Results of the Quarterly Tritium Survey of Fourmile Branch and its Seepelines in the F and H Areas of SRS: December 1993

by

J. Koch (Contact)

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

V. A. Rogers

K. L. Dixon

B. B. Looney

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(Name and Title)

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V. A. Rogers, K. L. Dixon, and B. B. Looney

Abstract

The Environmental Sciences Section (ESS) of the Savannah River Technology Center (SRTC) established a quarterly monitoring program of the Fourmile Branch (FMB) stream and its associated seepine down gradient from the F- and H-Area seepage basins. The program surveys and tracks changes in tritium, specific conductivity, and pH for the seepine water. Measurements from the seventh quarterly survey (December 1993) showed similar to slightly lower tritium and conductivity measurements and similar pH values compared to measurements from previous studies. Changes in tritium concentrations and conductivity values, as compared to previous surveys, are attributed to the flushing of tritium from the system and the seasonal rise in the water table since the September 1993 sampling event. Overall results of the tritium survey and related stream monitoring data (Looney, et al., 1993) continue to indicate that the tritium plume that resulted from operation of the seepage basins is flushing from the FMB system.

Executive Summary

In December 1993 the Environmental Sciences Section (ESS) surveyed the Fourmile Branch (FMB) seepine down gradient from the F- and H-Area seepage basins for tritium, specific conductivity, and pH. The survey was the seventh of ten quarterly surveys for monitoring the movement of contaminants from the basins since closure. Surface-water samples were collected from 60 locations along the seepine and three 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 (SRTC) (formerly the Savannah River Laboratory) as part of an extensive characterization study (Haselow et al. 1990). ESS found that tritium activities in F- and H-Area seepines in December 1993 were significantly lower than the activities measured by Haselow et al. (1990). Tritium increased at a few locations and were attributed to below normal rainfall in the months prior to the September and December 1993 sampling events. The lack of rainfall, which decreased recharge to the shallow groundwater, modified the trajectory of the tritium plume.

The contaminant plume is dynamic and sample point concentration is influenced by seasonal changes in amount and intensity of rainfall, infiltration rate, and vegetative

cover. Therefore, the more concentrated area of the plume moves about within the sampling zone at the seepine intercept. This results in changes to tritium concentrations at the seepine intercepts at F- and H-Area seepines.

Overall, sampling events have consistently shown a declining trend in tritium activity at the F- and H-Area seepine. Total tritium fluxes to the wetlands and FMB steadily declined since basin closure (Looney et al., 1993) and overall results from the tritium survey support this finding. Differences in tritium activities measured at individual seepine sampling locations from one sampling event to the next represent seasonal variability in depth to the water table, variable amounts of rainfall, as well as changes due to the flushing of the plume from the wetland system. Conclusions about tritium fluxes to the wetlands and FMB should consider the long-term surface water, seepine, and groundwater monitoring data and not rely exclusively on quarterly changes in concentrations at seepine monitoring stations.

December 1993 conductivity measurements exhibited the same general trends as tritium activities in F and H Areas. Concentrations of hydrogen ions also decreased in both areas, indicating that conditions are changing from strongly acid (pH < 4.5) to moderately acid (pH 5.1-6.0), which is near normal for these types of wetlands. Aluminum concentrations measured along the seepine in 1989

(Haselow et al., 1990) were high enough to be potentially toxic to plants. Each increase in pH reduces the solubility of aluminum, thereby decreasing the potential for aluminum toxicity to plants. Concentrations of aluminum, as well as other metals, measured along the seepline in July 1992 were substantially lower than 1989 concentrations reflecting the increase in pH (Dixon and Rogers, 1993e). Field observations revealed that vegetation in all areas, except the wetland below location FSP014, is showing noticeable recovery.

The seepline south of 643-E, along a tributary of FMB, is influenced by tritium migrating from the burial grounds. 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. December 1993 tritium activities ranged from 25 to 907 pCi/mL on the east side of the drainage and from 315 to 36,383 pCi/mL on the west side. The tritium activity measured in the stream of the natural drainage was 18,738 pCi/mL. Results suggest that the tritium outcrop area was 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 and were within the range of normal values for this type wetland. The low conductivity values measured along the drainage-way suggest that the tritium plume outcropping in the area emanates from 643-E because wastes introduced into 643-E contained low levels of salt ions, compared to the waste in the F- and H-Area seepage basins.

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 areas. The basins retained the effluent to slowly release it 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 most of the radioactivity (Fenimore and Horton, 1972).

SRTC conducted an extensive study designed to characterize the shallow groundwater outcropping into FMB and its associated seepline 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 seeplines and determined 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 eliminate the source of contaminants. Scientists hypothesized that after the elimination of the contaminant source, annual rainfall and natural groundwater flow 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. ESS sampled 44 seepline locations sampled by Haselow et al., (1990) for tritium, pH, and specific conductivity. The Haselow et al. (1990) results established the baseline to which the results from the quarterly 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. This sampling program is intended to complement semiannual sampling of the seepline for selected Resource Conservation Recovery Act, Appendix IX characterization, which began in July 1992. A report summarizing results from the semiannual sampling program is complete (Dixon and Rogers, 1993e).

The Environmental Protection Department expressed concern about possible seepage of tritium and other contaminants from an area in the southwest corner of 643-E. To investigate this possibility, numerous sampling locations on the H-Area seepline south of 643-E were established and incorporated into the quarterly sampling plan.

Methods

ESS conducted the seventh sampling for the quarterly tritium survey in December 1993. Sampling locations were the same as those selected in the sixth round of sampling. This selection, according to 1989 data, exhibited high and low values for the three variables of concern. Attempts were made to establish even ground coverage along both seeplines. ESS collected 60 samples from the seeplines in F and H Area: 22 from the F-Area seepline, 22 from the H-Area seepline, and 16 from the FHB seepline south of 643-E Area. ESS also collected samples from three locations on FMB. Figures 1 and 2 show the sampling locations.

Prior to sampling for the first quarter in May 1992, the Health Protection Department (HPD) collected soil samples from several locations along both seeplines and monitored them for gamma radioactivity. HPD did not detect gamma radiation; therefore, ESS selected rubber boots and disposable rubber gloves as protective clothing to prevent

dermal contact with seepage water during sampling operations.

Seepage sampling locations were 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 bucket soil auger, generally six inches and not more than eighteen inches deep to obtain 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 contamination. The small bags were then sealed in a large polyethylene bag. The Environmental Monitoring Section (EMS) performed tritium analysis (total activity). EMS counted 5 ml aliquots for 20 minutes, which yielded a lower detection limit of 1.3 pCi/mL (WSRC-3Q1-4, 1992).

ESS measured specific conductivity and pH *in situ* with conductivity and pH electrodes (WSRC-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

Concentrations of variables measured at seepage sampling locations fluctuate throughout the year. Climatic and seasonal conditions, especially rainfall amounts, influence measured concentrations. Seepage measurements are made on water collected from fixed locations at the distal end, or toe, of the contaminant plume. Because the plume is dynamic (i.e., influenced by weather and other activities in the area) seepage monitoring is sensitive to long-term changes and seasonal/transient influences. Groundwater flow paths in F- and H-Area are complex, as illustrated in Figure 3 and 4. Recharge to the groundwater is primarily due to infiltration of rainwater (rainfall minus runoff and evapotranspiration). Groundwater then moves laterally to FMB 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 seepage line and the stream (which acts as the groundwater "drain"). This classic 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 from the basins when they were

receiving water. 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 stations. Figure 5 summarizes the expected changes in the plume based on a range of transient activities. Increased rainfall (or other activities that increase infiltration such as harvesting trees) results in increased plume velocity and movement of the plume downward and away from the seepage line. This results in decreased contaminant concentrations as measured at the seepage sampling locations. Reduction in infiltration results in decreased plume velocity and movement of the plume center upward and closer to the seepage line. This results in increased contaminant concentrations as measured at the seepage sampling locations.

Low rainfall for a few months prior to sampling results in increased constituent concentrations, and high rainfall results in decreased constituent concentrations in the shallow groundwater at the seepage intercept. Rainfall measured at SRS at the weather station in F-Area from January through November 1993 was 120 cm. From 1960 to 1991, the average rainfall measured in F Area from the month of January through November was 123 cm. This indicates that average rainfall in F and H Areas was near normal for the period; however, about 50 percent of the rainfall occurred in the first three months of the year.

Figure 6 shows a comparison of 1993 rainfall to the long-term average (1960-1991) for the period January through November. This figure shows that except for June and September, rainfall was close to the long-term average. Rainfall totals for June and September were heavily influenced by brief, intense storms. Storms of this nature commonly yield large amounts of rainfall over short periods of time with high runoff and low infiltration. This type of event would not be expected to ameliorate the effects of six months of below average rainfall.

The below average rainfall observed in the area prior to the September 1993 sampling event, continued through October and November. The contaminant concentrations increased at some sampling locations. A 3.94 cm rainfall event was recorded ten days prior to the sampling event. In sandy areas this was sufficient time for the water to reach the seepage line. An increase in rainfall along with seasonal change was sufficient to lower the concentrations at a few sample locations.

Figures 7 through 12 show comparisons of March 1989 with September and December 1993 tritium, conductivity, and pH measurements for locations in F and H-Area seepine. Data for the first six surveys can be found in Dixon and Rogers (1992, 1993a, 1993b, 1993c, 1993d, and Dixon et al., 1994). Figures 13 through 18 show the data for the FMB locations and the seepine south of 643-E in H Area. They were identified with the prefix FHB.

F and H-Area Seepine Tritium Measurements

F Area

December 1993 tritium values in the F-Area seepine ranged from 13 to 10436 pCi/mL (see Figure 7 and Table 2). Three of the 22 sampling locations had above-background tritium activities that exceeded the 1989 measurements by more than 10%. Two of the three sample locations are adjacent to the floodplain of FMB and subject to stream flooding. The third sample location is close to the slope of a drainageway and therefore, subject to extreme sample variation. In 1989, maximum tritium activities (14,000 pCi/mL) were measured at FSP014 and FSP034 sample locations.

As with data from previous quarters, a Wilcoxon signed-rank test was conducted to compare December 1993 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. The results showed that the December 1993 concentrations were significantly less ($P=0.009$) than the 1989 concentrations.

H Area

Tritium values in the H-Area seepine ranged from 116 to 12688 pCi/mL (Figure 8 and Table 3). Of the 22 sampling locations, four had above-background tritium activities that exceeded the 1989 measurements by more than 10%. No tritium activity exceeded the maximum value of 24,000 pCi/mL measured in 1989 and three of the four locations showing an increase were influenced by the floodplain rather than only seepage from the uplands, therefore inducing greater variability. The one sample location close to the basins with an increase was only by 250 pCi/mL. This magnitude of change was likely due to sampling variation.

As with data from F Area, a Wilcoxon signed-rank test was conducted to compare December 1993 tritium

activities to March 1989 activities. The results showed that the December 1993 concentrations were significantly less ($P=0.0009$) than the 1989 concentrations for H Area. Even though tritium activities increased at several locations compared to previous sampling events, they remained substantially lower than those measured in 1989 at most locations.

Figures 7 and 8 show tritium activity at F and H Area for the December 1993 sampling event, to decrease at 23 sample locations while 16 increased and five locations remained relatively unchanged compared to previous sampling events. These results, for the most part, track rainfall and seasonal change. Previous sampling events consistently showed a declining trend in tritium concentrations at the F-and H-Area seepines. For six months prior to the December 1993 sampling event, the below average rainfall caused the plume to shift in the direction of FMB causing higher concentrations nearer FMB and lower concentrations close to the basins.

When rainfall returns to normal amounts, the plume should move deeper in the soil profile. This trend is noted in the December data. It is important to understand that total tritium fluxes to the wetlands and FMB 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 seepine sampling locations from one sampling event to the next represent seasonal variability, variable rainfall as well as changes due to the flushing of the plume from the wetland system. Conclusions about tritium fluxes to the wetlands and FMB should consider the complexity of the groundwater system and should be based on long-term surface water, seepine, and groundwater monitoring data and not on quarterly changes in concentrations at seepine monitoring locations.

F- and H-Area Seepine Conductivity Measurements

F Area

Conductivity measurements in the F-Area seepine ranged from 27 to 1650 mS/cm (Figure 9 and Table 2). Due to the variability of conductivity measurements, only differences of 100 mS/cm or more are considered significant. Of the 22 locations sampled at the F-Area seepine, two had measurements of more than 100mS/cm above the 1989 measurements. A comparison of the graphs 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 ($P < 0.001$). The rank correlation coefficient was found to be $r_s = 0.95$, suggesting that the two parameters exhibit the same trends. This similarity is expected because tritium serves to track the movement of the contaminant plume from the basins (Haselow et al., 1990).

H Area

Conductivity measurements in the H-Area seepline ranged from 52 to 612 mS/cm (Figure 10 and Table 3). Of the 22 sampling locations, one had a measurement of more than 100 mS/cm above the 1989 measurements. Data in Figures 8 and 10 suggest that conductivity and tritium are following the same general trends. The Spearman rank correlation test for nonparametric data was used to investigate the correlation of H Area tritium activities and conductivity values. Probability that the two parameters exhibited independent trends was $P < 0.001$. The rank correlation coefficient ($r_s = 0.87$) for H Area was lower than that for F Area, but still suggested a good correlation.

F- and H-Area Seepline pH Measurements

F Area pH values ranged from 3.7 to 6.3 with an average value of 5.1 (Figure 11 and Table 2). H Area pH values ranged from 4.8 to 6.4 with an average of 5.6 (Figure 12 and Table 3). The pH for the entire seepline (F and H Areas combined) averaged 5.4. The average increased 0.5 units over the 4.9 average in 1989 (Haselow et al., 1990). In each of the past six surveys, the hydrogen ion concentration decreased threefold compared to 1989 measurements. The 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 seepline in 1989 (Haselow et al., 1990) were high enough to be toxic to plants. Increases in pH from an average of 4.9 in 1989 to 5.4 reduced the amount of aluminum in solution and thereby reduce it as a possible source of plant toxicity. Concentrations of aluminum and other metals measured along the seepline in July 1992 were substantially lower than 1989 concentrations, reflecting the increase in pH (Dixon and Rogers, 1993e). Field observations revealed that vegetation in the stressed areas, except the wetland south of FSP014 sample location, is making noticeable recovery.

Fourmile Branch Measurements

Figures 13 through 15 show the tritium, conductivity, and pH values for the FMB sampling locations. Table 4 provides the data used in the figures. Tritium activities at these locations ranged from 37 to 567 pCi/mL. These

values were consistent with previous data and show increases in tritium down stream as the seepline water enters the channel of Fourmile Branch. Conductivity measurements ranged from 74 to 91 mS/cm and pH ranged from 6.1 to 6.5. The conductivity and pH values were at near normal levels.

Solid Waste Disposal Facility (643-E) Seepline Measurements

The graphs in Figures 16 through 18 show tritium, conductivity, and pH values for the seepline and stream sampling locations south of 643-E, which is part of the Solid Waste Disposal Facility. Sample points on the east side of the drain were established in December 1992 and the sample locations on the west side were added in March 1993. Table 5 provides the data used in the figures. This seepline 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 25 to 907 pCi/mL. Activities on the west side of the drainage ranged from 91 to 36,383 pCi/mL. The tritium activity in the stream at location (FHB012) was 18,738 pCi/mL. This represents a convergence of the contaminant plume with relatively clean water from the seepline on the east slope of this drainage system.

Conductivity measurements on both sides of the drainage were near background at most locations and ranged from 27 to 428 μ S/cm. Some locations exhibited elevated conductivity values; however, these values are typical of the conductivity values typically reported in the water table wells in the vicinity of the old F-Area effluent ditch (EMS, 1993). Using the Spearman rank correlation test, no correlation ($r_s = -0.03$) was found between conductivity and tritium for these locations. pH values ranged from 4.1 to 5.8, with an average of 5.0.

These results are consistent with the Haselow et al. (1990) results for the western portion of the H-Area seepline, 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 seepline down gradient of 643-E (particularly sample points on the west side) 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 is forcing the tritium plume to outcrop down gradient. It appears that the groundwater and tritium are moving below the fill material and outcropping on the west side of the drainage. The results suggest that the sampling locations on the west side of the drainage delineated the tritium plume with the center located at or near FHB018.

Conclusions

Tritium concentrations measured at most locations in December 1993 decreased or remained relatively unchanged compared to previous sampling events. These results vary only slightly from previous sampling events and are attributed to the dynamic nature of the tritium plume movement. Below-normal rainfall for the past six months caused the toe of the tritium plume to migrate toward the seepline intercept and away from FMB. As rainfall returns to normal and the winter season begins, the plume is expected to show higher tritium concentrations closer to the basins. Total tritium fluxes to the wetlands and FMB steadily declined since basin closure (Looney et al., 1993) and overall results from the tritium survey support this finding.

These data support the hypothesis that the tritium plume in F and H Areas is being flushed from the shallow groundwater. Differences in tritium concentrations measured at seepline sampling locations from one sampling event to the next represent seasonal changes in the amount and the intensity of rainfall, infiltration rate, and vegetative cover, as well as changes due to flushing of the contaminant plume from the wetland system. No correction has been made for normal tritium decay because of the short time between sample events. Conclusions about tritium fluxes to the wetlands and FMB should consider the complexity of the groundwater system and should be based on long-term surface water, seepline, and groundwater monitoring data and not on quarterly changes in concentrations at seepline monitoring locations.

Evaluation of data from 16 seepline locations south of the 643-E Area indicates that tritium migrating from 643-E is outcropping along the old F-Area effluent ditch, particularly on the west side of the channel. It appears that sampling locations on the west side of the channel delineated the tritium plume outcrop area as driven by the present climatic and hydrologic conditions.

References

- Daniel, W. W. 1978. *Applied Nonparametric Statistics*. Houghton Mifflin Company, Boston, MA.
- Dixon, K. L. and V. A. Rogers. 1992. *Results of the First Quarter Tritium Survey of the F- and H-Area Seeplines: May 1992*. WSRC-TR-92-304, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, SC.
- Dixon, K. L. and V. A. Rogers. 1993a. *Results of the Second Quarter Tritium Survey of the F- and H-Area Seeplines: September 1992*. WSRC-TR-93-129, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, SC.
- Dixon, K. L. and V. A. Rogers. 1993b. *Results of the Third Quarter Tritium Survey of the F- and H-Area Seeplines: December 1992*. WSRC-TR-93-284, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, SC.
- Dixon, K. L. and V. A. Rogers. 1993c. *Results of the Fourth Quarter Tritium Survey of the F- and H-Area Seeplines: March/April 1993*. WSRC-TR-93-526, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, SC.
- Dixon, K. L. and V. A. Rogers. 1993d. *Results of the Quarterly Tritium Survey of Fourmile Branch and Its Seeplines in the F- and H-Areas of SRS: June 1993*. WSRC-TR-93-656, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, SC.
- Dixon, K. L. and V. A. Rogers. 1993e. *Semi-Annual Sampling of Fourmile Branch and Its Seeplines in the F and H Areas of SRS: July 1992*. WSRC-TR-93-289, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, SC.
- Dixon, K. L., V. A. Rogers, and B. B. Looney. 1994. *Results of the Quarterly Tritium Survey of Fourmile Branch and Its Seeplines in the F and H Areas of SRS: September 1993*. WSRC-TR-94-0286, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, SC.
- Environmental Monitoring Section (EMS). 1993. *The Savannah River Site's Groundwater Monitoring Program, Second Quarter Report*. ESH-EMS-930097, Westinghouse Savannah River Company, Aiken SC.
- Fenimore, J. W. and J. H. Horton. 1972. *Rating History and Environmental Effects of Seepage Basins in Chemical Separations Areas of the Savannah River Plant*. DPST-72-548, E. I. du Pont de Nemours and Company, Savannah River Laboratory, Aiken, SC.

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- Haselow, J. S., M. Harris, B. B. Looney, N. V. Halverson, and J. B. Gladden. 1990. *Analysis of Soil and Water at the Fourmile Branch Seepage Near the F and H Area of SRS (U)*. WSRC-RP-90-0591, WSRC-TR-92-304, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, SC.
- Killian, T. H., N. L. Kolb, P. Corbo, and I. W. Marine. 1985a. *F-Area Seepage Basins*. DPST-85-704, E. I. du Pont de Nemours and Company, Savannah River Laboratory, Aiken, SC.
- Killian, T. H., N. L. Kolb, P. Corbo, and I. W. Marine. 1985b. *H-Area Seepage Basins*. DPST-85-706, E. I. du Pont de Nemours and Company, Savannah River Laboratory, Aiken, SC.
- Looney, B. B., J. S. Haselow, C. M. Lewis, M. K. Harris, D. E. Wyatt, C. S. Hetrick. 1993. *Projected Tritium Releases from F and H Area Seepage Basins and the Solid Waste Disposal Facilities to Fourmile Branch (U)*. WSRC-RP-93-459, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, SC.
- WSRC-3Q1-4. 1992. *Determination of Tritium in Water*. Procedure 2760, Rev 0. Westinghouse Savannah River Company, Aiken, SC.
- WSRC-L14.1. 1992a. *Procedure for Cole-Parmer Portable Conductivity Meter Model 1481-40*. Procedure 2-79, Rev 1. Westinghouse Savannah River Company, Aiken, SC.
- WSRC-L14.1. 1992b. *Procedure for Cole-Parmer Model 5985-80 pH Meter*. Procedure 2-81, Rev 1. Westinghouse Savannah River Company, Aiken, SC.

Figure 1. Location of F-Area Seepage Basins Relative to Seep line and Stream Sample Sites.

Figure 2. Location of H-Area Seepage Basins Relative to Seep line and Stream Sample Sites.

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

Figure 4. Schematic Diagram of Flow Lines in the Shallow Groundwater at the F- and H-Area Seepline During Basin Operation.

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

Figure 6. Comparison of 1993 Rainfall Totals (January–November 1993) to the Long-Term Average (1960–1991) for F-Area Weather Station.

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Figure 7. Comparison of March 1989 and September and December 1993 Tritium Concentrations for Selected F-Area Seepine Locations.

Figure 8. Comparison of March 1989 and September and December 1993 Tritium Measurements for Selected H-Area Seepine Locations.

Figure 9. Comparison of March 1989 and September and December 1993 Conductivity Measurements for Selected F-Area Seepage Locations.

Figure 10. Comparison of March 1989 and September and December 1993 Conductivity Measurements for Selected H-Area Seepage Locations.

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Figure 11. Comparison of March 1989 and September and December 1993 pH Measurements for Selected F-Area Seepine Locations.

Figure 12. Comparison of March 1989 and September and December 1993 pH Measurements for Selected H-Area Seepine Locations.

Figure 13. March, September, and December 1993 Tritium Measurements for Selected Stream Locations along Fourmile Branch.

Figure 14. March, September, and December 1993 Conductivity Measurements for Selected Stream Locations along Fourmile Branch.

Figure 15. March, September, and December 1993 pH Measurements for Selected Stream Locations along Fourmile Branch.

Results of the Quarterly Tritium Survey of Fourmile Branch
and the Seeplines in the F and H Areas of SRS: December 1993

Figure 16. Comparison of March, September, and December 1993 Tritium Concentrations for Selected Locations on the Seepline South of 643-E.

Figure 17. Comparison of March, September, and December 1993 Conductivity Measurements for Selected Locations on the Seepline South of 643-E.

Figure 18. Comparison of March, September, and December 1993 pH Measurements for Selected Locations on the Seepline South of 643-E.

Tables

Table 1. Comparison of 1993 Rainfall Totals to the Long-Term Average for F-Area Weather Station (January–November)

Months	1993 Rain (cm)	Long-Term Rain (cm)
January	22.6	11.8
February	12.9	10.8
March	21.5	13.3
April	3.5	8.6
May	4.0	10.7
June	15.3	10.9
July	7.3	12.9
August	8.8	14.3
September	16.7	9.5
October	1.6	5.7
November	5.8	6.6

Table 2. Comparison of F-Area Seepline Measurements of Tritium, Conductivity, and pH in March 1989 and September and December 1993.

Location	Tritium (pCi/mL)			Conductivity (μS/cm)			pH (- log H)		
	Mar 89	Sept 93	Dec 93	Mar 89	Sept 93	Dec 93	Mar 89	Sept 93	Dec 93
2	520	709	579	94	132	169	5.6	5.6	6.2
7	3400	667	1460	681	254	199	5.4	5.8	5.9
12	260	91	92	30	108	133	5.3	5.7	5.8
14	14000	134	15	666	32	27	4.2	4.5	5.1
19	4900	3710	4237	1424	917	1138	4.2	3.6	3.7
26	4400	2020	4019	1095	771	1135	6.5	6.0	6.3
32	3600	61	53	174	38	40	5.0	4.9	5.2
34	14000	5720	3884	810	1130	803	3.8	3.6	3.7
35	11000	17800	10436	1100	1948	1511	3.9	3.6	3.7
40	7800	8240	7434	900	898	1650	5.2	4.1	4.1
47	100	38	23	52	45	77	4.7	4.8	5.6
56	19	12	13	34	51	54	4.5	5.1	5.3
204	3000	2400	2623	895	695	650	4.4	4.7	4.2
213	2800	4140	3580	860	715	694	4.6	4.2	4.0
220	560	755	989	147	170	162	4.8	5.7	5.8
226	1300	820	967	306	154	234	5.1	5.4	5.7
235	580	Dry	529	84	Dry	107	5.7	Dry	5.9
241	560	583	496	36	245	92	4.7	5.9	5.4
249	580	320	297	84	86	87	4.4	5.3	5.4
256	400	736	397	56	179	94	5.1	5.7	5.9
270	40	49	63	50	65	30	4.1	5.1	4.6
290	35	55	48	49	39	47	3.6	5.6	5.3

Results of the Quarterly Tritium Survey of Fourmile Branch
and its Seepines in the F and H Areas of SRS: December 1993.

Table 3. Comparison of H-Area Seepine Measurements of Tritium, Conductivity, and pH in March 1989 and September and December 1993.

Location	Tritium (pCi/mL)			Conductivity (μ S/cm)			pH (-log H)		
	Mar 89	Sept 93	Dec 93	Mar 89	Sept 93	Dec 93	Mar 89	Sept 93	Dec 93
3	14000	3380	6050	468	216	259	5.2	6.0	5.9
4	11000	3060	1570	292	325	166	5.8	6.2	6.4
8	24000	4440	3730	556	267	213	5.7	6.5	6.4
11	960	123	116	80	65	67	5.1	5.5	5.3
13	12000	Dry	1055	592	Dry	191	6.2	Dry	6.3
15	1000	371	1250	82	270	160	5.2	5.8	5.6
20	6500	1190	971	183	143	109	6.2	6.0	5.5
25	3300	5120	3119	135	128	107	4.7	5.8	5.3
29	9200	510	597	257	116	119	5.2	5.3	4.9
34	5600	1990	1058	331	226	163	5.8	5.9	5.9
38	6500	307	465	227	228	98	4.9	6.2	5.9
43	10000	4680	4213	413	399	323	5.3	6.1	6.2
46	11000	3120	5459	318	155	257	5.5	6.3	6.2
49	11000	5850	3536	551	200	170	4.4	5.8	5.9
52	20000	15500	12688	699	685	612	4.1	5.5	5.5
57	15000	3250	4434	581	203	256	5.5	5.5	5.2
60	21000	3050	3901	473	167	188	5.9	6.1	5.9
64	320	124	179	38	85	56	4.7	5.2	4.8
71	450	852	479	40	65	52	5.1	4.9	5.5
76	400	344	768	146	79	150	5.1	5.4	6.1
97	1100	4020	3617	37	238	210	4.3	5.2	5.0
103	510	1420	1218	43	75	53	4.4	5.1	5.1

Table 4. Comparison of Fourmile Branch Stream Measurements of Tritium, Conductivity, and pH in March, September, and December 1993.

Location	Tritium (pCi/mL)			Conductivity (μ S/cm)			pH (-log H)		
	Mar 93	Sept 93	Dec 93	Mar 93	Sept 93	Dec93	Mar 93	Sept 93	Dec 93
1F	425	503	567	56	75	77	6.3	6.2	6.5
1H	47	41	37	46	93	74	6.4	6.2	6.1
2H	104	105	145	40	77	91	6.3	6.2	6.4

Table 5. Comparison of Seepage Below 643-E Measurements of Tritium, Conductivity, and pH in March, September and December 1993.

Location	Tritium (pCi/mL)			Conductivity ($\mu\text{S/cm}$)			pH (- log H)		
	Mar 93	Sept 93	Dec 93	Mar 93	Sept 93	Dec 93	Mar 93	Sept 93	Dec 93
1	387	598	553	60	71	91	5.8	5.7	5.35
2	37	35	25	40	93	51	5.2	5.5	4.97
3	682	408	370	52	42	40	5.7	5.2	5.32
4	175	853	785	51	44	40	4.8	5.2	5.05
5	263	947	907	29	27	40	5.4	5.4	5.03
6	217	190	378	45	59	33	5.5	4.9	5.07
8	134	432	419	29	30	32	5.2	4.8	4.52
*12	12000	17100	18738	37	30	40	5.4	5.2	5.03
13	2860	13800	13762	47	76	34	5.1	5.5	5.32
14	1150	1090	939	77	42	187	5.3	5.2	4.92
15	29	169	315	185	229	117	6.0	6.3	5.68
16	306	1360	785	88	140	57	6.2	5.3	5.33
17	14100	49200	36383	60	25	102	5.5	5.2	5.21
18	44000	59400	25966	110	428	55	5.6	6.7	5.33
19	546	29100	30537	52	43	125	4.4	5.0	4.13
20	38	95	42	35	91	40	5.0	5.9	5.83

*Stream Sample Location