Results of the Tritium Survey of Fourmile Branch and its Seeplines in the F- and H-Areas of SRS: September 1996 and 1989-1996 Trending

by

J. W. Koch, II

Westinghouse Savannah River Company
Savannah River Site
Aiken, South Carolina 29808

K. L. Dixon

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J. W. Koch II and K. L. Dixon, Environmental Analysis Section

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Approved by: D. B. Moore-Shedrow
D.B. Moore-Shedrow, ~~Section~~ Manager
Environmental Sciences and Technology Department

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D. B. Moore-Shedrow, mgr
(Name and Title)
Date: 8/19/97

Westinghouse Savannah River Company
Savannah River Site
Aiken SC 29808

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Table of Contents

Abstract.....	9
Executive Summary	9
Introduction	10
Methods.....	10
Results and Observations	11
Tritium Measurements	12
F Area	12
H Area	13
Conductivity Measurements.....	13
F Area	13
H Area	13
pH Measurements, F- and H-Area Seepline	13
Fourmile Branch Measurements	14
Solid Waste Disposal Facility (643-E) Seepline Measurements	14
Overall Summary	14
Conclusions	15
References	16

List of Figures

	Page
Figure 1	19
Figure 2	19
Figure 3	20
Figure 4	20
Figure 5	21
Figure 6	21
Figure 7	22
Figure 8	22
Figure 9	23
Figure 10	23
Figure 11	24
Figure 12	24
Figure 13	25
Figure 14	25
Figure 15	26
Figure 16	26
Figure 17	27
Figure 18	27
Figure 19	28
Figure 20	28
Figure 21	29
Figure 22	30
Figure 23	30
Figure 24	31
Figure 25	32
Figure 26	32
Figure 27	33
Figure 28	34
Figure 29	35
Figure 30	35

Note: Figures 1 through 18 present September 1996 sampling event information
 Figures 19 through 30 present overall summary information (1989-1996)

List of Tables

		Page
Table 1	Comparison of Monthly Rainfall to the Long Term Average	36
Table 2	Comparison of F-Area Seepine Measurements for Tritium ,Conductivity ,and pH for March 1989, March 1996, and September 1996 Sampling Events	37
Table 3	Comparison of H-Area Seepine Measurements for Tritium ,Conductivity ,and pH for March 1989, March 1996, and September 1996 Sampling Events	38
Table 4	Comparison of Fourmile Branch Stream Measurements for Tritium, Conductivity and pH for March 1989, March 1996, and September 1996 Sampling Events	38
Table 5	Comparison of 643-E Seepine Measurements for Tritium ,Conductivity ,and pH for March 1989, March 1996, and September 1996 Sampling Events	39
Table 6	Average Tritium, Conductivity, and pH Values for F- And H-Area Seepines (1989-1996)	39
Table 7	Average Tritium and Conductivity, Values for Seepine Below 643-E (1992-1996)	40
Table 8	Tritium Concentrations for Fourmile Branch (1992-1996)	40

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Results of the Tritium Survey of Fourmile Branch and its Seepines in the F and H Areas of SRS: September 1996 and 1989-1996 Trends

J.W. Koch II and K.L. Dixon

Abstract

The Environmental Sciences Section (ESS), now known as the Environmental Sciences and Technology Department (ES&TD) of the Savannah River Technology Center (SRTC) conducted a quarterly monitoring program of the Fourmile Branch (FMB) stream and its associated seepine located down gradient from the F- and H-Area Seepage Basins beginning May 1992 and ending in May 1995. The quarterly tritium survey was changed to a semi-annual schedule in 1996. This report details the results of the second semi-annual event in 1996 and summarizes the tritium data beginning with the baseline 1989 and 1992 sampling events. The primary focus of this program is to measure and track changes in tritium levels. Specific conductivity and pH were also measured and tracked. The measurements from this survey (September 1996) exhibited similar tritium levels, conductivity measurements, and pH values to data from the previous tritium surveys. The results of this tritium survey and stream monitoring data (Looney et al., 1993) indicate that the tritium plume resulting from the past operation of the seepage basins continues to flush from the seepines and wetlands to Fourmile Branch. The overall summary results indicate that the tritium plumes are surfacing in somewhat localized areas along the F-Area and 643-E seepines.

Executive Summary

In September 1996 the Environmental Sciences Section (ESS) surveyed the Fourmile Branch seepine down gradient from the F- and H-Area Seepage Basins for tritium, specific conductivity, and pH. This survey was the second of two surveys scheduled during FY96 to monitor the movement of contaminants from the basins since closure in 1990. Surface-water samples were collected from 60 locations along the seepine and from three stream locations along Fourmile Branch. The seepine locations included 22 from F Area, 22 from H Area, and 16 from the seepine south of 643-E, which is a decommissioned area in the Solid Waste Disposal Facility. Forty-four of the locations were sampled in 1989 by the Savannah River Technology Center as part of an extensive characterization study (Haselow et al. 1990). Tritium activities in both F- and H-Area seepines in September 1996 were significantly lower than the activities measured by Haselow et al. (1990). However, there were four locations from the

September 1996 survey that showed a increase in tritium activity over 10% above the March 1989 results. September 1996 conductivity measurements exhibited the same trends as tritium activities. This was true in both F and H Areas.

The average seepine pH was approximately the same as the last survey which was conducted in March 1996. The results continue to indicate that conditions have somewhat stabilized from extremely acid (pH < 4.5) to slightly acid (combined average pH of 5.4) which is closer to normal for this type of wetland. The seepine south of 643-E, along a tributary of Fourmile Branch, is influenced by tritium migrating from the Burial Ground Complex. The tributary (old F-Area effluent ditch) is a natural drainage that received effluent discharge from F-Area Separations prior to the construction of the engineered effluent canal. The September 1996 tritium activities on the east side of the natural

drainage ranged from 16 to 496 pCi/ml and on the west side from 209 to 19,100 pCi/ml. The tritium activity measured in the stream of the natural drainage was 18,500 pCi/ml. These results continue to suggest that the tritium outcrop area has been delineated by the sampling locations established on the west side of the drainage channel. Conductivity and pH measurements taken on both sides of the drainage were similar to those recorded in March 1996, and were within the range of normal values for this wetland. The maximum tritium levels have declined from 59,400 pCi/ml at sample location FHB018 to a maximum of 19,100 pCi/ml at this same sample location. Similar decreases have been seen at the other west side sample locations.

Introduction

Seepage basins in the F and H Areas of SRS received low-level radioactive waste effluent from the chemical separation processes in the General Separation Area, (GSA). The basins retained the effluent and allowed it to be slowly released into the soil. The waste effluent consisted principally of sodium hydroxide, nitric acid, low levels of various radionuclides, and some metals (Killian et al., 1985a and 1985b). Discharges of tritiated water to the seepage basins accounted for a majority of the radioactivity (Fenimore and Horton, 1972).

The Savannah River Technology Center conducted an extensive study designed to characterize the shallow groundwater outcropping into Fourmile Branch (FMB) and its associated seepage line in 1988 and 1989 (Haselow et al., 1990). As a part of this study, Haselow et al. (1990) surveyed for tritium, pH, and conductivity. Researchers found low pH and elevated conductivity and tritium values along the seep lines and concluded that contaminants leaching from the F- and H-Area Seepage Basins were impacting the wetlands below the basins. SRS stopped discharges to the seepage basins in 1988 and capped and sealed the basins in 1990 to isolate the contaminants from direct rainfall. Scientists hypothesized that after the elimination of the contaminant source, natural groundwater flow from annual rainfall would flush the remaining contaminant plume out of the shallow groundwater over time. After the contaminant plume in the shallow groundwater is flushed out, the impacted

wetland systems immediately down gradient from the basins should recover.

To investigate this hypothesis, a quarterly sampling program was established in May 1992 and concluded in May 1995. ESS sampled 44 of the seepage locations sampled by Haselow et al. (1990) for tritium, pH, and specific conductivity. The 1996 sampling program is intended to complement semi-annual sampling of the seepage line for selected Appendix IX constituents, which began in July 1992 and in 1996, was conducted annually. A report summarizing results from the semi-annual sampling program has been completed (Dixon and Rogers, 1993e, Dixon, Koch, and Rogers, 1995). The Haselow et al. (1990) results established the baseline to which the results from the quarterly tritium sampling program are compared. These collection points were chosen as the baseline because they are the only data available that were collected before the basin discharges were discontinued. The Haselow et al. (1990) data should be representative of conditions immediately prior to closing the basins.

There was expressed concern about the source of tritium and other contaminants that possibly emanate from an area in the southwest corner of 643-E rather than from the closed basins. To investigate this possibility, numerous sampling locations on the H-Area seepage line south of 643-E were established and were incorporated into the quarterly sampling plans beginning in March 1993 and continuing in FY96.

Methods

ESS conducted the second in a series of two FY96 sampling events for tritium in September 1996. Sampling locations were the same as those selected in the quarterly tritium surveys. These locations, according to 1989 data, exhibited high and low values for the three variables of concern. Attempts were made to establish an even ground coverage along both seep lines. ESS collected 56 samples from the seep lines in F and H Area: 22 from the F-Area seepage line, 18 from the H-Area seepage line, and 14 from the FHB seepage line south of 643-E Area. Four of the seepage locations were dry. One sample was taken from the old effluent stream. ESS also collected

three stream samples from locations on Fourmile Branch. Figures 1 and 2 approximate these sampling locations.

Prior to sampling for the first quarterly survey in May 1992, the Health Protection Department (HPD) collected soil samples from several locations along both seepines and monitored them for gamma radioactivity. HPD did not detect gamma radiation above levels of concern; therefore, ESS selected rubber boots and disposable rubber gloves as protective clothing to prevent skin contact with seepine water during sampling operations.

Seepine sampling locations had been previously marked and labeled with PVC stakes. Samples were collected within a three foot radius of the PVC stake by boring a hole into the soil with a small soil auger, generally six inches and not more than eighteen inches deep to obtain a sample. To collect water for tritium analysis, polyethylene sample containers (25 ml) were dipped into the water until full and then capped. The outside of each container was then rinsed with deionized water and sealed in a small polyethylene bag to minimize the possibility of cross contamination. The small bags were then sealed in a large polyethylene bag. General Engineering Laboratories (GEL) performed the tritium analysis for the standard and duplicate samples and the Environmental Monitoring Section (EMS) performed the analysis on split samples and the samples with activity levels that exceeded 2000 pCi/ml total activity counts.

ESS measured specific conductivity and pH *in situ* with conductivity and pH electrodes (WSRC Procedure Manual L14.1, 1992a and 1992b). The electrodes were rinsed with deionized water after each sampling. All sampling equipment was thoroughly rinsed with deionized water at the end of each day.

Results and Observations

Parameters measured at seepine sampling locations fluctuate throughout the year. Seepine measurements are made on water collected from fixed locations at the initial point of outcropping, or toe, of the contaminant plume in the streamside wetland. Because the plume is dynamic (i.e.,

influenced by weather and other activities in the area) seepine monitoring is sensitive to both long term changes and seasonal/transient influences. Climatic and seasonal conditions, especially rainfall amounts influence measured concentrations. Groundwater flow paths in F and H Area are complex, as illustrated in Figures 3 and 4. Recharge to the groundwater is primarily due to infiltration of rainwater (rainfall minus runoff and evapotranspiration). Groundwater then moves laterally, down and to Fourmile Branch and its tributaries.

As the water travels toward the stream, additional infiltration forces up-gradient water deeper. Near the stream, the flow lines rise to the surface, emerging between the seepine and the stream (which acts as the groundwater "drain"). This typical vertical trajectory, a path curving downward near the groundwater divide and then upward into draining surface water, is shown as flow lines on Figures 3 and 4.

Figure 3 shows the flow lines without contaminated water from the seepage basins and Figure 4 shows the addition of contaminated flow lines resulting from F and H Area operation of the basins. The theoretical plume geometry is clearly confirmed by the real vertical profile of the F-Area Seepage Basin plume based on the detailed grid wells available in the 1970s (Looney et al., 1993). Changes in the water balance in the area influence the flow velocity and tend to move the plume either deeper or shallower and cause the location of the contaminated water to move. This is especially important to data interpretation if the "toe" of the plume is shifting relative to the fixed sample locations. Figure 5 summarizes the projected changes in the plume based on a range of transient activities. Increased rainfall (or other activities that increase infiltration such as harvesting trees) result in increased plume velocity and movement downward and away from the seepine. This decreases contaminant concentrations at the seepine sampling locations. Less infiltration decreases plume velocity and causes the plume to move upward and outcrop closer to the basins. This results in increased contaminant concentrations as measured at the seepine sampling locations.

Low rainfall for a few months prior to sampling is expected to increase constituent concentrations, and high rainfall decreases constituent concentrations in the shallow groundwater at the seepage intercept. Rainfall measured at SRS at the weather station in F Area from June 1996 through September 1996 was 60.7 cm. From 1961 to 1994, the average rainfall measured for this same period was 49.1 cm. This indicates that rainfall amounts in the sampling area were well above average for the few months prior to this sample period. Figure 6 shows a comparison of October 1995-September 1996 rainfall to the long term average (1961-1994). It is hypothesized that above average rainfall observed in the area for this period would cause contaminant concentrations to decrease at sample locations closer to the basins and to increase at the more distant locations. This increase in infiltration causes the toe of the plume to migrate downward through the soil profile and the arrival point of the toe to move towards FMB and away from the basins. Note that the direction of the plume flow always remains the same, only the plume velocity and outcrop location changes relative to the changes in infiltration.

Tritium concentrations at four sample locations were above the March 1989 readings, with these sample locations showing an average tritium activity increase of 785 pCi/ml. Generally, these are the most distant sample location points from the closed basins along Fourmile Branch. Figures 7 through 12 show comparisons of March 1989 with May 1995 and September 1996 tritium, conductivity, and pH measurements for locations on the F- and H-Area seepage line. Data for the first thirteen surveys can be found in Dixon, Rogers, and Looney (1992, 1993a, 1993b, 1993c, 1993d and 1993e and 1994), Rogers et al. (1994a, 1994b, and 1994c) and Koch and Dixon (1994 1995, and 1996). Figures 13 through 15 show the data for the Fourmile Branch stream locations. Figures 16 through 18 show the data for the sampling locations along the old effluent seepage line and include one stream sample from the branch channel south of 643-E. These sampling locations were identified with the prefix FHB.

F- and H-Area Seepage Tritium Measurements

Figures 7 and 8 show tritium activity at F and H Area for the September 1996 sampling event. Tritium concentrations increased at 9 sample locations, while 29 locations either decreased or were relatively unchanged compared to the March 1996 sampling event. There were four dry sites. Overall, sampling has shown a declining trend in tritium concentrations at the F-and H-Area seepage lines (Figures 19 and 20).

It is important to note that total tritium fluxes to the wetlands and FMB have steadily declined since basin closure (Looney et al., 1993) and that overall results of the tritium survey support this finding. Differences in tritium concentrations measured at seepage sampling locations from one sampling event to the next represent seasonal variability and variable rainfall as well as changes due to the flushing of the plume from the wetland system. Variability may also result from reduction in plume size along margins.

F Area

September 1996 tritium values in the F-Area seepage line ranged from 7-7150 pCi/ml (Figure 6 and Table 2). One of the 22 sampling locations was dry, and one sampling location had a tritium activity that exceeded the 1989 measurements by more than ten percent. No sample exceeded the maximum value of 14,000 pCi/ml measured in March 1989 at this seepage line.

As with data from previous sampling events, a Wilcoxon signed-rank test was conducted to compare September 1996 tritium activities to March 1989 activities. The Wilcoxon signed-rank test uses the sign and the magnitude of the rank of the differences between pairs of measurements to compare nonparametric data (Daniel, 1978). This test was chosen because it allows comparisons of paired data without assumptions of normality. If the P value is less than or equal to 0.05, then the September 1996 tritium levels are significantly less than the March 1989 tritium levels. The results from this test gave a P value < 0.002. This test shows that the September 1996 concentrations were significantly lower than the 1989 concentrations for this seepage line.

H Area

Tritium values in the H-Area seepine ranged from 20-1980 pCi/ml (Figure 8 and Table 3). Three of the 22 sampling locations were dry, and three sampling locations had tritium activities that exceeded the 1989 measurements by more than ten percent. These locations, HSP071, HSP097, and HSP103 are among the furthest locations from the closed basins. No sample exceeded the maximum value of 24,000 pCi/ml measured in March 1989 at this seepine.

Figure 22 shows the downward trend of tritium concentrations and the conductivity trends in this area. It presents the mean of the tritium concentrations from each sampling event beginning with the March 1989 event (Table 6). Figure 23 shows the pH trends using the mean pH of each sampling event.

As with data from F Area, a Wilcoxon signed-rank test was conducted to compare September 1996 tritium activities to March 1989 activities. The results showed that the September 1996 concentrations were significantly less ($P < 0.005$) than the 1989 concentrations for H Area.

F- and H-Area Seepine Conductivity Measurements

F Area

Conductivity measurements in the F-Area seepine ranged from 28-1210 $\mu\text{S}/\text{cm}$ (Figure 9 and Table 2). Due to the variability of conductivity measurements, only differences of 100 $\mu\text{S}/\text{cm}$ or more are considered significant. Of the 22 locations sampled at the F-Area seepine, two of the locations measured more than 100 $\mu\text{S}/\text{cm}$ above the 1989 measurements. A comparison of the results in Figures 7 and 9 suggests that conductivity follows the same general trends as the tritium activities. Using a Spearman rank correlation test for nonparametric data, it was found that the probability that tritium and conductivity exhibited independent trends was $P < 0.001$. The Spearman rank correlation coefficient was found to be $r_s = 0.92$, suggesting that the two parameters are exhibiting dependent trends. This similarity is consistent with past results.

(Haselow et al., 1990). A rank correlation coefficient of 1.0 is a perfect correlation between variables.

H Area

Conductivity measurements in the H-Area seepine ranged from 22-375 $\mu\text{S}/\text{cm}$ (Figure 10 and Table 3). None of the sampling locations, had a measurement of more than 100 $\mu\text{S}/\text{cm}$ above the 1989 measurements. The Spearman rank correlation test for nonparametric data was used to investigate the correlation of H Area tritium activities and conductivity values. The probability that the two parameters exhibited independent trends was $P < 0.10$. The rank correlation coefficient ($r_s = 0.35$) for H Area was less than that for F Area and suggests a much weaker correlation. In past tritium surveys, 1992 to March 1996, this correlation has been positive and significant.

F- and H-Area Seepine pH Measurements

F-Area pH values ranged from 3.5 to 6.1 with an average value of 4.8 (Figure 11 and Table 2). H-Area pH values ranged from 5.6 to 6.8 with an average of 6.1 (Figure 12 and Table 3). The pH for the entire seepine (F and H Areas combined) averaged 5.4. This represents an increase of 0.5 units over the 4.9 average in 1989 and is slightly higher than the overall average for the May 1995 and March 1996 sampling events. An increase in pH will affect the solubility of metals in the soil which should improve the soil water chemistry and enhance the recovery of wetland vegetation stressed indirectly by low pH.

Aluminum concentrations measured along the seepine in 1989 were high enough to be toxic to plants (Haselow et al., 1990). Increases in pH from an average of 4.9 in 1989 have likely reduced the amount of aluminum in solution and thereby reduced it as a possible source of plant toxicity. Concentrations of aluminum and other metals measured along the seepine in July 1992 were substantially lower than 1989 concentrations, consistent with the observed pH (Dixon and Rogers, 1993e), (Chappell et al., 1995). Field observations

have revealed that vegetation in most of the stressed areas is making noticeable recovery (Nelson and Irwin, 1994; Nelson and Rogers, 1995). Studies have also shown that the toxicity of these areas is decreasing, (Nelson and Westbury, 1994; Westbury and Nelson, 1994).

Fourmile Branch Measurements

Figures 13 through 15 show the tritium, conductivity, and pH values for the Fourmile Branch stream sampling locations. Table 4 provides the data used in the figures. Tritium activities at these locations ranged 35-520 pCi/ml. These values were consistent with previous data and show increases in tritium downstream as the seepage water enters the channel of Fourmile Branch. Conductivity measurements ranged from 49-62 $\mu\text{S}/\text{cm}$ and pH ranged from 5.4 to 6.1. Both conductivity and pH values were at near normal levels.

Solid Waste Disposal Facility (643-E) Seepage Measurements

The graphs in Figures 16 through 18 show tritium, conductivity, and pH values for the seepage and stream sampling locations south of 643-E, which is part of the Solid Waste Disposal Facility. Table 5 provides the data used in the figures. This seepage line is along the natural drainage (old F-Area effluent ditch) that was used to discharge effluent from F-Area separations prior to the construction of the engineered effluent canal.

Tritium activities for the locations on the east side of the drainage ranged from 16 to 496 pCi/ml. Activities on the west side of the drainage ranged from 209 to 19,100 pCi/ml. The tritium activity at the stream location in the drainage (FHB012) was 18,500 pCi/ml.

The pH values ranged from 5.1 to 6.1 with an average of 5.5. Conductivity measurements on both sides of the drainage were near background at most locations and ranged from 18 to 80 $\mu\text{S}/\text{cm}$. Conductivity values are typical of the conductivity values being reported in the water table wells in the vicinity of the old F-Area effluent ditch (EMS,

1993). Using the Spearman rank correlation test a significant correlation was found between conductivity and tritium for these locations ($r_s = 0.69$). This indicates that these two variables behave dependently. In the past this correlation was very weak.

These results are consistent with the Haselow et al. (1990) results for the west side sample locations of the 643-E seepage line, particularly near location HSP103. Haselow et al. (1990) found that down gradient from 643-E, conductivity values were near background while tritium concentrations were elevated.

This was attributed to tritiated wastes deposited in 643-E. Tritium activities measured along the seepage line down gradient of 643-E (particularly sample points on the west side of the drainage) suggest that tritium migrating from 643-E and outcropping in this area is substantial. The appearance of tritium on the west side as opposed to the east side of the drainage suggests that soil material placed in the northern reaches of the natural drainage forced the tritium plume to outcrop down gradient. It appears that the groundwater containing tritium is moving below the fill material and outcropping on the west side of the drainage channel. The results suggest that the sampling locations on the west side of the drainage have delineated the tritium plume with the center located at or near FHB018.

Figure 30 was developed to show the tritium data from all the sampling events for this seepage area beginning with the 1992 sampling event. A majority of the tritium measured can be accounted for at four locations all on the west side of the drainage. These locations are FHB013, 017, 018, and 019.

Overall Summary

F- and H-Area Seepage Lines, 643-E and Fourmile Branch

Figure 19 shows the downward trend of tritium concentrations for the F-Area seepage line and the conductivity trends. This figure depicts the mean tritium and conductivity concentration from each sampling event beginning with the March 1989

baseline event through the September 1996 sampling event (Table 6). Figure 20 shows the pH trends using the mean pH of each sampling event. Each sampling event since 1989 has shown a statistically significant decrease in tritium concentrations when compared to the 1989 baseline event.

Figure 21 shows the tritium data from all the sampling events for the F-Area seepine. It shows that a majority of the tritium measured can be accounted for at eight of the 22 sample locations. These locations, are FSP019, 026, 032, 034, 035, 040, 204, and 213. Very little of the tritium plume has been detected east of sample location FSP040 or south and west of sample location FSP0213. It further appears that there are two distinct groupings of sample locations which delineate the bulk of the tritium plume from the seepage basins. These two groupings appear to be separated by Road C-4.

Figure 22 shows the downward trend of tritium concentrations for the H-Area seepine and the conductivity trends. This figure depicts the mean tritium and conductivity concentration from each sampling event beginning with the March 1989 baseline event through the September 1996 sampling event (Table 6). Figure 23 shows the pH trends using the mean pH of each sampling event. Each sampling event since 1989 has shown a statistically significant decrease in tritium concentrations when compared to the 1989 baseline event.

Figure 24 shows all the tritium data from all the sampling events conducted for the H-Area seepine. The sampling locations that have had the highest and lowest tritium values over the sampling interval, 1989-1996, can be seen in this figure.

Figures 25-27 summarize the tritium concentrations, conductivity, and pH measurements of each sampling event. The delineation of the contamination is apparent in Figure 25. Figure 27 shows that a majority of the contaminant plume appears at four sample locations. These locations are on the west side of the drainage and are identified as FHB013, 017, 018, and FHB019.

Figures 28-30 show the tritium concentrations, conductivity, and pH measurements for the Fourmile Branch sample locations from 1992-1996. Each point on these figures represents the actual concentrations or readings and are not averages.

Conclusions

F- and H-Area Seepines, Seepine Below 643-E and Fourmile Branch

- Tritium concentrations measured at most locations during September 1996 remained relatively unchanged compared to the previous sampling event yet are significantly lower than the 1989 baseline tritium levels.
- Total tritium fluxes to the wetlands and FMB have steadily declined since basin closure (Looney et al., 1993) and overall results from the tritium survey support this finding. These findings support the hypothesis that the tritium plume in F and H Area is being flushed from the shallow groundwater.
- A majority of the tritium detected along the F-Area seepine is at two localized areas which can be identified by eight of the 22 sample locations. These eight sample locations are FSP019, 026, 032, 034, 035, 040, 204, and 213.
- The tritium concentrations have steadily decreased at the west side sample locations along the seepine below 643-E since August 1993.
- A major portion of the tritium detected along the seepine below 643-E is on the west side of the drainage at four sample locations. These four sample locations are FHB013, 017, 018, and 019.
- Differences in tritium concentrations measured at seepine sampling locations from one sampling event to the next represent seasonal and rainfall variability as well as changes due to flushing of the contaminant plume from the wetland system. No correction has been made for tritium decay because of the short time

groundwater system and should be based on long-term surface water, seepage, and groundwater monitoring data and not on quarterly changes in concentrations at seepage monitoring locations.

Solid Waste Disposal Facility (643-E) Seepage

Evaluation of data from 16 seepage locations south of the 643-E Area indicates that tritium migrating from 643-E is outcropping at the F- Area effluent ditch, particularly on the west side of the stream channel. It appears that sampling locations on the west side of the ditch have delineated the tritium outcrop area with the present climatic and hydrologic conditions. Data indicates that the tritium has decreased over the past eight sampling events.

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Results of the Tritium Survey of Fourmile Branch and
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Figure 1. Location of F-Area Seepage Basins and Seepine Sampling Points.

Figures 2. Location of H-Area Seepage Basins and Seepine Sampling Points and FHB Sampling Points.

Figures 3. Schematic Diagram of Flow Lines in the Shallow Groundwater at the F- and H-Area without Seepage Basins.

Figures 4. Schematic Diagram of Flow Lines in the Shallow Groundwater at the F- and H-Area during Basin Operation.

Results of the Tritium Survey of Fourmile Branch and
its Seepines in the F and H Areas of SRS: September 1996

Figure 5. Schematic Diagram of the Tritium Plume Migrating from F- and H-Area Seepage Basins

Figure 6. Comparison of October 1995-September 1996 Monthly Rainfall to the Long Term Average (1961-1994) for the F-Area Weather Station

Figure 7. Comparison of Tritium Concentrations for Selected F-Area Seepline Locations

Figure 8. Comparison of Tritium Measurements for Selected H-Area Seepline Locations

Results of the Tritium Survey of Fourmile Branch and
its Seepines in the F and H Areas of SRS: September 1996

Figure 9. Comparison of Conductivity Measurements for Selected F-Area Seepine Locations

Figure 10. Comparison of Conductivity Measurements for Selected H-Area Seepine Locations.

Figure 11. Comparison of pH Measurements for Selected F-Area Seep Line Locations

Figure 12. Comparison of pH Measurements for Selected H-Area Locations

Results of the Tritium Survey of Fourmile Branch and
its Seepelines in the F and H Areas of SRS: September 1996

Figure 13. Comparison of Tritium Concentrations for Selected Fourmile Branch Locations

Figure 14. Comparison of Conductivity Measurements for Selected Fourmile Branch Locations

Figure 15. Comparison of pH Measurements for Selected Fourmile Branch Locations

Figure 16. Comparison of Tritium Concentrations for Selected Locations on the Seepline South of 643-E

Results of the Tritium Survey of Fourmile Branch and
its Seepelines in the F and H Areas of SRS: September 1996

Figure 17. Comparison of Conductivity Concentrations for Selected Locations on the Seepine South of 643-E

Figure 18. Comparison of pH Concentrations for Selected Locations on the Seepine South of 643-E

Figure 19. Tritium and Conductivity Trends for F-Area Seepage. Each point represents the mean value of a sampling event.

Figure 20. pH trends for the F-Area Seepage. Each point represents the mean value of a sampling event.

Results of the Tritium Survey of Fourmile Branch and
its Seepines in the F and H Areas of SRS: September 1996

Figure 21. Scatter plot of tritium concentrations for F-Area Seepine (1989-1996)
Plot shows distribution of tritium throughout the entire sampling period.

Figure 22. Tritium and conductivity trends for H-Area Seepage. Each point represents the mean value of a sampling event.

Figure 23. pH trends for the H-Area Seepage. Each point represents the mean pH value of a sampling event.

Results of the Tritium Survey of Fourmile Branch and
its Seep Lines in the F and H Areas of SRS: September 1996

Figure 24. Scatter plot of tritium concentrations for the H-Area Seep Line (1989-1996)
Plot shows distribution of tritium throughout the entire sampling period.

Figure 25. Comparison of tritium concentrations for Seepline below 643-E. Each point represents the mean value of a sampling event.

Figure 26. Comparison of conductivity concentrations for the Seepline below 643-E. Each point represents the mean value of a sampling event.

Results of the Tritium Survey of Fourmile Branch and
its Seep Lines in the F and H Areas of SRS: September 1996

Figure 27. Scatter plot of tritium concentrations for the seepage below 643E, (1992-1996)
Plot shows distribution of tritium throughout the entire sampling period.

* Stream sample location

Figure 28. Tritium, conductivity, and pH measurements for samples location FMC001F (Fourmile Branch)

Results of the Tritium Survey of Fourmile Branch and
its Seepelines in the F and H Areas of SRS: September 1996

FMC001H

Figure 29. Tritium, conductivity, and pH measurements for samples location FMC001H (Fourmile Branch)

FMC002H

Figure 30. Tritium, conductivity, and pH measurements for samples location FMC002H (Fourmile Branch)

Table 1. Comparison of 1995/1996 Monthly Rainfall to the Long Term Average Rainfall From the F-Area Weather Station

<i>Month</i>		<i>Rainfall (cm)/F-Area</i>	
		<i>Oct 1995-Sept 1996</i>	<i>Long-Term Rainfall, (1961-1994)</i>
Oct	95	5.88	7.80
Nov	95	5.41	7.12
Dec	95	9.91	8.97
Jan	96	7.82	11.14
Feb	96	5.28	10.74
Mar	96	17.30	12.62
April	96	4.30	8.01
May	96	6.10	9.31
June	96	11.66	11.77
July	96	14.10	13.97
Aug	96	26.92	14.56
Sept	96	7.98	8.77

Results of the Tritium Survey of Fourmile Branch and
its Seepines in the F and H Areas of SRS: September 1996

Table 2. Comparison of F-Area Seepine Measurements for Tritium, Conductivity, and pH for the March 1989, March 1996, and September 1996 Sampling Events.

Location	Tritium (pCi/ml)			Conductivity ($\mu\text{S/cm}$)			H(-log H)		
	Mar-89	Mar-96	Sep-96	Mar-89	Mar-96	Sep-96	Mar-89	Mar-96	Sep-96
2	520	612.5	779	95	63	90	5.6	6.3	6.1
7	3400	809	1010	681	208	241	5.4	6.2	5.5
12	260	19.1	70	30	49	62	5.3	5.4	4.8
14	14000	10.8	51	666	26	28	4.2	4.0	5.3
19	4900	4530	4270	1424	1117	1007	4.2	3.5	3.7
26	4400	7740	3980	1095	1799	884	6.5	3.2	3.9
32	3600	32.7	232	174	27	38	5.0	4.3	4.3
34	14000	677	2910	810	232	585	3.8	3.8	4.3
35	11000	5260	7150	1100	1014	1210	3.9	3.9	3.5
40	7800	4600	4640	900	1066	940	5.2	3.3	5.5
47	100	15.3	20	52	40	63	4.7	3.0	4.9
56	19	7.38	7	34	42	41	4.5	3.5	5.1
204	3000	2560	2880	895	449	576	4.4	4.3	3.9
213	2800	1790	2200	860	384	486	4.6	4.2	3.9
220	560	698	955	147	84	232	4.8	5.3	5.2
226	1300	776	443	306	288	162	5.1	5.9	6.1
235	580	290	176	84	84	134	5.7	6.1	5.6
241	560	456	dry	36	133	154	4.7	5.7	5.5
249	580	67.8	345	84	50	86	4.4	5.3	4.7
256	400	307	285	56	78	126	5.1	6.3	5.4
270	40	35.5	42	50	31	39	4.1	5.0	4.0
290	35	24.7	35	49	25	34	3.6	5.1	4.3

Table 3. Comparison of H-Area Seepage Measurements for Tritium, Conductivity, and pH for the March 1989, March 1996, and September 1996 Sampling Events.

Location	Tritium (pCi/ml)			Conductivity ($\mu\text{S/cm}$)@25deg C			pH (-log H)		
	Mar-89	Mar-96	Sep-96	Mar-89	Mar-96	Sep-96	Mar-89	Mar-96	Sep-96
3	14000	780	1740	468	125	170	5.2	6.3	6.3
4	11000	545	386	292	133	198	5.8	6.6	6.4
8	24000	1865	1190	556	163	237	5.7	6.4	6.7
11	960	148	dry	80	52	dry	5.1	5.6	dry
13	12000	1260	435	592	137	148	6.2	6.5	6.3
15	1000	561	776	82	86	168	5.2	5.6	6.0
20	6500	180	228	183	71	127	6.2	5.7	5.9
25	3300	655	799	135	57	94	4.7	6.0	5.9
29	9200	98	70	257	61	54	5.2	5.3	5.9
34	5600	341	dry	331	86	dry	5.8	6.0	dry
38	6500	2310	dry	227	dry	dry	4.9	dry	dry
43	10000	603	dry	413	114	dry	5.3	6.4	dry
46	11000	1870	663	318	167	170	5.5	6.3	6.0
49	11000	7660	1060	551	121	112	4.4	5.5	5.8
52	20000	24	1310	699	332	375	4.1	5.8	5.9
57	15000	334	1080	581	110	120	5.5	5.6	6.0
60	21000	1260	dry	473	142	174	5.9	5.9	6.1
64	320	20	20	38	30	22	4.7	5.1	5.8
71	450	1340	1160	40	94	96	5.1	6.5	6.5
76	400	152	410	146	151	74	5.7	6.7	6.7
97	1100	1440	1980	37	94	129	4.3	5.7	6.3
103	510	357	1660	43	48	80	4.4	5.1	5.6

Table 4. Comparison of Fourmile Branch Stream Measurements for Tritium, Conductivity, and pH for the May 1995, March 1996, and September 1996 Sampling Events.

Location	Tritium (pCi/ml)			Conductivity ($\mu\text{S/cm}$)			pH (-log H)		
	May-95	Mar-96	Sep-96	May-95	Mar-96	Sep-96	May-95	Mar-96	Sep-96
1F	643	456	520	75	30	62	6.99	6.00	5.36
1H	63	29	35	71	38	49	6.44	6.25	6.12
2H	97	88	76	71	42	56	6.59	5.41	5.89

Results of the Tritium Survey of Fourmile Branch and
its Seep Lines in the F and H Areas of SRS: September 1996

Table 5. Comparison of 643-E Seep Line Measurements for Tritium, Conductivity, and pH for the May 1995, March 1996, and September 1996 Sampling Events.

Location	Tritium (pCi/ml)			Conductivity (μ S/cm)			pH (-log H)		
	May-95	Mar-96	Sep-96	May-95	Mar-96	Sep-96	May-95	Mar-96	Sep-96
1	258	102	dry	61	25	dry	5.1	4.9	dry
2	25	15.4	16	49	36	47	5.3	4.8	5.7
3	176	115	87	27	33	38	5.0	5.1	5.1
4	249	115	247	32	32	18	5.2	4.7	5.4
5	774	406	496	53	41	52	5.6	5.1	5.6
6	344	207	211	35	29	34	5.3	5.2	5.4
8	287	156.5	200	191	25	29	4.6	4.9	5.3
12	20600	15000	18500	41	35	46	4.7	5.1	5.4
13	8800	8120	7190	48	31	42	5.1	4.8	5.4
14	639	307	209	34	29	33	4.9	5.0	5.2
15	134	dry	dry	187	dry	dry	5.9	dry	dry
16	407	240	278	86	66	80	5.3	5.2	5.6
17	9660	10400	8830	70	31	42	5.4	5.2	5.6
18	23900	20200	19100	66	106	74	5.6	5.8	6.1
19	2870	5630	dry	63	54	dry	3.9	4.2	dry
20	49	24.1	22	69	68	38	6.1	5.6	5.8

Note: Location #12 is a stream sample location.

Table 6. Average Tritium, Conductivity, and pH values for F and H Area Seep Lines (March 1989-September 1996)

Sampling Event Date	F Area Seep Line-Average Values			H Area Seep Line-Average Values		
	tritium (pCi/ml)	Conductivity (μ S/cm)	pH	tritium (pCi/ml)	Conductivity (μ S/cm)	pH
Mar-89	3357	438	4.8	8402	297	5.2
May-92	1934	335	4.7	4131	183	5.9
Sep-92	1990	352	5.2	2904	182	6.0
Dec-92	1823	300	5.3	3001	165	6.0
Mar-93	1398	293	5.0	2063	124	5.9
Jun-93	1936	330	5.1	2885	157	6.0
Sep-93	2384	404	5.0	2876	205	5.7
Dec-93	1920	415	5.1	2749	181	5.7
Mar-94	1525	371	5.0	1818	140	5.6
Jun-94	1688	344	5.0	2053	153	5.8
Sep-94	1806	381	5.1	1953	159	6.0
Dec-94	1698	366	4.9	2836	179	5.8
May-95	1634	311	5.0	1547	131	5.6
Mar-96	1424	331	4.7	1082	113	5.9
Sep-96	1545	328	4.8	880	142	6.1

Table 7. Average Tritium and Conductivity, values for Seep line below 643-E

<i>Sampling Event Date</i>	<i>Tritium (all) (pCi/ml)</i>	<i>Tritium (East) (pCi/ml)</i>	<i>Tritium (West) (pCi/ml)</i>	<i>Conductivity (All) (μS/cm)</i>	<i>Conductivity (East) (μS/cm)</i>	<i>Conductivity (West) (μS/cm)</i>
Mar-93	4808	242	8999	62	43	88
Jun-93	7617	389	14779	82	53	122
Sep-93	10924	445	22017	92	57	140
Dec-93	8182	435	15527	68	56	86
Jun-94	8557	324	14557	58	53	68
Sep-94	8065	303	15469	57	53	65
Dec-94	<i>no data</i>	<i>no data</i>	<i>no data</i>	<i>no data</i>	<i>no data</i>	<i>no data</i>
May-95	4323	270	6630	69	64	79
Mar-96	4069	143	7483	43	36	53
Sep-96	4260	183	7121	44	37	54

Table 8. Tritium concentrations for Fourmile Branch

<i>Sample date</i>	<i>Sample ID</i>	<i>Tritium (pCi/ml)</i>	<i>Sample date</i>	<i>Sample ID</i>	<i>Tritium (pCi/ml)</i>
Dec-92	FMC001H	55	Jun-94	FMC002H	82
Dec-92	FMC001F	455	Sep-94	FMC001F	567
Dec-92	FMC002H	2050	Sep-94	FMC001H	52
Apr-93	FMC001H	47	Sep-94	FMC002H	93
Apr-93	FMC001F	425	Dec-94	FMC001F	312
Apr-93	FMC002H	104	Dec-94	FMC001H	59
Sep-93	FMC001H	41	Dec-94	FMC002H	113
Sep-93	FMC002H	105	May-95	FMC001F	643
Sep-93	FMC001F	503	May-95	FMC001H	63
Dec-93	FMC001H	37	May-95	FMC002H	97
Dec-93	FMC001F	567	Mar-96	FMC001F	138
Dec-93	FMC002H	145	Mar-96	FMC001H	34
Mar-94	FMC001H	34	Mar-96	FMC002H	65
Mar-94	FMC001F	375	Sep-96	FMC001F	520
Mar-94	FMC002H	91	Sep-96	FMC001H	35
Jun-94	FMC001F	331	Sep-96	FMC002H	76
Jun-94	FMC001H	42			