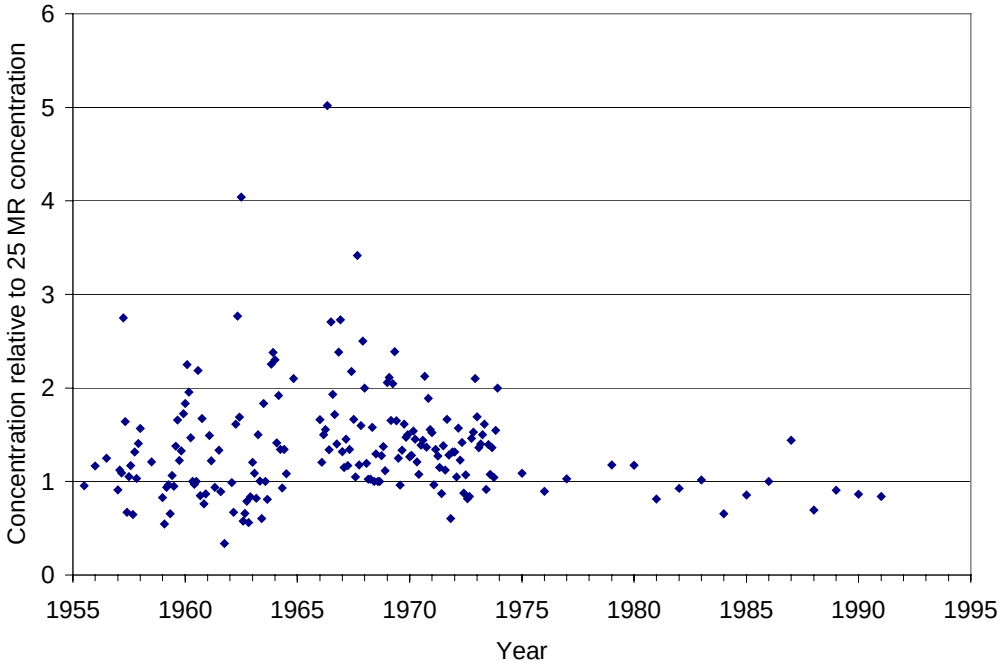

Figure 9-17. Ratio of nonvolatile beta concentrations measured in vegetation (dry weight) at the F-Area and H-Area to those measured at 25-mi radius locations. Link to tabulated figure data.

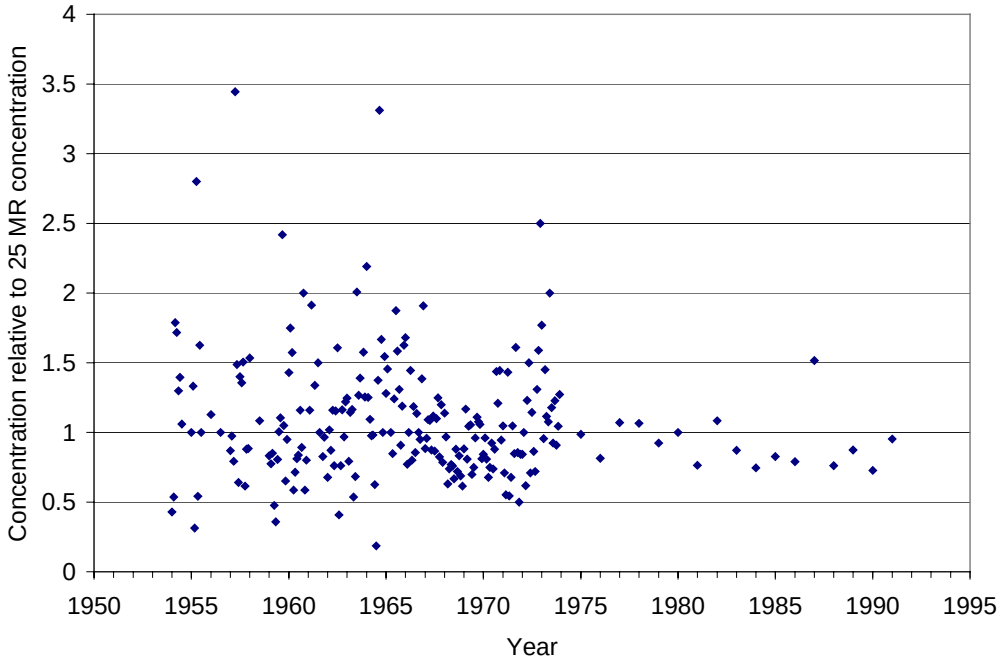

Figure 9-18. Ratio of nonvolatile beta concentrations measured in vegetation (dry weight) at the plant perimeter to those measured at the 25-mi radius locations. Link to tabulated figure data.

Based on the concentrations reported in the documents we reviewed, nonvolatile beta concentrations appear to be elevated at the F-Area and H-Area locations compared to both the plant perimeter and 25-mi radius locations. However, it is difficult to distinguish between reported concentrations at the plant perimeter and 25-mi radius locations, and it is likely that the majority of nonvolatile beta activity detected at these locations was the result of atmospheric deposition.

Gamma-Emitting Radionuclide Concentrations

Gamma-emitting radionuclides (^{144}Ce, ^{137}Cs, ^{106}Ru, and ^{95}Zr/Nb) have routinely been detected in vegetation and have been reported since July 1961. Concentrations of ^{137}Cs, ^{144}Ce, ^{106}Ru, and ^{95}Zr/Nb are shown in Figures 9-19, 9-20, 9-21, and 9-22, respectively. There do not appear to be any significant differences between concentrations of these radionuclides measured at the plant perimeter and 25-mi locations. However, as was noted for gross alpha and nonvolatile beta activity, F-Area and H-Area locations appear elevated compared to the 25-mi radius and plant perimeter locations. Where lower limits of detection (LLDs) were reported, they are included in the figures. However, from approximately 1973 through 1985, these values were not reported. Ashley and Zeigler (1984) states, "Where samples are analyzed by gamma spectrometry, the lower level of detection of a given radionuclide varies with the background of each individual channel grouping, with the geometry and volume of the sample analyzed, and with the number of radionuclides present in the sample."

Comparing plant perimeter and F-Area and H-Area concentrations to 25-mi radius concentrations again confirmed elevated concentrations at the F-Area and H-Area locations and generally indistinguishable concentrations at the plant perimeter and 25-mi radius locations. For brevity, the plots are not shown, but the same general trends discussed for alpha and nonvolatile beta activity were evident. F-Area and H-Area concentrations appear elevated for the four radionuclides, as illustrated in Figures 9-14 and 9-17, and plant perimeter concentrations appear generally indistinguishable from 25-mi radius concentrations for the four radionuclides, as illustrated in Figures 9-15 and 9-18.

Based on the concentrations reported in the documents we reviewed, gamma-emitting radionuclide (^{144}Ce, ^{137}Cs, ^{106}Ru, and ^{95}Zr/Nb) concentrations appear to be elevated at the F-Area and H-Area locations compared to both the plant perimeter and 25-mi radius locations. However, it is difficult to distinguish between reported concentrations at the plant perimeter and 25-mi radius locations, and it is likely that the majority of gamma-emitting radionuclides detected at these locations were the result of atmospheric deposition.

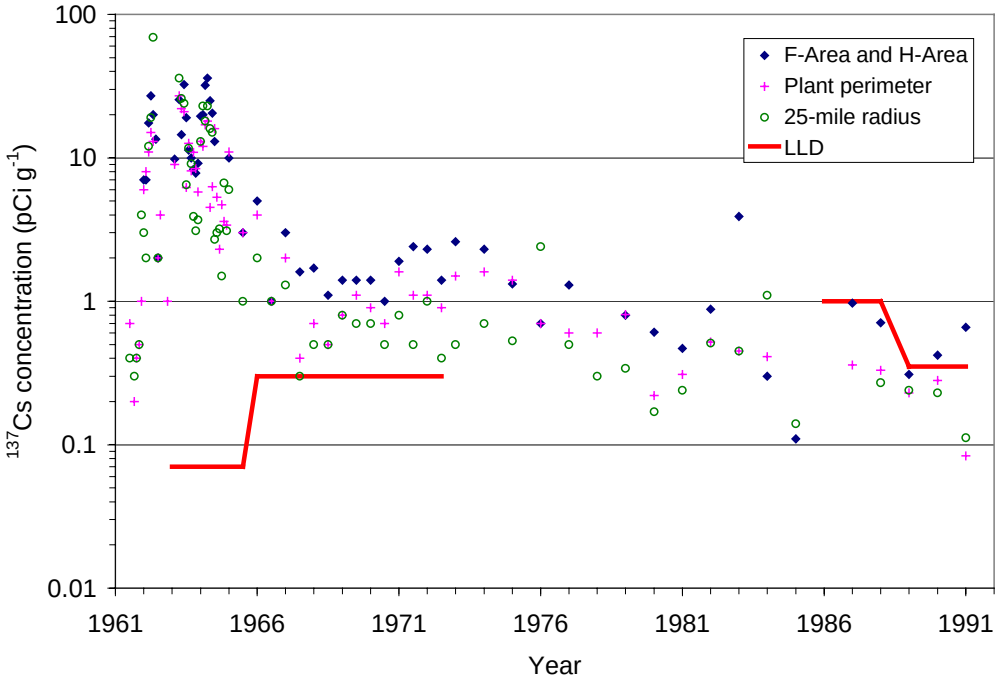

Figure 9-19. Cesium-137 concentrations measured in vegetation (dry weight) at the F-Area and H-Area, plant perimeter, and 25-mi radius locations. Link to tabulated figure data.

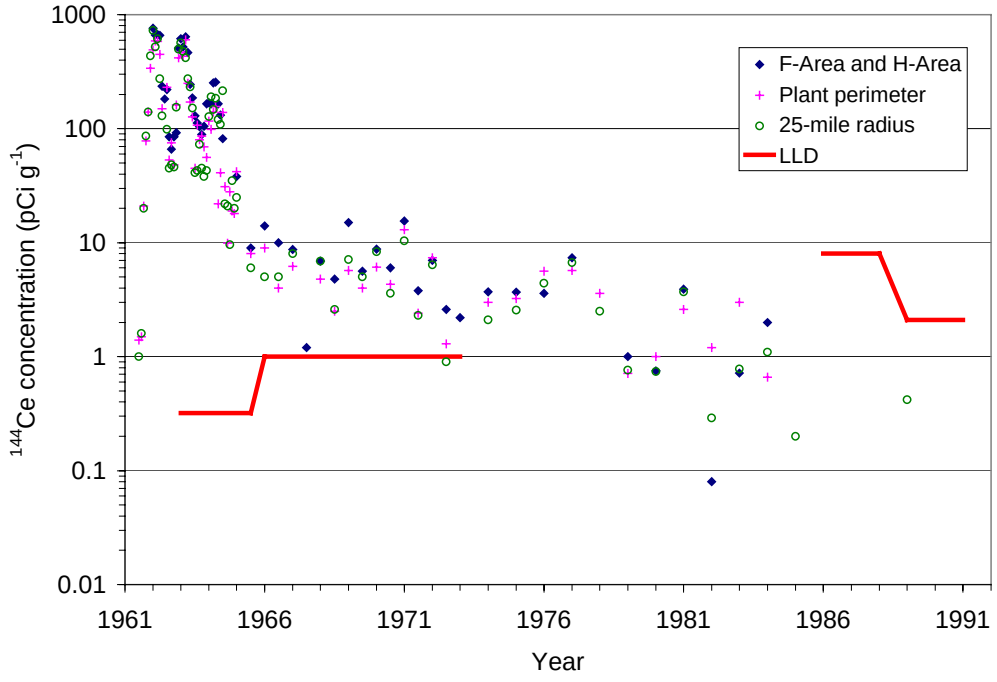

Figure 9-20. Cerium-144 concentrations measured in vegetation (dry weight) at the F-Area and H-Area, plant perimeter, and 25-mi radius locations. Link to tabulated figure data.

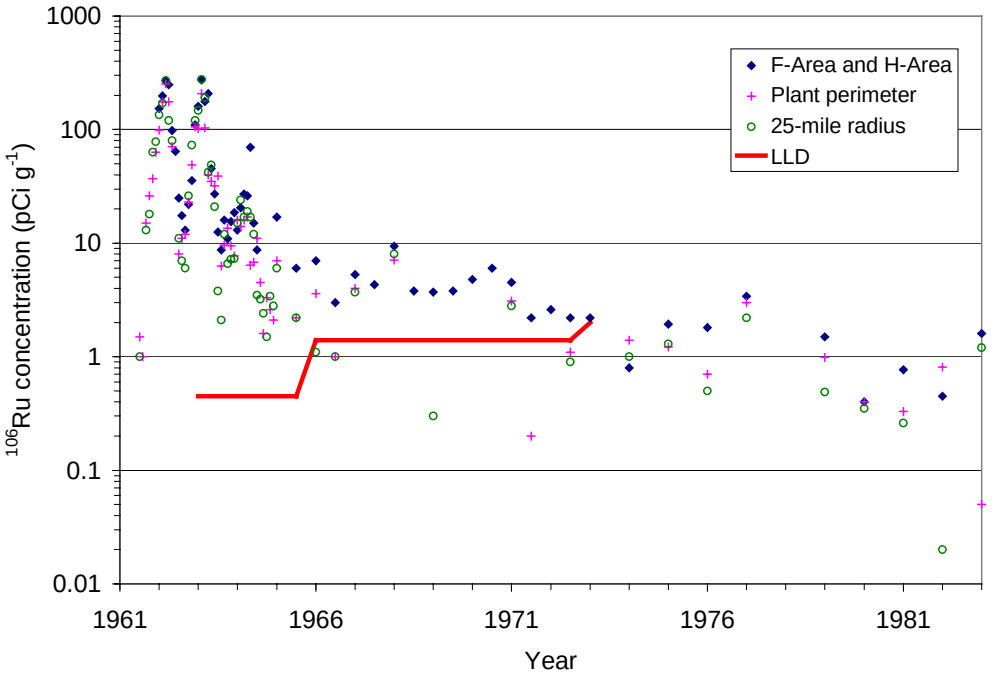

Figure 9-21. Ruthenium-106 concentrations measured in vegetation (dry weight) at the F-Area and H-Area, plant perimeter, and 25-mi radius locations. Link to tabulated figure data.

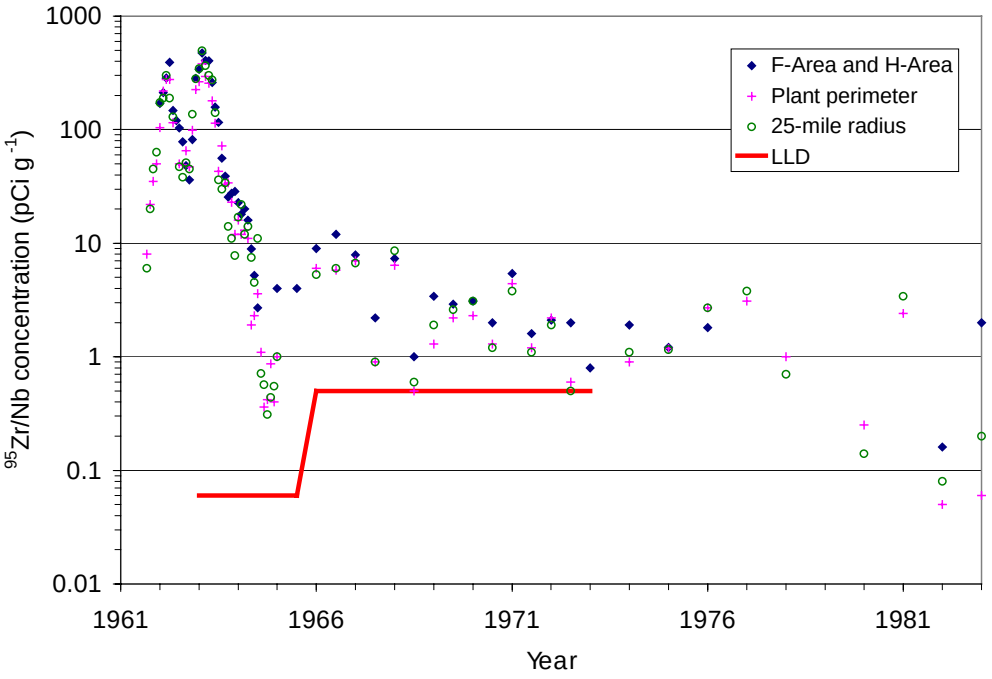

Figure 9-22. Zirconium/Niobium-95 concentrations measured in vegetation (dry weight) at the F-Area and H-Area, plant perimeter, and 25-mi radius locations. Link to tabulated figure data.

Naturally Occurring Radionuclide Concentrations

It is interesting to note that gross alpha activity, nonvolatile beta activity, and gamma-emitting radionuclide concentrations measured at the F-Area and H-Area locations have typically been elevated compared to the plant perimeter and 25-mi radius locations. Naturally occurring ^{7}Be concentrations have been measured at all locations since 1965. Because ^{7}Be is primarily a product of cosmic interactions in the atmosphere and is not extensively associated with weapons testing or SRS activities, it is instructive to examine concentrations at the various locations to determine whether the same trends are evident (Figure 9-23).

The same general trends are evident, with F-Area and H-Area concentrations consistently higher than plant perimeter and 25-mi radius concentrations. Examining F-Area and H-Area and plant perimeter concentrations compared to 25-mi radius concentrations (Figures 9-24 and 9-25) confirms higher concentrations at the F-Area and H-Area locations, and plant perimeter and 25-mi radius concentrations appear indistinguishable. Close inspection of the data also reveals higher concentrations during the first half of the year, which is consistent with expected patterns of atmospheric deposition.

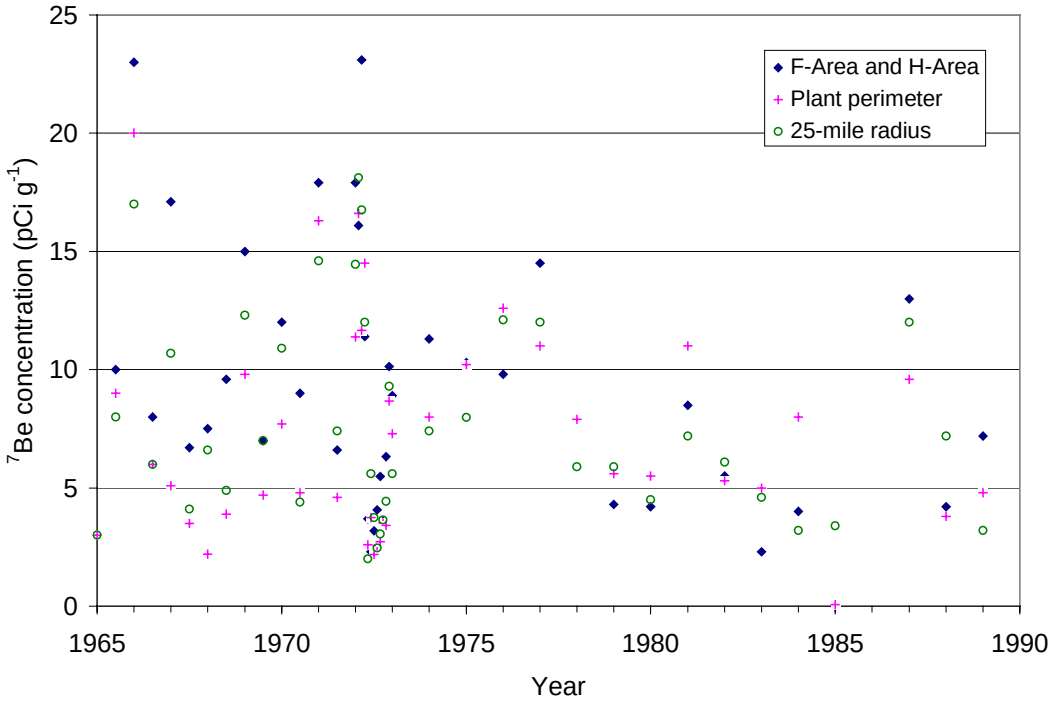

Figure 9-23. Beryllium-7 concentrations measured in vegetation (dry weight) at the F-Area and H-Area, plant perimeter, and 25-mi radius locations. Link to tabulated figure data.

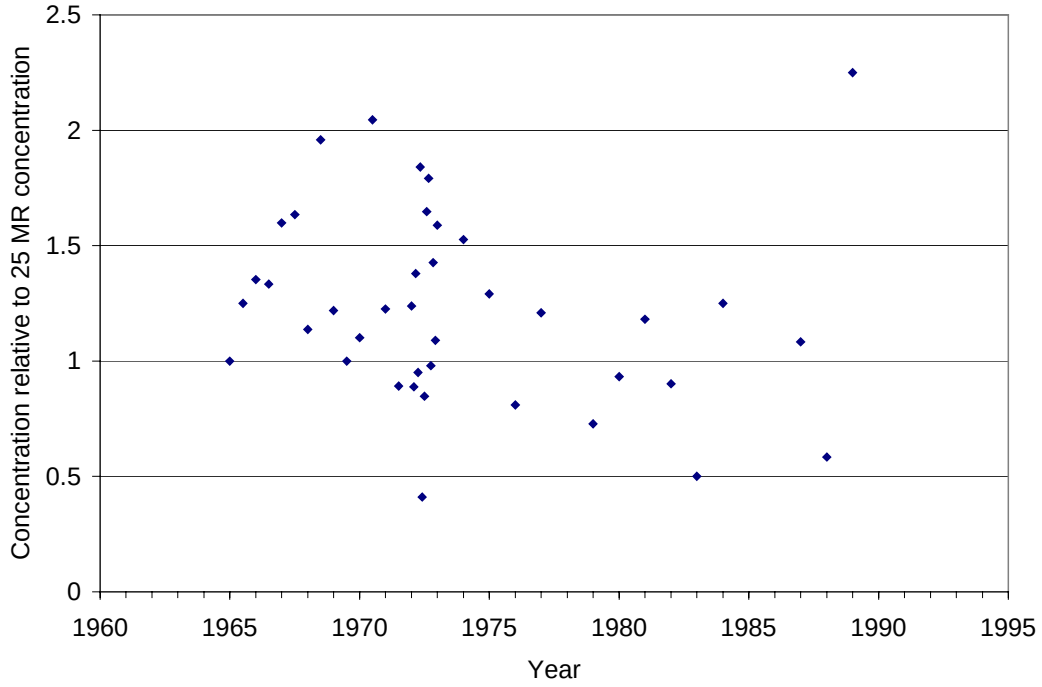

Figure 9-24. Ratio of ^{7}Be concentrations measured in vegetation (dry weight) at the F-Area and H-Area to those measured at 25-mi radius locations. Link to tabulated figure data.

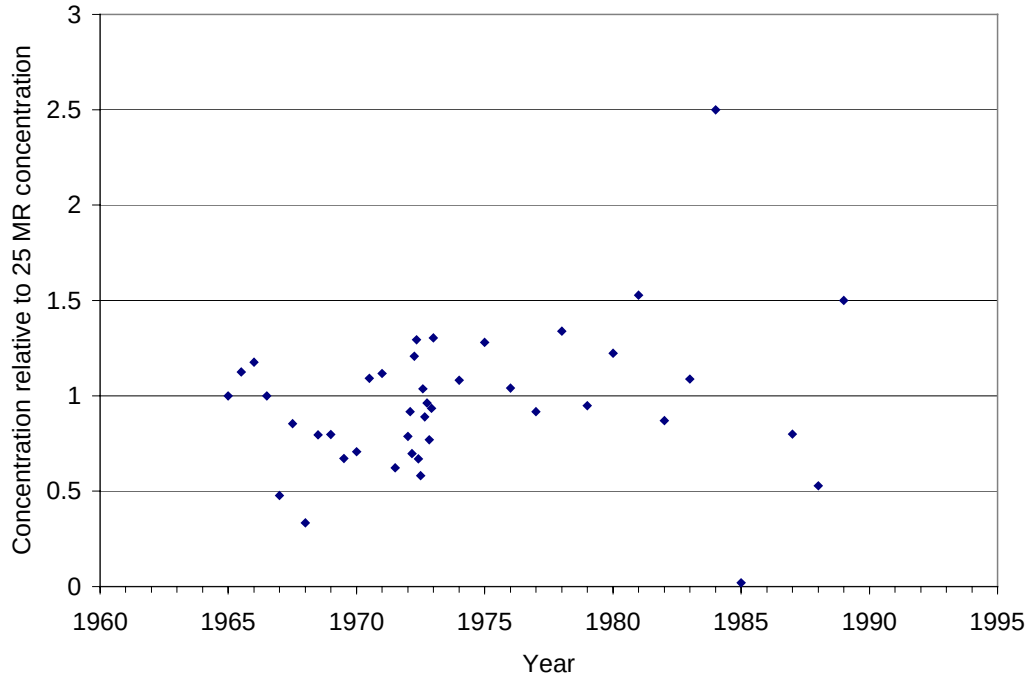

Figure 9-25. Ratio of ^{7}Be concentrations measured in vegetation (dry weight) at the plant perimeter to those measured at 25-mi radius locations. Link to tabulated figure data.

Naturally occurring ^{40}K concentrations have also been reported since 1979. Concentrations of ^{40}K have been similar for the plant perimeter and 25-mi radius locations and higher for the 100-mi radius locations (Figure 9-26). Concentrations also appear to have increased from 1985 through 1989. The variations noted for ^{40}K concentrations are possibly due to natural spatial heterogeneity. However, Horton (1954) attributed higher ^{40}K concentrations at the 25-mi radius locations to the use of commercial fertilizers in this region, which contain naturally occurring ^{40}K. The plant perimeter vegetation, on the other hand, was collected from unfertilized fields. Therefore, at least some of the variation noted for ^{40}K concentrations may be due to differences in fertilizer use.

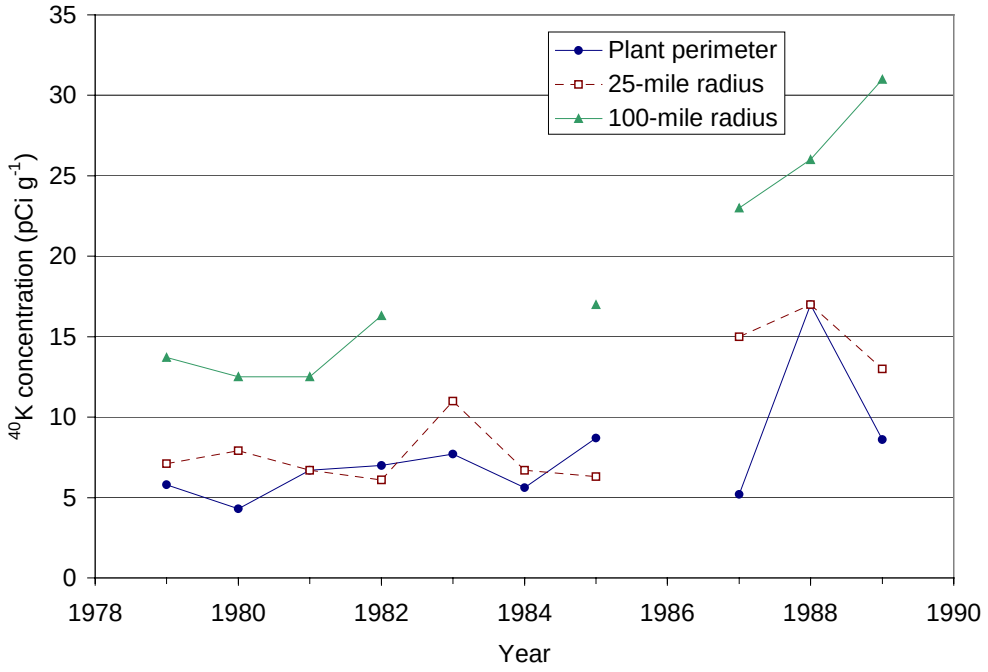

Figure 9-26. Potassium-40 concentrations measured in vegetation (dry weight) at the plant perimeter, 25-mi radius, and 100-mi radius locations. Link to tabulated figure data.

Summary

Close inspection of the gross alpha, nonvolatile beta, and gamma-emitting radionuclide data reveals consistently higher concentrations during the first half of the year for the F-Area and H-Area, plant perimeter, and 25-mi radius locations. This also implies deposition of atmospheric fallout because fallout rates are typically highest during late winter and spring because of accelerated sinking of stratospheric air and generally greater amounts of precipitation during the spring and early summer (Whicker and Schultz 1982).

There is little question that SRS activities have resulted in elevated tritium concentrations in vegetation outside the plant perimeter. The SRS has attributed all other radionuclides detected offsite to atmospheric fallout resulting from weapons testing. However, there is evidence to support elevated concentrations of ^{131}I in 1957 (and likely 1955 and 1956) extending at least to the plant perimeter locations. There is little evidence to suggest elevated concentrations for

radionuclides other than tritium and ^{131}I at the plant perimeter, 25-mi radius, or 100-mi radius locations.

Based on the data we examined, F-Area and H-Area concentrations appear elevated for all radionuclides. However, with the exception of tritium and ^{131}I, SRS activities do not appear to have resulted in elevated concentrations in vegetation at the plant perimeter or offsite locations. Elevated ^{131}I concentrations at the F-Area and H-Area locations are likely the result of releases from the F-Area and H-Area stacks. Elevated gross alpha, nonvolatile beta, and gamma-emitting radionuclide concentrations at the F-Area and H-Area locations, on the other hand, may be partially related to areal variations in atmospheric deposition rates. The concentrations are consistent with seasonal patterns of deposition at all locations, and the same trend of higher F-Area and H-Area concentrations was noted for naturally occurring ^{7}Be. Higher concentrations of fission products (also plutonium and uranium) in general would be expected at the F-Area and H-Area locations because of chronic releases of small amounts of radionuclides associated with the chemical separation processes carried out in these areas. However, it would be difficult to conclude with any confidence that SRS activities have resulted in elevated radionuclide (except tritium and ^{131}I) concentrations in vegetation at any location beyond the SRS plant perimeter.

A further complicating factor in assessing potential SRS contributions to radioactivity detected in vegetation is the fact that the exact type of vegetation sampled is not known with any certainty. Since 1971, the monitoring reports have stated that Bermuda grass has been the primary species sampled. However, little information is provided before 1971 regarding the specific types of vegetation that were sampled. Harvey et al. (1959a) indicated greater sampling of Bermuda and crab grass at the F-Area and H-Area and inner perimeter locations compared to the plant perimeter and 25-mi radius locations. Horton (1954) indicated onsite samples were comprised of trees and weeds while 25-mi radius samples were collected from grain fields. Reinig et al. (1953) and Albenesius (1954) provide nonvolatile beta concentrations for various vegetation species, including oats and oak and pine trees. Mealing and Horton (1957) provides nonvolatile beta concentrations for Bermuda grass and oak and pine trees. The concentrations vary by more than a factor of 2 between the various species.

Table 9-3 lists the calculated ratios based on concentrations for various radionuclides measured at the F-Area and H-Area, plant perimeter, and 100-mi radius locations compared to concentrations measured at 25-mi radius locations. The numbers represent mean and median relative concentrations for all years during which concentrations were reported at both locations. Mean or median ratios close to one suggest little difference from the 25-mi radius location concentrations while mean or median ratios significantly greater than one suggest consistently higher concentrations than those measured at the 25-mi radius locations. The F-Area and H-Area concentrations clearly appear elevated based on both mean and median ratios, and concentrations measured at the plant perimeter and 100-mi radius locations appear quite similar. In most instances, the mean and median ratios at all locations are within about a factor of 2, except F-Area and H-Area ^{131}I concentrations. The fact that the 100-mi radius and plant perimeter locations appear similarly elevated compared to 25-mi radius locations also lends credibility to the conclusion that general variability in areal deposition rates and a variety of sampled plant species may account for the variations noted for different locations. Cesium and ruthenium concentrations do appear slightly more elevated at the plant perimeter locations. However, considering the possible areal variations in deposition and the lack of knowledge regarding species of vegetation that have been sampled, it would be extremely difficult to attribute any plant

perimeter or offsite vegetation radionuclide burdens to SRS operations. Additionally, median values for all radionuclides at the plant perimeter and 100-mi radius locations suggest little difference from 25-mi radius locations.

Table 9-3. Mean and Median Ratios Calculated Based on Comparison of Radionuclide Concentrations at the F-Area and H-Area, Plant Perimeter, and 100-Mi Radius Locations to the 25-Mi Radius Locations

Radionuclide	F-Area and H-Area		Plant perimeter		100-mi radius	
	Mean	Median	Mean	Median	Mean	Median
Gross alpha	1.65	1.33	1.15	1.0	1.42	0.90
Nonvolatile beta	1.37	1.28	1.09	1.0	1.02	0.85
^{137}Cs	2.32	2.0	1.44	1.10	1.06	0.84
^{144}Ce	1.54	1.39	1.19	1.04	1.09	1.0
^{106}Ru	2.62	1.57	2.02	1.04	2.71	1.86
^{95}Zr/Nb	1.70	1.18	1.02	0.97	1.34	1.38
^{131}I	4.38	1.41	1.20	1.0	a	a
^{7}Be	1.23	1.21	0.96	0.94	1.01	0.96

[a]Insufficient data to calculate.

Special Studies

In response to periodic releases of radionuclides from the SRS, particularly tritium releases, several special studies have been initiated to quantify the extent and magnitude of dispersal. These studies have generally involved vegetation sampling at onsite, plant perimeter, and distant locations. The samples have been collected along the projected plume centerline and have assisted in confirming plume trajectory predictions. Table 9-4 summarizes information pertaining to reported releases of tritium since 1963 and resultant vegetation concentrations.

Detailed information regarding the environmental effects of the 1974 and 1975 releases can be found in Marter (1974, cited in Du Pont 1975) and Jacobsen (1976, cited in Du Pont 1976), respectively. Additional tabular information pertaining to episodic releases occurring in 1983–1987 and 1990 is compiled in the annual environmental monitoring reports for those years (Ashley et al. 1984; Zeigler et al. 1985, 1986b, 1987b; Mikol et al. 1988b, and Cummins et al. 1991).

Additional special monitoring of vegetation for tritium was conducted in 1973 and 1974. Samples of pine needles, oak leaves, and grass were collected at 1-mi intervals in north, south, east, and west directions from the H-Area. Concentrations generally decreased as a power function with increasing distance from H-Area for both years.

In January 1965, samples of Spanish moss and Bermuda grass were collected at several onsite locations to examine fallout radionuclide concentrations in each species. Ratios of total activity on moss to grass ranged from approximately 2 to 4, indicating that Spanish moss is a more effective collector of atmospheric fallout than Bermuda grass. This is likely due to a greater surface area to mass ratio for the Spanish moss.

On November 6, 1978, approximately 32 Ci of ^{106}Ru and 1 Ci of ^{103}Ru were released from a fuel separations facility. In response to this release, over 300 environmental samples, including

vegetation, were collected for analysis. Concentrations decreased rapidly with distance from the separations area, and only 1 of approximately 50 samples collected beyond the plant perimeter showed detectable ^{106}Ru activity (20 pCi g^{-1}). The maximum concentration in plant perimeter vegetation was 48 pCi g^{-1}. Both of these samples were collected in a northwest direction from the point of release.

In March 1982, approximately 44 mCi of ^{106}Ru and 3 mCi of ^{103}Ru were released from a fuel separations facility. Vegetation samples collected downwind from the stack indicated no measurable ^{103,106}Ru activity.

Table 9-4. Maximum Tritium Concentrations Measured in Vegetation Following Reported Episodic Releases[a]

Date	Release in curies (form of tritium)[b]	Maximum measured concentration (pCi mL^{-1})		
		Onsite	Plant perimeter	Offsite (miles from SRS)
5/2/74	479,000 (HT)	–[c]	–	–
12/31/75	182,000 (HT)	687	92	9
3/27/81	33,000 (HTO)	–	270	100
3/23/83	4,000 (HTO)	216	–	–
5/17/83	1,100 (HTO)	25	–	–
7/16/83	56,000 (HT)	–	110	80 (25), 27 (50)
8/31/83	2,000 (HTO)	–	2.8	2.3
9/16–19/83	11,500 (HTO)	–	119	17 (25)
11/7/83	150 (HT)			96 (15), 46 (25)
2/16/84	900 (HTO)	1,010	115	103 (25)
3/23/84	7500	95	560	1380 (25), 190 (50)
9/2-3/84	43,800 (HTO)	501	2,500	9859 (25), 240 (77)
1/24/85	9,000 (55% HTO)	1,100	210	70 (25)
1/31/85	9,300 (50% HTO)	7,600	450	380 (25)
3/27/85	19,400 (HTO)	61,890	970	589 (25), 143 (60)
11/4/85	6000 (97% HT)	240	13	–
5/29/86	5900 (95% HTO)	2,600	66	12 (25)
7/31/87	172,000	5,760	4,690	8 (25)
2/7/90	100	–	11	–

[a] Data are from annual environmental monitoring reports.
[b] HT = elemental tritium and HTO = tritium oxide.
[c] – = not reported.

ELECTRONICALLY COMPILED VEGETATION DATA

Vegetation sampling data were reported beginning in 1954 for the inner perimeter, plant perimeter, and 25-mi radius locations. Reporting of data began for the F-Area and H-Area locations in July 1955 and for 100-mi radius locations in 1962. Sampling, and consequently reporting, at inner perimeter locations was discontinued in 1959.

The various data summarized in this chapter are electronically compiled in two Microsoft Excel® workbooks. One workbook (Ch9-Figure_data.xls) contains the figures depicted in this chapter (including the addendum to this chapter) as well as the tabulated data that were used to produce the figures. In this workbook, there is a separate worksheet for each figure and one worksheet contains the tabulated data for all of the figures. The second workbook (Ch9-

All_data.xls) contains the data that have been tabulated from various environmental monitoring reports, aperture card printouts, and raw data sheets. The workbook contains several named worksheets that include brief summary of the compiled data.

Table 9-5 summarizes the data that have been electronically compiled for wild game collected as part of the routine environmental monitoring program maintained by the SRS. It also provides the names of the individual spreadsheets in which these data are compiled (including a brief description of the data). Monthly (and weekly for ^{131}I) data have been compiled from aperture card printouts for 1957 and 1959 through 1973. All other data have been compiled from semiannual and annual environmental monitoring reports.

Table 9-5. Description of Radionuclide Concentration Data Electronically Compiled for Vegetation

Workbook name	Worksheet name	Brief description of data
Ch9-Figure data.xls	Figures 9-1 through 9-26	Each worksheet contains a separate figure depicted in this chapter
	Figures 9A-1 through 9A-4	Each worksheet contains a separate figure depicted in the addendum to this chapter
	Data for figures	This worksheet contains the tabulated data for each of the figures
Ch9-All data.xls	F-Area	Concentrations measured in F-Area vegetation
	H-Area	Concentrations measured in H-Area vegetation
	Outer perimeter	Concentrations measured in vegetation collected from plant perimeter locations
	25-mi radius	Concentrations measured in vegetation collected from 25-mi radius locations
	100-mi radius	Concentrations measured in vegetation collected from 100-mi radius locations
	Inner perimeter	Concentrations measured in vegetation collected from inner perimeter locations
	Nonvolatile beta	Nonvolatile beta concentrations at all locations
	Alpha	Gross alpha concentrations at all locations
	I-131	^{131}I concentrations at all locations
	I-131 (weekly)	Weekly ^{131}I concentrations for 1957 and 1959—1961
	Cs, Ce, Ru, Zr	Cs, Ce, Ru, and Zr/Nb concentrations at all locations
	Be-7	^{7}Be concentrations at all locations
	K-40	^{40}K concentrations at all locations
	H-3 by location	Tritium concentrations at specific plant perimeter and 25-mi radius locations
	Average H-3	Average tritium concentrations at four distances (F-Area and H-Area, plant perimeter, 25-mi radius, and 100-mi radius locations)

RADIONUCLIDE CONCENTRATIONS MEASURED IN AGRICULTURAL PRODUCTS

Collection of local agricultural products began in May 1961. Samples have routinely been collected at 14 locations in the 6 counties surrounding the SRS, with 6 locations situated near the plant perimeter and 8 locations situated approximately 25 mi distant. Food products that have been sampled include collards, plums, peaches, oats, wheat, soybeans, rye, corn, and meat (including chicken and beef).

Food products were prepared as if they were to be eaten. Peelings, seeds, and other nonedible portions were removed. Wheat (containing the whole grains only) and oats (containing both grains and husks) were processed unwashed. In general, the majority of samples were collected during the harvest season.

Only annual average concentrations for all 14 locations were reported in the annual environmental monitoring reports. Since 1970, all radionuclide concentrations (except tritium) were reported as near or below the limits of detection. The annual environmental monitoring reports stated that the concentrations for all radionuclides (except tritium) were indistinguishable from weapons testing fallout. However, based on the vegetation data, there is evidence to suggest that SRS activities resulted in elevated offsite concentrations of radioiodine as well as tritium. Unfortunately, elevated radioiodine concentrations at offsite locations likely would have occurred primarily during years before 1962, and the agricultural product sampling program did not begin until May 1961. The environmental monitoring reports did not report concentrations for radioiodine, presumably because they were below the limits of detection, and aperture card printouts are not available for that time period. Tritium concentrations were reported from 1970 through 1991. In 1964, soybeans were noted to selectively concentrate ^{137}Cs, and collards contained the highest ^{90}Sr concentrations for the majority of years.

The fact that only average concentrations for all 14 locations were reported in the annual monitoring reports precludes any spatial or temporal analyses of these data. Ashley and Zeigler (1978a) stated that there was no significant difference between the plant perimeter and 25-mi distant locations for fallout radionuclides. Based on data provided for vegetation (primarily Bermuda grass), it seems unlikely that any significant differences would have been noted for any of the other years. The exception to this might be radioiodine concentrations during the early 1960s. In general, tritium concentrations were reported to be highest at the plant perimeter locations. This is consistent with data provided for vegetation. Because food products were generally collected during late summer and fall, it is not possible to examine the data for expected seasonal patterns of atmospheric deposition.

Concentrations for specific locations were provided in the aperture card printouts. This would allow for further spatial analysis of the data. However, based on vegetation concentrations, impact beyond the plant perimeter from SRS releases is not evident during the years for which aperture cards have been obtained.

USEFULNESS AND LIMITATIONS OF THE VEGETATION AND AGRICULTURAL PRODUCT DATA FOR DOSE RECONSTRUCTION

There are a number of factors that impact how the vegetation and agricultural product data may be used during subsequent phases of the dose reconstruction project. These factors include the availability of sufficient original monitoring data sets to verify reported summary data and evaluate spatial and temporal trends, as well as the ability to distinguish between Site releases of contaminants and other sources of the same contaminants in the environment (i.e., establish appropriate background concentrations).

Vegetation Data

Semiannual and annual vegetation concentrations in the monitoring reports are consistent with weekly and monthly concentrations reported in the aperture card printouts from 1957 and 1959 through 1973. This provides a good measure of the quality of the reported data and suggests that routinely reported summary data accurately reflect the original, more detailed data.

Concentrations of radionuclides at all plant perimeter and offsite locations have been consistent with periods of reported atmospheric testing and with expected patterns of seasonal deposition. Measured radionuclide concentrations at plant perimeter and offsite locations have generally been indistinguishable, with the exception of ^{131}I and tritium. Based on vegetation concentrations, resultant exposure to the general public from radionuclides other than ^{131}I and tritium appears almost entirely attributable to deposition from weapons testing fallout. Furthermore, it appears that 25-mile radius and 100-mile radius location concentrations are accurate predictors of expected regional background concentrations (i.e., concentrations related to sources other than SRS).

F-Area and H-Area concentrations have been consistently elevated compared to plant perimeter and offsite concentrations for all radionuclides. There is some evidence, based on measured concentrations of naturally occurring ^{7}Be, that these elevated concentrations may partially be the result of areal variations in deposition rates. However, elevated ^{131}I and tritium concentrations at the F-Area and H-Area locations are likely primarily the result of releases from the F-Area and H-Area stacks. The fact that concentrations have generally been reported for composite samples at each distance precludes further spatial analysis of the data to quantitatively determine what impact areal differences in deposition may have on higher onsite concentrations.

There are no apparent spatial trends for tritium, and reported concentrations have been similar in all directions and at all locations for each distance. Concentrations appear to decrease as a power function (i.e., concentrations decrease exponentially as distance increases exponentially) with increasing distance from the SRS. This may be useful for determining vegetation concentrations, as well as verifying air concentrations and deposition rates, at any given distance from the plant. The usefulness is limited, though, by the fact that only annual average concentrations are available for tritium.

The monitoring reports typically state that tritium is the only radionuclide of SRS-origin to be detected in offsite vegetation. However, based on the information in the documents we reviewed regarding vegetation concentrations, there is also evidence to suggest that SRS operations have resulted in offsite deposition of ^{131}I, particularly during the late 1950s and early 1960s. Measured concentrations of ^{131}I in vegetation indicate offsite deposition during periods of

high releases in the first half of 1957. It is likely that offsite deposition also occurred in 1955 and 1956 based on the magnitude of Site releases during those years, but data availability for those years (i.e., only monthly and semiannual averages) and the relatively short half-life of ^{131}I limits the comparisons that can be made. To more closely examine temporal trends and potential SRS contributions to ^{131}I concentrations in offsite vegetation during 1955 and 1956, monthly and, if possible, weekly measured concentrations would be necessary. Unfortunately, these data do not appear to be available. In addition, results were composited for each distance, which limits the usefulness of the data with respect to source term verification and model validation and may hinder quantifying elevated plant perimeter concentrations at specific locations.

It is assumed that results have been reported for Bermuda grass since 1971, but various species appear to have been sampled before then, particularly during the 1950s. Depending on the extent to which these data are used for future model validation, it may be necessary to make some assumptions and generalizations about vegetation species to select appropriate radionuclide uptake and concentration factors.

In summary, the information provided in the documents we reviewed is quite useful for quantifying radionuclide content in vegetation at the plant perimeter, 25-mi radius, and 100-mi radius locations. The information is particularly useful for establishing the primary source of atmospherically deposited radionuclides and may eventually be useful to some extent for source term and model validation. However, the fact that samples were composited and only average concentrations at each distance were reported during the major iodine releases limits the amount of spatial analyses that can be done. Tritium concentrations are available for individual locations at each distance, but only annual average concentrations were routinely reported. For some episodic tritium releases, more detailed information is available in the annual environmental monitoring reports that may be useful for source term verification and model validation (see Special Studies section).

Agricultural Product Data

The usefulness of the agricultural product data for dose reconstruction is limited based on the available data. The fact that only average concentrations for all locations have been reported in the annual environmental monitoring reports precludes spatial analyses of the data. Concentrations for individual locations are available in the aperture card printouts. However, based on vegetation data, it seems likely that the majority of radionuclides detected in food products (with the exception of tritium and ^{131}I) have resulted from atmospheric fallout and that SRS contributions have been minimal. Further analyses will depend on the identification of data reported for individual locations during the years for which specific episodic releases were important beyond the plant perimeter. At this point, food product data have not been compiled, and future compilation of the data will depend on the availability of useful data collected during identified episodic atmospheric releases.

There is little evidence to suggest that the patterns of deposition for agricultural products would be different than those for vegetation. Concentrations could vary between species because of differences in their ability to concentrate particular radionuclides. For example, collards appear to selectively concentrate ^{90}Sr to a greater extent than other vegetable products. Further analyses should be focused on tritium and ^{131}I concentrations or on available information during identified episodic releases.

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ADDENDUM 9A

TRITIUM CONCENTRATIONS IN VEGETATION AT PLANT PERIMETER LOCATIONS

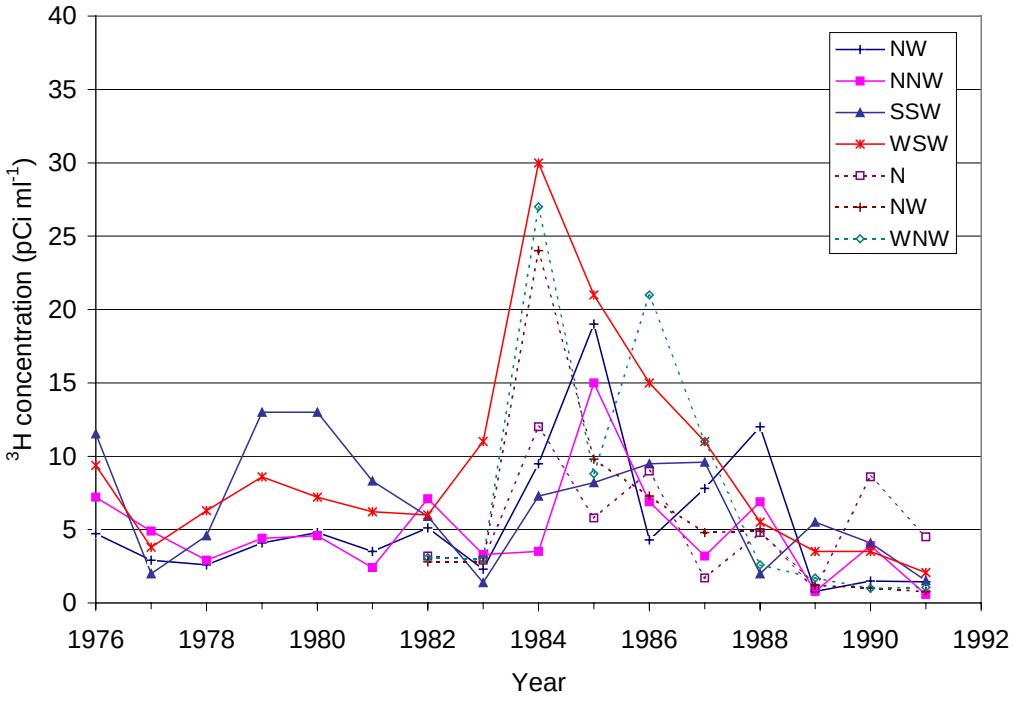

Figure 9A-1. Tritium concentrations in vegetation at individual plant perimeter locations since 1976. See Table 9-1 for location names. Link to tabulated figure data.

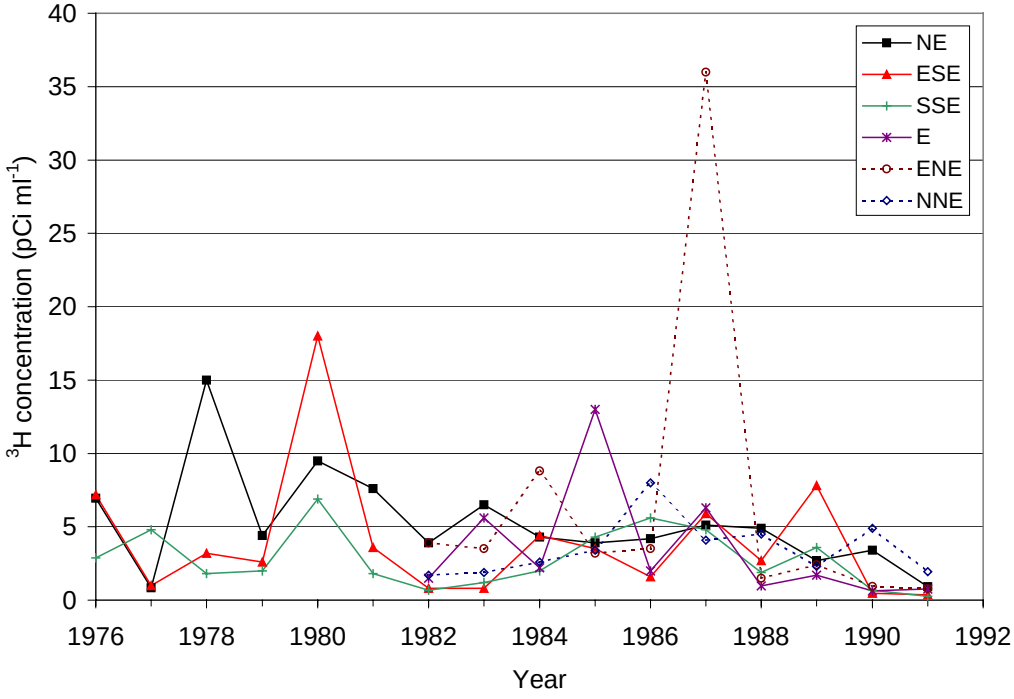

Figure 9A-2. Tritium concentrations in vegetation at individual plant perimeter locations since 1976. See Table 9-1 for location names. Link to tabulated figure data.

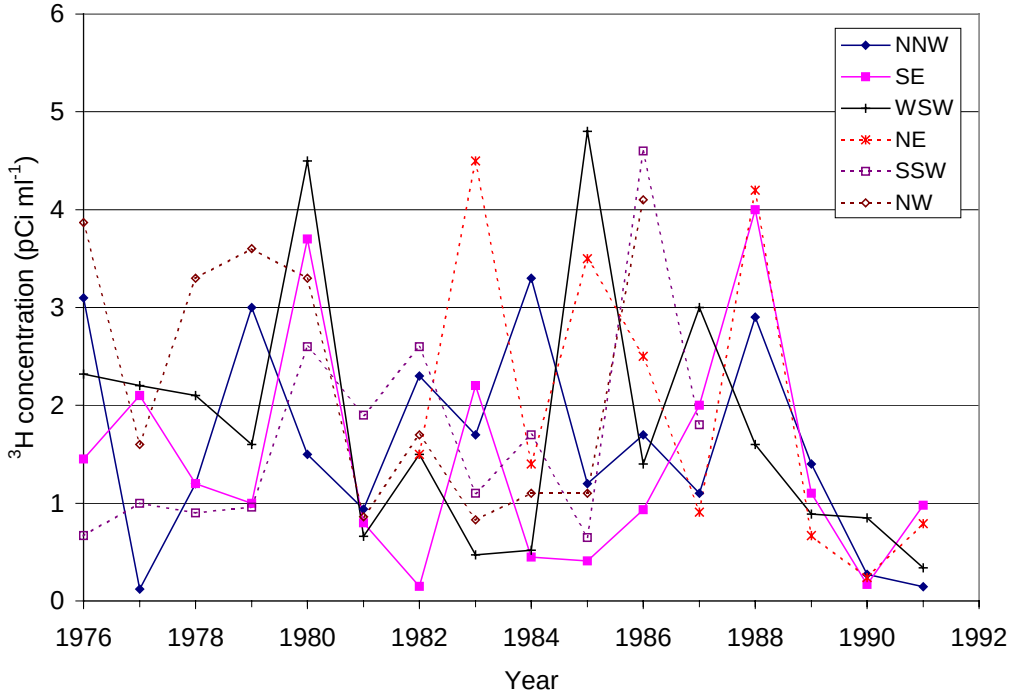

Figure 9A-3. Tritium concentrations in vegetation at individual 25-mi radius locations since 1976. See Table 9-1 for location names. Link to tabulated figure data.

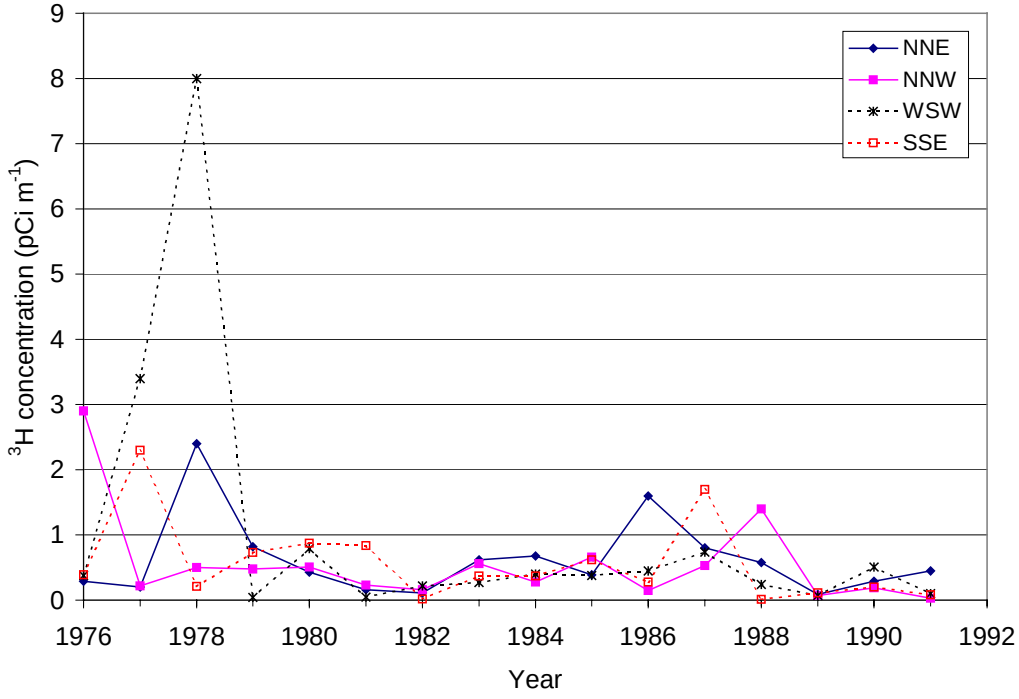

Figure 9A-4. Tritium concentrations in vegetation at individual 100-mi radius locations since 1976. See Table 9-1 for location names. Link to tabulated figure data.