November 08, 1999
WSRC-TR-99-00425

Results of Annual Comprehensive Sampling of the F- and H-Area Seeplines Along Fourmile Branch: April 1998 (U)

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Prepared for the U. S. Department of Energy under contract no. DE-AC09-96SR18500

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List of Acronyms

BAF-Bioaccumulation Factor
BG-Background
CFR-Code of Federal Regulations
COPC-Contaminant of Potential Concern
DCF®-Disposable Capsule Filter
DOT-Department of Transportation
EGG-Environmental Groundwater Group
EMS-Environmental Monitoring Section
EPA-Environmental Protection Agency
EPD-Environmental Protection Department
EP-Environmental Physics
ESV-Ecological Screening Value
ExR-Exploration Resources
FMB-Fourmile Branch
GEL-General Engineering Laboratory
GSA-General Separations Area
HQ-Hazard Quotient
LOD-Limit of Detection
MCL-Maximum Contaminant Levels
MDA-Minimum Detectable Activity
PDWS-Primary Drinking Water Standards
PVC-Polyvinyl Chloride
QA-Quality Assurance
QC-Quality Control
RCRA-Resource Conservation and Recovery Act
SCDHEC-South Carolina Department of Health and Environmental Control
SAIC-Science Applications International Corporation
SDWS-Secondary Drinking Water Standards
SRS-Savannah River Site
SRTC-Savannah River Technology Center
TN-Thermo Nuclear
VOA-Volatile Organic Analysis
WA-Weston Analytical

Executive Summary

In April 1998 water samples were collected from Fourmile Branch (FMB) and its seeplines in the vicinity of the F- and H-Area Seepage basins. This annual sampling event is a continuation of previous sampling events. The objective of this study is to characterize the shallow groundwater outcropping into FMB and its wetlands. In the past, this groundwater has been shown to contain contaminants migrating from the F- and H-Area Seepage basins. The samples were analyzed for Resource Conservation and Recovery Act (RCRA) Appendix IX metals, selected radionuclides, and selected inorganic constituents. Analyses of volatile organic compounds were discontinued in 1996 because concentrations were below the method detection limit or insignificant (Dixon et al., 1995).

Results from this sampling event (April 1998) indicate that the seeplines of F and H Areas and FMB continue to be influenced by contaminants in groundwater originating from the capped seepage basins, but to a lesser degree than in the past. This suggests that the most concentrated portion of the contaminant plume may have dissipated.

Contaminant concentrations measured during this sampling event were compared to primary drinking water standards (PDWS), secondary drinking water standards (SDWS), and maximum contaminant levels (MCL) enforceable in 1998. Results were also compared to the 1989 baseline measurements at corresponding locations.

Those contaminants with concentrations greater than the PDWS SDWS or MCL were:

Area	Analyte
F seepline	aluminum, chloride, manganese, iron, nitrate, gross alpha, I-129, nonvolatile beta, tritium
H seepline	aluminum, chloride, iron, nitrate gross alpha, I-129, nonvolatile beta, tritium
BG	aluminum, chloride, iron, manganese, nitrate, gross alpha
FMB	aluminum, chloride, iron, manganese, tritium

Those analytes found to have concentrations greater than the 1989 baseline measurements at one or more location were:

Area	Analyte
F seepline	aluminum, chloride, uranium-238
H seepline	aluminum, chloride
FMB	none

An ecological screening was also conducted using the analytical results from samples obtained at these locations. The analytes determined to be "retained for further study" when applying EPA Region IV protocol were:

Area	Analyte
F seepline	aluminum, barium, beryllium, chromium, cobalt, and zinc
H seepline	aluminum, arsenic, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, and zinc

Comprehensive Sampling of the F- and H- Area Seeplines AlongFourmile Branch: April 1998

J.W. Koch and G. P. Friday

Introduction

Environmental monitoring studies have been conducted in the vicinity of the General Separations Area (GSA) on the Savannah River Site since the early 1960's. The purpose of these studies was to assess the effects of operations by F-Area, H-Area, and the Burial Ground complex, facilities which comprise the GSA, on human health and ecological resources.

Beginning in 1989, sampling and analyses of surface waters at the seepline and in Fourmile Branch were initiated and continue to date. Analytical constituents which nave been examined include selected radioisotopes, metal, volatile organic compounds, and other physical parameters. This report presents the results of the April 1998 sampling event. Specifically, the objectives of this report are to (1) summarize the analytical results for surface waters at the seepline and Fourmile Branch, (2) compare the April 1998 sampling results to human health and ecological thresholds, (3) contrast concentrations for the baseline period (1989) with subsequent years (1992-1999), and (4) identify trends in concentrations over time.

Background

The F and H-Area seepage basins (FHSB) consist of seven seepage basins located within the General Separations Area of the SRS (Figure 1). The basins, which occupy approximately 23 acres are covered with impermeable clay caps and closed under RCRA authority. The nearest stream, Fourmile Branch, is located approximately 1300 ft from the H-Area basins and approximately 1970 ft from the F-Area basins. The FHSB consists of two principal areas: (1) the western area which contains the three F-Area seepage basins and (2) the eastern area which contains four H-Area seepage basins. The F-Area basins cover approximately 7 acres whereas the H-Area basins cover approximately 16 acres. The F- and H-Area seepage basins were constructed and began operations in 1955. The F-Area seepage basins consisted of three unlined basins that were hydraulically connected by vitrified clay process sewers. The seepage basins received process wastewater from the F-Area Separations Facilities for a period of 33 years. The major sources of waste were cooling water from tritium facilities, nitric acid recovery overheads, general purpose evaporator overheads, and retention basin transfers (Killian et al., 1985a). Other relatively mobile radionuclides introduced into the basins via the waste effluent were ^{90}Sr, ^{99}Tc, and ^{129}I (Looney et al., 1988**).** Discharges to the basins ceased in November 1988, and closure caps were placed over the basins to minimize infiltration through the basin sediments in 1990. The H-Area Seepage basins also consisted of three unlined basins that were constructed in 1955. In 1962, however, one basin was made inactive and replaced by a fourth basin. The basins received process wastewater from the H-Area Separations Facilities until 1988. The main sources of waste water included those listed for the F-Area Seepage basins, overheads from the two H-Area Tank Farm evaporators, and liquids from the Receiving Basin for Offsite Fuels Facility (Killian et al., 1985b). Discharges to the basins terminated in November 1988. Closure caps were placed over the seepage basins in 1991 to minimize infiltration through the basin sediments

In 1988 and 1989, the Savannah River Technology Center (SRTC) conducted an extensive study aimed at characterizing the shallow groundwater outcropping into FMB and its associated seeplines (Looney et al., 1988, Haselow et al., 1990). These studies were prompted by observed vegetation stress and tree dieback. This was occurring in relatively small and isolated areas of the wetlands on the northern side of FMB.

Looney et al. (1988) collected water samples from upstream and downstream locations on FMB and from its associated seeplines in suspect areas. The samples were analyzed for a wide range of nonradioactive parameters including selected metals, inorganic constituents and parameters, pH, conductivity, and nitrate/nitrite. Results from the analysis of the seepline water suggested the following:

- Sodium, nitrate, and hydrogen ions had reached the seepline from the basins and were affecting the bulk chemistry of the seepline water.

- Several constituents (aluminum, calcium, copper, etc.) were leaching from the soil due to the low pH shallow groundwater.

- Cadmium in F Area and nitrate in both F and H Areas were elevated above the PDWS.

- FMB was affected by constituents (primarily nitrate and sodium) from either the seepline water or local outfalls.

Looney et al. (1988) concluded that these factors, combined with the flooding of previously dry areas resulting from basin operations, were primarily responsible for the observed vegetation stress in the seepline areas. This suggested that a more extensive study be performed to further characterize the occurrence of particular analytes in the stream and seepline water.

Subsequently, Leblanc and Loehle (1990) collected cores from trees adjacent to the dieback areas, along with cores from trees in unaffected areas along the F-and H-Area Seeplines for tree ring analysis and chemical analysis. The purpose of the study was to determine, using tree ring analysis, the historical development of forest decline in the dieback areas, and to identify relationships between climatic stresses and growth decline. Chemical analyses were also performed on dated wood samples to determine any relationships between altered soil chemistry and growth decline. Positive growth correlations with rainfall were found to exist and flooding was subsequently ruled out as a cause of tree stress. Leblanc and Loehle (1990) suggested that drought affected both the trees adjacent to the dieback areas, and those from unaffected areas. However, the trees near dieback areas were slower to recover. They concluded that aluminum, sodium, acidity, and heavy metal pollution, with drought acting as a trigger, were the primary causes of the vegetation stress and tree dieback. They also hypothesized that after the contaminant plume is diluted and flushed out, the FMB wetland systems below the capped basins should begin to recover.

Haselow et al. (1990) collected soil cores and stream and seepline water samples from FMB and its seeplines in 1988 and 1989 as a follow-up to the Looney et al. (1988) study. These samples were analyzed for both radioactive and nonradioactive parameters. Between the 1988 and 1989 sampling events, an extensive survey for tritium, pH, and conductivity was conducted along the seeplines. These studies confirmed that contaminants migrating from the seepage basins were impacting the water chemistry along the F- and H-Area seeplines.

To monitor temporal changes in the contaminant levels outcropping along the FMB Seepline after closure of the basins, two sampling programs were established. These were the quarterly F- and H-Area tritium survey and a semi-annual sampling program for monitoring metals listed in Title 40 CFR, Part 264, Appendix IX; various inorganics; and selected radionuclides. Results from the tritium surveys, in which tritium, pH, and conductivity are measured at 22 locations along each seepline, have been presented by Dixon and Rogers (1992, 1993 a,b,c,d), Dixon et el. (1994), Koch and Dixon (1995, 1996, 1997a, 1998), and Koch (1998). The results of the tritium sampling events show a significant decrease in tritium concentrations and conductivity values with average pH values over each of the F- and H- Area seeplines increasing to more natural ranges (pH 5 to 6) when compared to 1989. The most recent combined average pH was reported as 5.5 (Koch, 1998). The pH during the 1989 baseline sample event was below 4.5. The chronic screening values for pH are 6.5-9.0 for ecological and 5.0-9.0 for human health.

Methods

The laboratories conducting the analyses provided all sample containers, preservatives, blue ice, and coolers necessary to collect and ship the samples. At each location, a sample was collected to measure tritium concentration for Department of Transportation (DOT) shipping clearance. Tritium analyses were performed onsite at EMS laboratory facilities. Lists of the constituents analyzed by each laboratory, along with the methods used and method for a given parameter are shown in Appendix A.

A list of organizations involved in these sampling events and their participation is included in the acknowledgement section.

Sampling Locations

The following paragraphs discuss how the sample locations were prepared prior to beginning this sampling program (1992).

To initially establish a sampling station, a hole was excavated within a three-foot radius of the desired marked location using a clean stainless steel shovel. A five-gallon plastic bucket, screened on the sides and bottom, was placed into the excavated hole and covered with a lid. One such bucket was set at each location, except locations HSP008, HSP043, FSP047 and FSP290 where two buckets were set adjacent to one another. A second bucket was needed at these locations to collect sufficient water for duplicate and split samples.

FMB stream water samples were collected from three locations and seepline water samples were collected from ten locations as identified in Table 1 and shown on Figures 1, 2, and 3. Sampling locations were selected in areas that, according to 1989 and 1992 data (Haselow et al., 1990; Dixon and Rogers, 1992), were being influenced by constituents migrating from the seepage basins. Attempts were also made to establish even sample coverage along both seeplines. In the event that a sampling location would not yield an adequate volume of water for analysis, the location was listed as a dry hole and no sample was collected. There were no dry holes during the April 1998 sampling event. Background seepline samples for these sampling events were collected at four locations from areas upstream of the GSA. For Quality Assurance/Quality Control (QA/QC) purposes, duplicate samples were collected at locations and sent to the primary laboratory for analysis.

One trip blank sample was carried throughout sampling for this event. The trip blank sample consisted of one of each sample container type filled with deionized water. This sample was carried to each designated sampling location, handled like the collected samples, and shipped to the analytical laboratories for analyses.

Table 1. Comparison of sample locations in March 1989 and April 1998.

	Sample	**SRS Coordinates**		**March**	**April**
Seepline	**Location**	**North**	**East**	**1989**	**1998**
F Area	FSP012	73602	49644	***X***	***X***
	FSP032	73367	50258	***X***	***X***
	FSP047	73609	50607	***X***	***X***
	FSP204	73281	48801	***X***	***X***
	FSP290	73160	46865		***X***
H Area	HSP008	71005	56990		***X***
	HSP029	71278	56257		***X***
	HSP043	71644	55722	***X***	***X***
	HSP060	71629	55190		***X***
	HSP092	72672	54129		***X***
Background	BG001	67208	59153		***X***
	BG002	67229	59363		***X***
Stream					
F Area	FMC001F	72200	43900		***X***
H Area	FMC001H	70350	57050	***X***	***X***
	FMC002H	72600	53000	***X***	***X***
Background	BG003	67633	59281		***X***
	BG004	64723	68527		***X***

X Indicates a Sample was collected

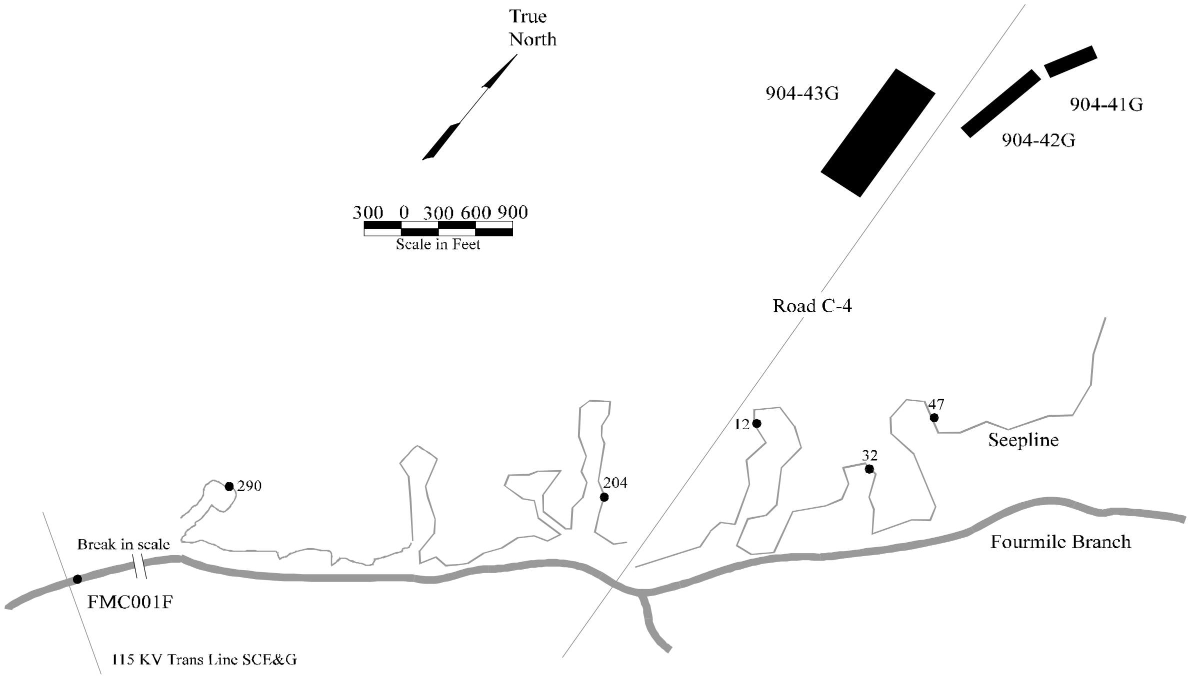


Figure 1. F-Area Seepline (FSP) and Fourmile Branch Sampling Locations, April 1998.

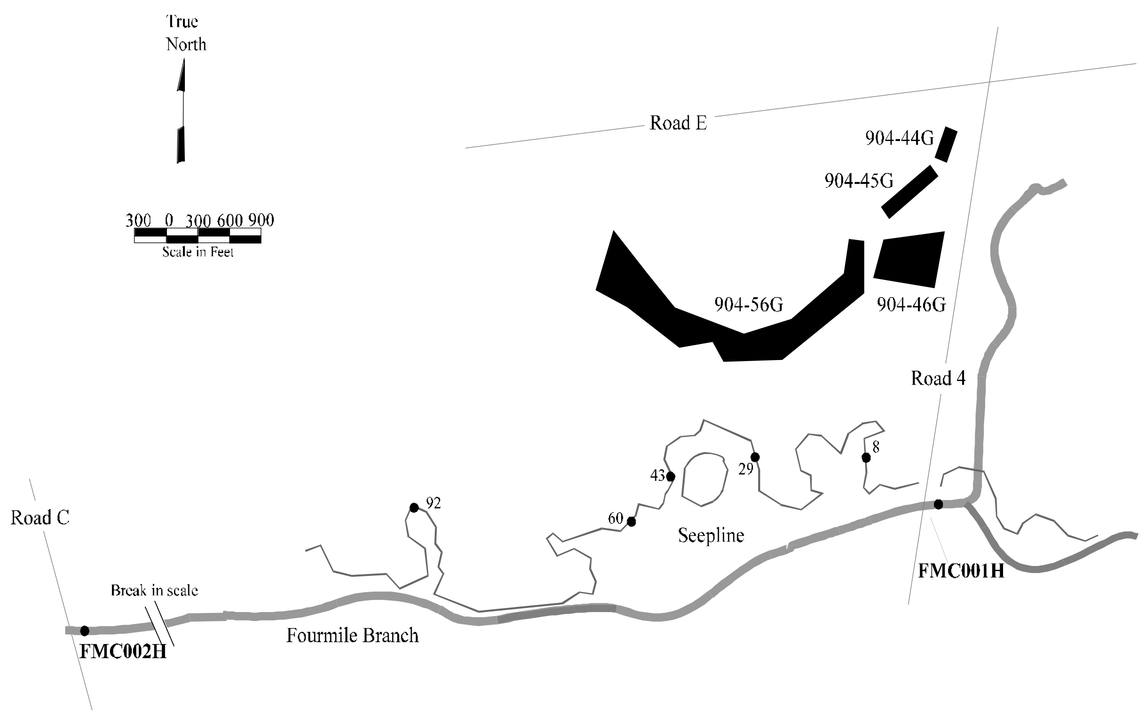


Figure 2. H-Area Seepline (HSP) and Fourmile Branch Sampling Locations, April 1998.

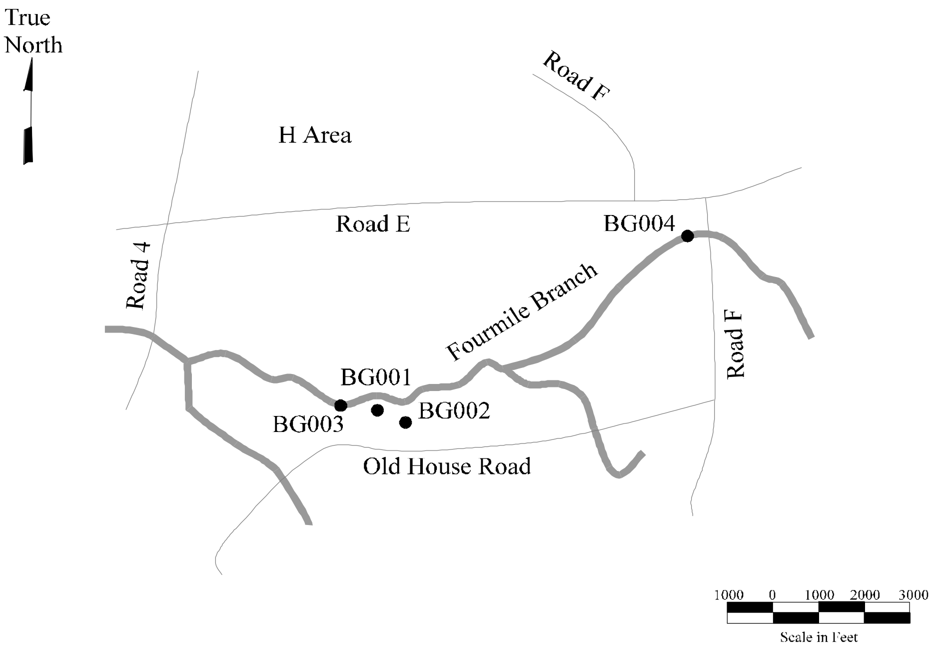


Figure 3. Background Sampling (BG) Locations, April 1998.

Sample Collection Procedures

All sampling events were scheduled during periods of hydraulic stability in order to ensure the collection of representative samples. No samples were collected within three days of 0.25 inches of rainfall. Stream and seepline sampling locations were identified with polyvinyl chloride (PVC) stakes with identification numbers, which served as the sample location ID. The SRS area designation and ID number identified sample locations. The following area identifiers were used:

- HSP: H-Area Seepline
- FSP: F-Area Seepline
- FMC: Fourmile Branch Stream
- BG: Background.

Seepline Water

Buckets were bailed one day prior to sample collection using a one-gallon plastic container.

Using a peristaltic pump powered by a 12-volt battery and equipped with Tygon® tubing, water was pumped from the bucket to the remaining sample containers. New tubing was used for each sampling location and was flushed for 20 seconds with water from the in-ground bucket prior to sample collection.

All samples were filtered through a 10 µ disposable filter to remove fine particulate matter from the sample. All metals samples for the April 1998 sampling event were filtered at each location by connecting a 10µ disposable capsule filter to a piece of Tygon® tubing. Discharge from the filter was collected directly into the sample container. A new piece of tubing and a new filter was used for each sample. Use of dedicated tubing and filters eliminated the need for collecting rinsate samples. At each location the filtered sample was the final sample collected. Collection by this methodology prevented possible alteration (i.e. if unfiltered samples were collected then remotely filtered).

No analysis for volatile organic compounds were conducted beginning with the April 1996 sampling event since the concentration of this class of compounds was insignificant or not detected during the previous events, (Dixon, et al., 1995).

Stream Water Sampling

Surface grab samples were collected in the middle of the stream from the top of the water column. The container was placed into the water with the mouth facing upstream such that water flowed directly into the container.

All containers were filled to the shoulder with water. Water collected for metals analysis was filtered in the field prior to preservation using the filtering technique employed for the particular sampling event. The filled sample containers were then capped tightly and placed in plastic ziplock bags in coolers and kept cool. The in-situ pH and conductivity of the stream was measured and recorded in the red field notebook at the time of sampling.

Evidence of sample collection, shipment, and laboratory acceptance and custody prior to sample disposal was documented to ensure sample traceability. Documentation was achieved through a chain-of-custody record that contained the necessary information for individual sample identification and listed the individuals responsible for sample collection, shipment, and receipt, along with the necessary signatures and dates.

Sample Processing

In order to determine the packaging and shipping requirements of specific samples, 25 milliliter (ml) plastic sample containers were filled from selected sample locations and taken to the WSRC-Par Pond Laboratory to determine the tritium concentration. Previous total activity analysis revealed that the radioactivity associated with each sample was primarily attributable to tritium in the samples. This is why tritium concentration was used as the basis for count rates. Sample locations, which yielded tritium concentrations greater than 1000 picoCuries per milliliter (pCi/ml) during previous sampling events, were selected for tritium concentration screening.

If the tritium concentration in the sample for a particular location and sampling event exceeded 2000 pCi/ml, then each sample collected from that location during that event was considered a radioactive sample. Sample packaging and shipping followed applicable procedures.

Discussion

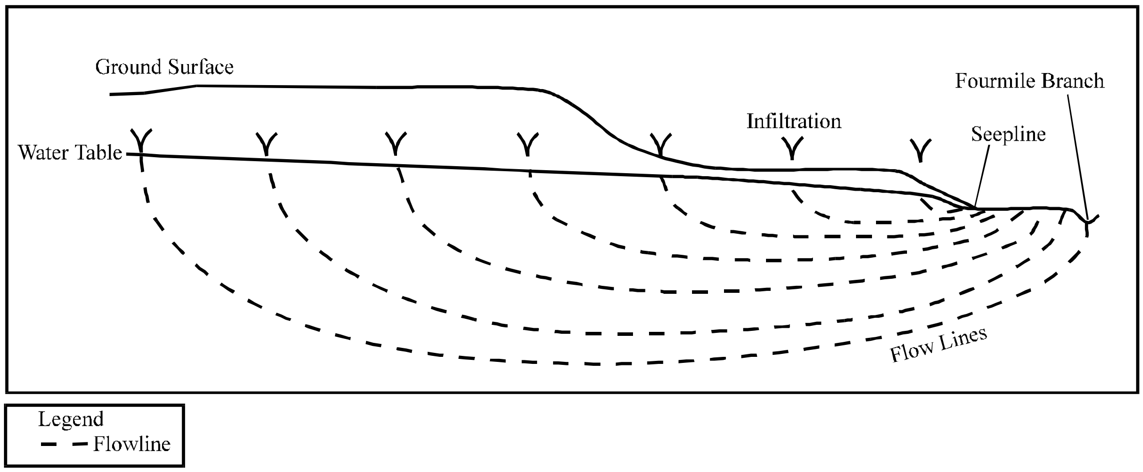
Based on previous sampling events concentrations of constituents measured at seepline sampling locations fluctuate throughout the year. Climate influences measured concentrations, especially rainfall. As discussed in Dixon et al. (1994), seepline measurements are made on water collected from fixed locations 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) seepline monitoring is sensitive to long-term changes and seasonal/transitional influences. Ground-water flow paths in F and H Area are complex. Recharge to the groundwater is primarily due to infiltration of rainwater (rainfall minus runoff and evapotrans-piration). Groundwater then moves laterally toward 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 seepline and the stream, which acts as the groundwater "drain" (Dixon and Rogers, 1993 a,b,c,d,e). This classic vertical trajectory (a path curving downward near the groundwater divide then moving upward into the draining surface water) is shown in the form of flow lines. Figure 4 illustrates the theoretical flow lines devoid of the contaminated water contribution coming from the seepage basins. It also depicts theoretical contaminated flow lines resulting from basin operations. The theoretical plume geometry was 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 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 seepline. This, in turn, results in decreased contaminant concentrations as measured at the seepline sampling locations. Reduction in infiltration, decreases plume velocity and causes movement of the plume upward and closer to the seepline. Consequently, increased contaminant concentrations are seen at the seepline sampling locations (Dixon et al., 1994).

Low rainfall for a few months prior to sampling generally causes an increase in constituent concentrations, and high rainfall causes a decrease in constituent concentrations in the shallow groundwater at the seepline intercept. Figures 6 compares rainfall data for several months prior to each sampling event to the long-term average. Rainfall during the six months prior to the April 1998 sampling event was approximately twice the long-term average (101.4 vs. 58.4 cm). This would hypothetically cause the constituent concentrations to be lower.

For this report, samples analyzed by the primary laboratory and their subcontractors were considered to be the reference samples on which all analyses and interpretation were based. Samples analyzed by the split laboratory and their subcontractors were considered to be QA samples and were not used in any analyses or interpretations. This should prevent inter-laboratory variability of constituent concentrations from biasing any analyses and interpretations.



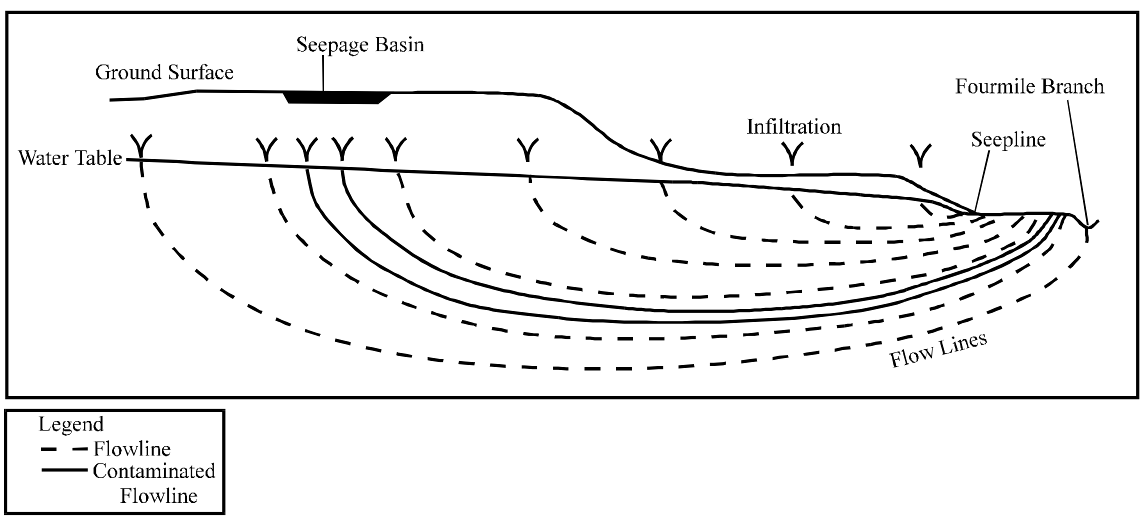


Figure 4. Schematic diagram of flow lines after and before closure of seepage basins.

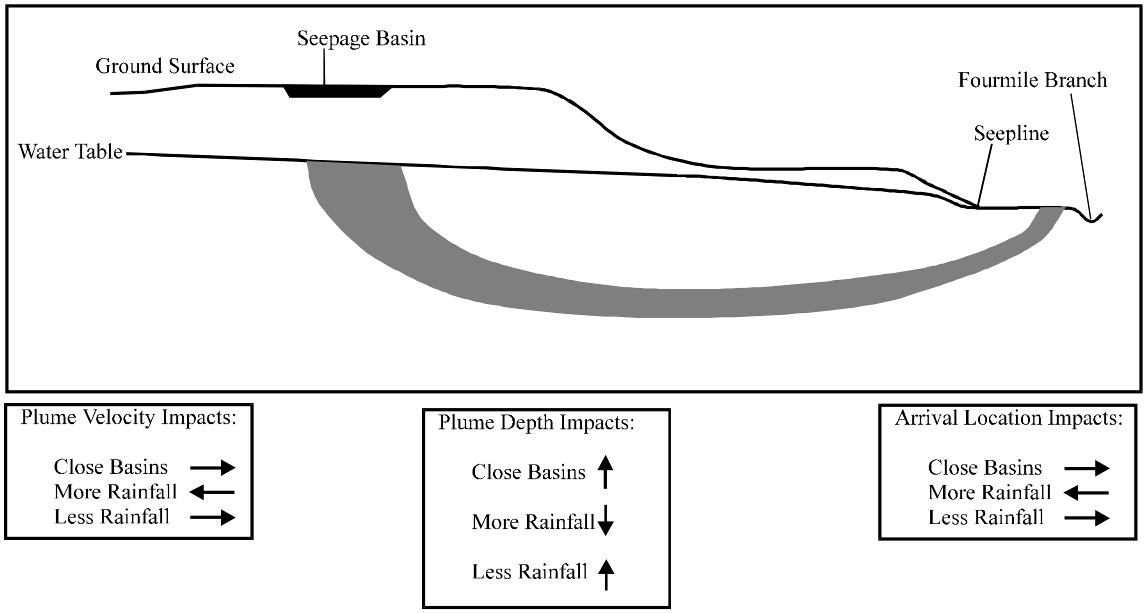


Figure 5. Schematic Diagram of Plume and Rainfall Impacts.

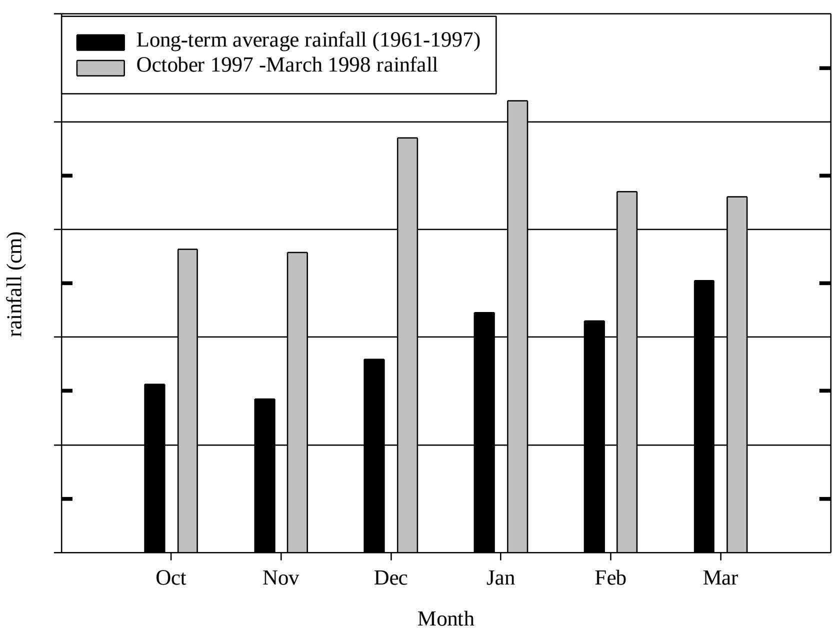


Figure 6. Rainfall six months prior to sampling and Long term average for F-Area. [p/

Analytical results for this sampling event are presented in the Data Summary Reports (EPD 1998). Included in the laboratory analyses table for each analyte is the laboratory that performed the analyses, analytical modifiers, the analytical result, the accuracy of the result (detected radiological parameters only) and the units in which the results are reported (AN95 format). For locations where split samples were collected, results from each laboratory are presented for each analyte. Laboratory duplicates were averaged with their corresponding reference sample for statistical analysis purposes.

Comparison of Seepline Locations Concentrations to Background Concentrations

In the past, analytical data from more than one event were used in this comparison. Since this report includes data from only one sampling event (April 1998) this comparison was not made. The small sample size from one sampling event would provide information of very little value. Combining data from the next scheduled sampling event would be of much greater value. Table 1B and Table 1C in Appendix B and C show the results of this comparison in past years (1993-1997).

Comparison of Stream and Seepline Concentrations to Established Standards

Table 2 represents the EPA Region IV established human health standards for which the data was compared. Lists of those analytes occurring above LOD are provided in Table 7.

Lists of the analytes, along with the corresponding sampling area where concentrations were at levels greater than those established by the PDWS SDWS or MCL, are shown as follows:

Area	Analyte
F seepline	aluminum, chloride, manganese, iron, nitrate gross alpha, I-129, nonvolatile beta, tritium
H seepline	aluminum, chloride, iron, nitrate gross alpha, I-129, nonvolatile beta, tritium
BG	aluminum, chloride, iron, manganese, nitrate, gross alpha
FMB	aluminum, chloride, iron, manganese, tritium

Nine analytes in April 1998 were found to be above these standards at one or more sampling locations. They included gross alpha, Iodine-129, nonvolatile beta, tritium, aluminum, chloride, iron, manganese, and nitrogen as nitrate. This continues to indicate, overall; concentrations of analytes may be decreasing with time. Further analysis is required to confirm this trend.

Ecological Evaluation

An evaluation of non-radiological constituents in surface water associated with the F- and H-Area Seeplines, Fourmile Branch, and reference areas was performed to identify stressors that may pose unacceptable risk to ecological receptors. This information is important in designing subsequent investigations and to identify data gaps if a more comprehensive ecological risk assessment is warranted. This screening level assessment was done in accordance with protocols developed with and approved by EPA and SCDHEC (Friday, 1998; WSRC 1999 a,b,c,d,e). It should be noted that if a chemical is identified as a potential constituent of concern (COC) through this screening evaluation, it does not necessarily mean that ecological risk is unacceptable, but that additional evaluations such as a formal ecological risk assessment are warranted. The concentration of selected constituents was measured from surface waters along the F- and H-area seeplines and in Fourmile Branch. Concentrations of antimony, arsenic, cyanide, mercury, selenium, silver, thallium, and tin were below method detection limits at all locations (Table 1). Mean concentrations of nitrate-nitrite as nitrogen and nitrate as nitrogen were markedly higher in F-Area than H-Area. Mean concentrations of aluminum and sodium, however, were two to three times higher in H-Area than F-Area. Concentrations of calcium, chloride, and potassium were similar at F- and H-Areas.

Ecological screening of analytes in surface waters at F-Area, H-Area, and Fourmile Branch are presented in Tables 4, 5, and 6, respectively. Contaminants of primary concern (COPCs) were identified for all three areas, indicating that some analytes potentially could affect ecological resources. Cobalt, copper, manganese, nitrate, nitrate/nitrite, silver, and zinc were identified as COPCs in Fourmile Branch. With the exception of cobalt in F-Area and copper in H-Area, 12 COPCs were common to F- and H-Areas. These included aluminum, barium, beryllium, cadmium, chromium, iron, lead, manganese, nitrate, nitrate/nitrite, and zinc. These constituents should be retained for further evaluation to assess their potential effects on ecological systems.

Comparison of April 1998 Stream and Seepline Data with March 1989 Data

As previously noted in Table 1, some of the locations sampled during both sampling events were also sampled in 1989. A list of analytes along with the corresponding sampling locations where the subsequent sampling event's concentrations exceeded those measured at the same locations in 1989 is given in the following paragraphs.

Analytes where concentrations exceeded those measured in 1989 at one or more sampling locations included:

Area	Analyte
F seepline	aluminum, chloride, uranium-238
H seepline	aluminum, chloride
FMB	none

Aluminum, barium, calcium, magnesium, manganese, and potassium are likely being leached from the soil profile by low pH water as suggested by Looney et al. (1988) and Haselow et al. (1990). Observation of the data suggests that the concentrations of these constituents have decreased at most locations for which 1989 measurements were available for comparison. This can be attributed to a general increase in pH of the seepline water since 1989 (Koch and Dixon, 1996). An increase in pH (approximately neutral) will reduce the solubility of these metals and their concentrations in the seepline water. The general trend, when compared to 1989 concentrations, appears to be toward decline. Results documenting this decline have been presented by Dixon and Rogers (1992, 1993 a,b,c,d), Dixon et el. (1994), Koch and Dixon (1994 through 1998), Koch (1998).

This was less than one-half the number of analytes earlier found to exceed the 1989 concentrations. There were three analytes found to exceed the 1989 concentrations in both 1996 and 1997 (Koch and Dixon 1998).

Stream and Seepline Water Conductivity and pH

Conductivity and pH are often used as indicator parameters of overall water quality and can aid the researcher in the overall assessment of the contamination at a site. Conductivity has been particularly useful in delineating areas exhibiting high ion concentrations. The extensive study of pH, conductivity, and tritium in 1989 (Haselow et al., 1990) showed that the seepline water in both F and H Areas exhibited low pH and high conductivity. Since 1989, quarterly surveys of pH, conductivity, and tritium (Dixon and Rogers, 1992 and 1993 a,b,c,d), (Rogers et al), (Koch and Dixon, 1994 through 1998) and (Koch 1998) have shown these parameters have been trending toward more normal ranges. The pH of the F-and H-Area Seepline water in the April 1998 sampling event ranged from 4.2 to 5.5 and 4.7 to 6.0, respectively.

The conductivity of the F-and H-Area Seepline water ranged from 23 to 318 micro Seimens per centimeter (µS/cm) and 35 to 115 µS/cm respectively. This was consistent with pH and conductivity measurements recorded during the semi-annual tritium surveys in 1998.

The pH and conductivity the background samples ranged from 4.7 to 5.8 and 18 to 51 µS/cm respectively. This pH was lower than expected and previously measured at these locations. FMB stream water in April 1998 ranged from 5.6 to 5.9 and 29 to 44 µS/cm.

The conductivity values suggest that some locations are being influenced by elevated concentrations of ions. This is substantiated by the fact that locations exhibiting high conductivity values also exhibit high concentrations of ions, particularly aluminum, calcium, iron, magnesium, and sodium. The pH values for FMB appear to be near normal. Conductivity values in FMB are somewhat greater than background values as a result of ion contribution (particularly calcium and sodium) from the F- and H-Area Seeplines.

The pH and conductivity trends from the tritium surveys (at coinciding sample locations) present a more realistic picture of the pH and conductivity in these areas, (Koch, 1998). These surveys show that the pH has continued to increase to a near normal range, (combined average of 5.5).

Comparison to Baseline 1989/1992 Concentrations

Tables 3B and 3C in Appendices B and C summarize the comparisons of all sampling events made to the initial sampling events conducted in 1989 for nonradionuclides and 1992 for radionuclides. Since 1992 the number of analytes exceeding 1989 concentrations has decreased by 70 percent. Only aluminum and chloride concentrations were above the 1989 concentrations in the 1998 sampling event.

Table 2. PDWS, SDWS, and MCL Standards Used in Data Comparisons.

Analyte	Standard	Units	Source	Status
Aluminum	50	µg/L	EPA, 1994	94-SMCL
Americium-241	6.34**	pCi/L	EPA, 1991	Proposed
Antimony	6	µg/L	EPA, 1994	94-MCL
Antimony-125	300**	pCi/L	EPA, 1977	Final
Arsenic	50	µg/L	EPA, 1994	94-MCL
Barium	2000	µg/L	EPA, 1994	94-MCL
Benzene	5	µg/L	EPA, 1994	Final
Beryllium	4	µg/L	EPA, 1994	94-MCL
Cadmium	5	µg/L	EPA, 1994	94-MCL
Calcium	NS	-	-	-
Cerium-144	261**	pCi/L	EPA, 1991	Proposed
Cesium-134	81.3**	pCi/L	EPA, 1991	Proposed
Cesium-137	200**	pCi/L	EPA, 1991	Proposed
Chloride	250	µg/L	EPA, 1994	94-SMCL
Chromium	100	µg/L	EPA, 1994	94-MCL
Cobalt-57	1000**	pCi/L	EPA, 1977	Final
Cobalt-60	100**	pCi/L	EPA, 1977	Final
Copper	1300***,tt	µg/L	EPA, 1994	94-MCL
Curium-242	0.133**	pCi/L	EPA, 1991	Proposed
Curium-243,244	8.3**	pCi/L	EPA, 1991	Proposed
Europium-152	NS	-	-	-
Europium-154	200**	pCi/L	EPA, 1977	Final
Europium-155	600**	pCi/L	EPA, 1977	Final
Gross Alpha	15	pCi/L	EPA, 1994	94-MCL
Iodine-129	1**	pCi/L	EPA, 1977	Final
Iron	300	µg/L	EPA, 1994	94-SMCL
Lead	15tt	µg/L	EPA, 1994	94-MCL
Magnesium	NS	-	-	-
Manganese	50	µg/L	EPA, 1994	94-SMCL
Manganese-54	300**	pCi/L	EPA, 1977	Final
Mercury	2	µg/L	EPA, 1994	94-MCL
Neptunium-237	7.06**	pCi/L	EPA, 1991	Proposed
Nickel	100	µg/L	EPA, 1994	94-MCL
Nitrate as nitrogen	10	mg/L	EPA, 1994	94-MCL
Nonvolatile Beta	50	pCi/L	EPA, 1986a	Proposed
Plutonium-238	7.02**	pCi/L	EPA, 1991	Proposed
Plutonium-239,240	62.1**	pCi/L	EPA, 1991	Proposed
Potassium	NS	-	-	-
Potassium-40	300**	pCi/L	EPA, 1986a	Proposed
Promethium-144	NS	-	-	-
Promethium-146	NS	-	-	-
Radium-226	20	pCi/L	EPA, 1994	94-MCL

continued

Table 2 (continued)

Analyte	Standard	Units	Source	Status
Radium-228	20	pCi/L	EPA, 1994	94-MCL
Ruthenium-106	30**	pCi/L	EPA, 1977	Final
Sodium	NS	-	-	-
Strontium-90	8**	pCi/L	EPA, 1994	94-MCL
Technetium 99	900	pCi/L	EPA,1977	Final
Thallium	2	µg/L	EPA, 1994	94-MCL
Thorium-228	125**	pCi/L	EPA, 1991	Proposed
Thorium-230	79.2**	pCi/L	EPA, 1991	Proposed
Thorium-232	88**	pCi/L	EPA, 1991	Proposed
Tin	NS	-	-	-
Tritium	20	pCi/ml	EPA, 1994	94-MCL
Uranium-234	13.9**	pCi/L	EPA, 1991	Proposed
Uranium-235	14.5**	pCi/L	EPA, 1991	Proposed
Uranium-238	14.6**	pCi/L	EPA, 1991	Proposed
Vanadium	NS	-	-	-
Zinc	5000	µg/L	EPA, 1994	94-SMCL
Zinc-65	300**	pCi/L	EPA, 1977	Proposed

* NS = No Standard

** Based on 4 mrem standard for beta particle and photon activity.
(formerly man-made radionuclides)

*** The 1994 SMCL is 1000 µg/L **** The 1994 SMCL is 2 mg/L.

***** The 1994 SMCL is 100 mg/L, MCL: Maximum Contaminant Level.

tt Treatment Standard, SMCL: Secondary Maximum Contaminant Level.

Table 3: List of mean concentrations and ranges for analytes used in statistical analysis for April 1998.

Analyte	Seepline	Units	Mean	Range
Aluminum, total recoverable	BG	µg/L	273.5	174.0-453.0
Aluminum, total recoverable	FMB	µg/L	175.33	392.0-8590.0
Aluminum, total recoverable	FSP	µg/L	2163.4	391.0-8590.0
Aluminum, total recoverable	HSP	µg/L	6077.8	469.0-13100.0
Barium, total recoverable	BG	µg/L	17.1	11.80-24.00
Barium, total recoverable	FMB	µg/L	19.8	18.00-22.10
Barium, total recoverable	FSP	µg/L	99.54	30.40-199.00
Barium, total recoverable	HSP	µg/L	70.38	14.10-216.00
Beryllium	BG	µg/L	BD	NA
Beryllium	FMB	µg/L	BD	NA
Beryllium	FSP	µg/L	0.24	0.11-0.74
Beryllium	HSP	µg/L	0.45	0.11-1.78
Calcium, total recoverable	BG	µg/L	724.5	410.00-1020.00
Calcium, total recoverable	FMB	µg/L	1856.67	1380.00-2180.00
Calcium, total recoverable	FSP	µg/L	1565.2	355.00-4620.00
Calcium, total recoverable	HSP	µg/L	1088	584.00-2230.00
Chloride, total recoverable	BG	µg/L	1920	1460.00-2380.00
Chloride, total recoverable	FMB	µg/L	3283.67	2110.0-4090.0
Chloride, total recoverable	FSP	µg/L	2276	1610.0-3560.0
Chloride, total recoverable	HSP	µg/L	1808	1380.0-2040.0
Chromium, total recoverable	BG	µg/L	BD	NA
Chromium, total recoverable	FMB	µg/L	BD	NA
Chromium, total recoverable	FSP	µg/L	0.57	0.36-1.07
Chromium, total recoverable	HSP	µg/L	3.49	0.36-8.58
Cobalt, total recoverable	BG	µg/L	BD	NA
Cobalt, total recoverable	FMB	µg/L	0.93	0.34-1.39
Cobalt, total recoverable	FSP	µg/L	7.34	0.94-28.4
Cobalt, total recoverable	HSP	µg/L	4.49	0.34-20.70
Copper, total recoverable	BG	µg/L	BD	NA
Copper, total recoverable	FSP	µg/L	0.79	0.66-1.32
Copper, total recoverable	HSP	µg/L	1.08	0.66-2.75
Copper, total recoverable	FMB	µg/L	3.57	1.54-4.82
Iron, total recoverable	BG	µg/L	1113.45	83.80-2360.00
Iron, total recoverable	FSP	µg/L	2859.13	8.65-8430.00
Iron, total recoverable	HSP	µg/L	2591.8	429.00-6990.00
Iron, total recoverable	FMB	µg/L	1098	832.00-1580.00
Lead, total recoverable	BG	µg/L	ND	NA
Lead, total recoverable	FSP	µg/L	ND	NA
Lead, total recoverable	FSP	µg/L	0.84	0.34-2.52
Lead, total recoverable	HSP	µg/L	5.46	0.34-18.70
Magnesium, total recoverable	BG	µg/L	396.25	288.00-458.00
Magnesium, total recoverable	FSP	µg/L	1016.8	348.00-2640.00
Magnesium, total recoverable	HSP	µg/L	782	445.00-1100.00
Magnesium, total recoverable	FMB	µg/L	501.67	452.00-570.00
Manganese, total recoverable	BG	µg/L	56.55	19.80-97.20
Manganese, total recoverable	FSP	µg/L	520.42	65.10-1020.00
Manganese, total recoverable	HSP	µg/L	307	19.40-1140.00
Manganese, total recoverable	FMB	µg/L	86.5	31.90-147.00
Nickel	BG	µg/L	1.69	1.14-3.36
Nickel	FMB	µg/L	ND	NA
Nickel	FSP	µg/L	2.79	1.14-9.42
Nickel	HSP	µg/L	5.52	1.14-17.80
Potassium	BG	µg/L	146.05	69.90-273.00
Potassium	FMB	µg/L	340.67	297.00-409.00
Potassium	FSP	µg/L	312.96	37.80-880.00
Potassium	HSP	µg/L	380.6	164.00-766.00
Sodium, total recoverable	BG	µg/L	1244.75	927.00-1650.00
Sodium, total recoverable	FSP	µg/L	5316	1480.0-17600.0
Sodium, total recoverable	HSP	µg/L	12588	3750.0-25400.0
Sodium, total recoverable	FMB	µg/L	3940	3630.00-4250.00

Table 3 continued

Analyte	Seepline	Units	Mean	Range

Vanadium, total recoverable	BG	µg/L	0.55	.021-1.57
Vanadium, total recoverable	FMB	µg/L	BD	NA
Vanadium, total recoverable	FSP	µg/L	0.89	0.21-1.55
Vanadium, total recoverable	HSP	µg/L	7.56	1.46-18.4
Zinc, total recoverable	BG	µg/L	3.46	2.65-5.88
Zinc, total recoverable	FSP	µg/L	24.68	12.10-35.70
Zinc, total recoverable	HSP	µg/L	10.33	2.65-27.80
Zinc, total recoverable	FMB	µg/L	9.72	8.53-11.90

ND: nondetect

NA: not applicable

Table 4. Ecological Screening of analytes in Surface Water at the F-Area Seepline, April 1998.

Analytes (Inorganics)	Frequency of Detection	Maximum Detect (µg/L)	Method Detection Limit (µg/L)	ESV[a] (µg/L)	Screening-level HQ[b]	COPC[c] (HQ > 1)?	2X Average Background[d]	Maximum Detect > 2X Average Background?	Is BAF of Potential Concern[e]?	Retained Constituent[f]?
Aluminum	5/5	8.59E+03	3.76E+01	8.70E+01	9.87E+01	yes	5.47E+02	yes	yes	yes
Antimony	0/5	1.64E+00	1.64E+00	1.60E+02	1.03E-02	no	1.64E+00	no	no	no
Arsenic	0/5	2.98E+00	2.98E+00	1.90E+02	1.57E-02	no	2.98E+00	no	yes	no
Barium	5/5	1.99E+02	3.32E-01	3.90E+00	5.10E+01	yes	3.42E+01	yes	no	yes
Beryllium	1/5	7.40E-01	2.23E-01	5.30E-01	1.40E+00	yes	2.20E-01	yes	no	yes
Cadmium	2/5	3.13E+00	2.08E-01	6.60E-01	4.74E+00	yes	2.00E-01	yes	yes	yes
Calcium	5/5	4.62E+03	1.54E+01	1.16E+05	3.98E-02	no	1.45E+03	yes	no	no
Chloride	5/5	3.56E+03	7.00E+00	2.30E+05	1.55E-02	no	3.84E+03	no	no	no
Chromium	1/5	1.07E+00	7.29E-01	1.10E+01	9.73E-02	no	7.20E-01	yes	yes	yes
Cobalt	5/5	2.84E+01	6.71E-01	3.00E+00	9.47E+00	yes	2.25E+01	yes	yes	yes
Copper	0/5	1.32E+00	1.32E+00	6.54E+00	2.02E-01	no	1.32E+00	no	yes	no
Cyanide	0/5	1.67E+00	3.40E+00	5.20E+00	3.21E-01	no	3.34E+00	no	no	no
Iron	4/5	8.43E+03	8.63E+00	1.00E+03	8.43E+00	yes	2.23E+03	yes	no	yes
Lead	1/5	2.52E+00	6.78E-01	1.32E+00	1.91E+00	yes	6.80E-01	yes	yes	yes
Magnesium	5/5	2.64E+03	3.33E+00	8.20E+04	3.22E-02	no	7.93E+02	yes	no	no
Manganese	5/5	1.02E+03	9.03E-01	8.00E+01	1.28E+01	yes	1.13E+02	yes	yes	yes
Mercury	0/5	5.20E-02	1.04E-01	1.20E-02	4.33E+00	yes	1.00E-01	no	yes	no
Nickel	1/5	9.42E+00	2.70E+00	8.77E+01	1.07E-01	no	3.38E+00	yes	yes	yes
Nitrate	5/5	3.42E+04	6.00E+00	None	NA	yes	3.26E+02	yes	no	yes
Nitrate/Nitrite	5/5	3.58E+04	7.00E+00	None	NA	yes	8.47E+02	yes	no	yes
Potassium	5/5	8.80E+02	5.87E+00	5.30E+04	1.66E-02	no	2.92E+02	yes	no	no
Selenium	0/5	7.00E-01	1.40E+00	5.00E+00	1.40E-01	no	1.40E+00	no	no	no
Silver	0/5	3.10E-01	6.20E-01	1.20E-02	2.58E+01	yes	6.20E-01	no	no	no
Sodium	5/5	1.76E+04	2.91E+01	6.80E+05	2.59E-02	no	2.49E+03	yes	no	no
Thallium	0/5	2.63E+00	2.63E+00	4.00E+00	6.58E-01	no	2.64E+00	no	no	no
Tin	0/5	2.94E+00	2.94E+00	7.30E+01	4.03E-02	no	2.94E+00	no	no	no
Vanadium	3/5	1.55E+00	4.27E-01	1.90E+01	8.16E-02	no	1.11E+00	yes	no	no
Zinc	5/5	3.57E+01	5.30E+00	5.89E+01	6.06E-01	no	6.92E+00	yes	yes	yes

[a] ESV = ecological screening value. ESVs are obtained from the protocol for "Ecological Screening Values (ESVs)" (Friday 1998).

[b] Screening-level HQ = screening-level hazard quotient = maximum concentration/ESV.

[c] COPC = constituent of potential concern = screening-level HQ > 1. [d] 2X average background for surface water.

[e] Based on the protocol for "Bioaccumulation and Bioconcentration Screening" (WSRC 1999c); BAF = bioaccumulation factor.

[f] Constituent retained if the maximum detect > 2X average background and the constituent has bioaccumulation potential as identified in the protocol for "Bioaccumulation and Bioconcentration Screening" (WSRC 1999c).

Analytes inorganics	Frequency of Detection	Maximum Detect (µg/L)	Method Detection Limit (µg/L)	ESV[a] (µg/L)	Screening-level HQ[b]	COPC[c] (HQ > 1)?	2X Average Background[d]	Maximum Detect > 2X Average Background?	Is BAF of Potential Concern[e]?	Retained Constituent[f]?
Aluminum	5/5	1.31E+04	3.76E+01	8.70E+01	1.51E+02	yes	5.47E+02	yes	yes	yes
Antimony	0/5	8.20E-01	1.64E+00	1.60E+02	5.13E-03	no	1.64E+00	no	no	no
Arsenic	0/5	1.49E+00	2.98E+00	1.90E+02	7.84E-03	no	2.98E+00	no	yes	no
Barium	5/5	2.16E+02	3.32E-01	3.90E+00	5.54E+01	yes	3.42E+01	yes	no	yes
Beryllium	1/5	1.78E+00	2.23E-01	5.30E-01	3.36E+00	yes	2.20E-01	yes	no	yes
Cadmium	1/5	2.13E+00	2.08E-01	6.60E-01	3.23E+00	yes	2.00E-01	yes	yes	yes
Calcium	5/5	2.23E+03	1.54E+01	1.16E+05	1.92E-02	no	1.45E+03	yes	no	no
Chloride	5/5	2.04E+03	7.00E+00	2.30E+05	8.87E-03	no	3.84E+03	no	no	no
Chromium	4/5	8.58E+00	7.29E-01	1.10E+01	7.80E-01	no	7.20E-01	yes	yes	yes
Cobalt	2/5	2.07E+01	6.71E-01	3.00E+00	6.90E+00	yes	2.25E+01	no	yes	no
Copper	1/5	2.75E+00	1.32E+00	6.54E+00	4.20E-01	no	1.32E+00	yes	yes	yes
Cyanide	0/5	1.67E+00	3.40E+00	5.20E+00	3.21E-01	no	3.34E+00	no	no	no
Iron	5/5	6.99E+03	8.63E+00	1.00E+03	6.99E+00	yes	2.23E+03	yes	no	yes
Lead	3/5	1.87E+01	6.78E-01	1.32E+00	1.42E+01	yes	6.80E-01	yes	yes	yes
Magnesium	5/5	1.10E+03	3.33E+00	8.20E+04	1.34E-02	no	7.93E+02	yes	no	no
Manganese	5/5	1.14E+03	9.03E-01	8.00E+01	1.43E+01	yes	1.13E+02	yes	yes	yes
Mercury	0/5	5.20E-02	1.04E-01	1.20E-02	4.33E+00	yes	1.00E-01	no	yes	no
Nickel	3/5	1.78E+01	2.70E+00	8.77E+01	2.03E-01	no	3.38E+00	yes	yes	yes
Nitrate	5/5	2.70E+03	6.00E+00	None	NA	yes	3.26E+02	yes	no	yes
Nitrate/Nitrite	5/5	2.48E+03	7.00E+00	None	NA	yes	8.47E+02	yes	no	yes
Potassium	5/5	7.66E+02	5.87E+00	5.30E+04	1.45E-02	no	2.92E+02	yes	no	no
Selenium	0/5	7.00E-01	1.40E+00	5.00E+00	1.40E-01	no	1.40E+00	no	no	no
Silver	0/5	3.10E-01	6.20E-01	1.20E-02	2.58E+01	yes	6.20E-01	no	no	no
Sodium	5/5	2.54E+04	2.91E+01	6.80E+05	3.74E-02	no	2.49E+03	yes	no	no
Thallium	0/5	1.32E+00	2.63E+00	4.00E+00	3.30E-01	no	2.64E+00	no	no	no
Tin	0/5	1.47E+00	2.94E+00	7.30E+01	2.01E-02	no	2.94E+00	no	no	no
Vanadium	5/5	1.84E+01	4.27E-01	1.90E+01	9.68E-01	no	1.11E+00	yes	no	no
Zinc	2/5	2.78E+01	5.30E+00	5.89E+01	4.72E-01	no	6.92E+00	yes	yes	yes

[a] ESV = ecological screening value. ESVs are obtained from the protocol for "Ecological Screening Values (ESVs)" (Friday 1998).

[b] Screening-level HQ = screening-level hazard quotient = maximum concentration/ESV.

[c] COPC = constituent of potential concern = screening-level HQ > 1. [d] 2X average background for surface water.

[e] Based on the protocol for "Bioaccumulation and Bioconcentration Screening" (WSRC 1999c); BAF = bioaccumulation factor.

[f] Constituent retained if the maximum detect > 2X average background and the constituent has bioaccumulation potential as identified in the protocol for "Bioaccumulation and Bioconcentration Screening" (WSRC 1999c).

Table 6. Ecological Screening of Analytes in Surface Water at the Fourmile Branch Seepline, April 1998.

Analytes inorganics	Frequency of Detection	Maximum Detect (µg/L)	Method Detection Limit (µg/L)	ESVa (µg/L)	ESVa	Screening-level HQb	COPCc (HQ > 1)?	2X Average Background	Maximum Detect > 2X Average Background?	Is BAF of Potential Concern?	Retained Constituent?
Aluminum	3/3	1.94E+02	3.76E+01	3.76E+01	8.70E+01	2.23E+00	yes	5.47E+02	no	yes	no
Antimony	0/3	8.20E-01	1.64E+00	1.64E+00	1.60E+02	5.13E-03	no	1.64E+00	no	no	no
Arsenic	0/3	1.49E+00	2.98E+00	2.98E+00	1.90E+02	7.84E-03	no	2.98E+00	no	yes	no
Barium	3/3	2.21E+01	3.32E-01	3.32E-01	3.90E+00	5.67E+00	yes	3.42E+01	no	no	no
Beryllium	0/3	1.10E-01	2.23E-01	2.23E-01	5.30E-01	2.08E-01	no	2.20E-01	no	no	no
Cadmium	0/3	1.00E-01	2.08E-01	2.08E-01	6.60E-01	1.52E-01	no	2.00E-01	no	yes	no
Calcium	3/3	2.18E+03	1.54E+01	1.54E+01	1.16E+05	1.88E-02	no	1.45E+03	yes	no	no
Chloride	3/3	4.09E+03	7.00E+00	7.00E+00	2.30E+05	1.78E-02	no	3.84E+03	yes	no	no
Chromium	0/3	3.60E-01	7.29E-01	7.29E-01	1.10E+01	3.27E-02	no	7.20E-01	no	yes	no
Cobalt	2/3	1.39E+00	6.71E-01	6.71E-01	3.00E+00	4.63E-01	no	6.80E-01	yes	yes	yes
Copper	3/3	4.82E+00	1.32E+00	1.32E+00	6.54E+00	7.37E-01	no	1.32E+00	yes	yes	yes
Cyanide	0/3	1.67E+00	3.40E+00	3.40E+00	5.20E+00	3.21E-01	no	3.34E+00	no	no	no
Iron	3/3	1.58E+03	8.63E+00	8.63E+00	1.00E+03	1.58E+00	yes	2.23E+03	no	no	no
Lead	0/3	3.40E-01	6.78E-01	6.78E-01	1.32E+00	2.58E-01	no	6.80E-01	no	yes	no
Magnesium	3/3	5.70E+02	3.33E+00	3.33E+00	8.20E+04	6.95E-03	no	7.93E+02	no	no	no
Manganese	3/3	1.47E+02	9.03E-01	9.03E-01	8.00E+01	1.84E+00	yes	1.13E+02	yes	yes	yes
Mercury	0/3	5.20E-02	1.04E-01	1.04E-01	1.20E-02	4.33E+00	yes	1.00E-01	no	yes	no
Nickel	0/3	1.14E+00	2.70E+00	2.70E+00	8.77E+01	1.30E-02	no	3.38E+00	no	yes	no
Nitrate	3/3	9.19E+02	6.00E+00	6.00E+00	None	NA	yes	3.26E+02	yes	no	yes
Nitrate/Nitrite	3/3	1.02E+03	7.00E+00	7.00E+00	None	NA	yes	8.47E+02	yes	no	yes
Potassium	3/3	4.09E+02	5.87E+00	5.87E+00	5.30E+04	7.72E-03	no	2.92E+02	yes	no	no
Selenium	0/3	7.00E-01	1.40E+00	1.40E+00	5.00E+00	1.40E-01	no	1.40E+00	no	no	no
Silver	0/3	3.10E-01	6.20E-01	6.20E-01	1.20E-02	2.58E+01	yes	6.20E-01	yes	no	yes
Sodium	3/3	4.25E+03	2.91E+01	2.91E+01	6.80E+05	6.25E-03	no	2.49E+03	yes	no	no
Thallium	0/3	1.32E+00	2.63E+00	2.63E+00	4.00E+00	3.30E-01	no	2.64E+00	no	no	no
Tin	0/3	1.47E+00	2.94E+00	2.94E+00	7.30E+01	2.01E-02	no	2.94E+00	no	no	no
Vanadium	0/3	2.10E-01	4.27E-01	4.27E-01	1.90E+01	1.11E-02	no	1.11E+00	no	no	no
Zinc	3/3	1.19E+01	5.30E+00	5.30E+00	5.89E+01	2.02E-01	no	6.92E+00	yes	yes	yes

[a] ESV = ecological screening value. ESVs are obtained from the protocol for "Ecological Screening Values (ESVs)" (Friday 1998).

[b] Screening-level HQ = screening-level hazard quotient = maximum concentration/ESV.

[c] COPC = constituent of potential concern = screening-level HQ > 1. [d] 2X average background for surface water.

[e] Based on the protocol for "Bioaccumulation and Bioconcentration Screening" (WSRC 1999c); BAF = bioaccumulation factor.

[f] Constituent retained if the maximum detect > 2X average background and the constituent has bioaccumulation potential as identified in the protocol for "Bioaccumulation and Bioconcentration Screening" (WSRC 1999c).

Summary, 1989-1998

Concentrations of constituents were compared to primary drinking water standards (PDWS), secondary drinking water standards (SDWS), and maximum contaminant levels (MCLs), and ecological screening values (ESVs).

Aluminum, chloride, iron, nitrate, gross alpha, iodine 129, nonvolatile beta, and tritium exceeded PDWS or MCL's in F-Area and H-Areas. Iron was found in each sample area (F seepline, H seepline, FMB, and BG) and exceeded water quality standards.

Concentrations of aluminum, chloride, iron and tritium in Fourmile Branch exceeded standards. These stream samples showed a decrease in the number of analytes exceeding water quality standards compared to those in March of 1989. When comparing April 1998 results to the July 1992 sampling results, a decrease was observed in the number of radionuclides exceeding the standards (from five to one). Moreover, the number of all analytes exceeding the standards decreased from twelve to four between 1989 to 1998.

In order to evaluate trending, comparisons were also made against the 1989 results reported by Haselow et al., (1990).
Results indicated that most of the nonradiological constituents, particularly sodium and aluminum, had declined at the seeplines and in Fourmile Branch.

In April 1996, organic and inorganic analyses were discontinued because none of the constituents exceeded primary drinking water standards (PDWS), secondary drinking water standards (SDWS), or maximum contaminant levels (MCLs).

Tables 1B-4B in Appendix B and 1C-4C in Appendix C summarize the comparisons that have been made throughout the sampling program (1989-1998). The results in these tables are discussed in the following sections.

Comparisons to EPA Standards

Using the pooled nonradiological and radiological data from all sampling events (Table 2B in Appendix B and Table 2C in Appendix C), aluminum, cadmium, chloride, iron, manganese, nitrate, americium-249, gross alpha, iodine-129, nonvolatile beta, radium 226, radium 228, strontium-89, strontium 90 tritium uranium-233/234, and uranium 238 have exceeded the PDWS, SDWS, or MCL at one or more locations, 1989-1998.

More recently, 1996-1998, nitrate/nitrite no longer exceeded these standards. This occurred at both the F and H seepline areas for both analytes.

Ecological screening of analytes identified constituents of potential concern in F-Area, H-Area, and Fourmile Branch. Cobalt, copper, manganese, nitrate, nitrate/nitrite, silver, and zinc were identified as COPCs in Fourmile Branch. With the exception of cobalt in F-Area and copper in H-Area, 12 COPCs were common to F- and H-Areas.

Table 7: Analytes Reported at Concentrations Greater Than Their Method Detection Limit for April 1998.

Analyte	Analyte
Aluminum, total recoverable	Manganese, total recoverable
Americium-241	Neptium-237
Barium, total recoverable	Nickel, total recoverable
Calcium, total recoverable	Nitrate as nitrogen
Chloride	Nitrate-nitrite as nitrogen
Chromium, total recoverable	Nonvolatile beta
Cobalt, total recoverable	Potassium, total recoverable
Cobalt-60	Potassium-40
Curium 243/244	Radium-226
Gross alpha	Radium-228
Hardness as CACO3	Sodium, total recoverable
Iodine-129	Tritium
Iron, total recoverable	Zinc, total recoverable
Lead, total recoverable	Uranium-233/244
Lead-212	Uranium-238
Magnesium, total recoverable	

These included aluminum, barium, beryllium, cadmium, chromium, iron, lead, manganese, nitrate, nitrate/nitrite, and zinc. These constituents should be retained for further evaluation to assess their potential effects on ecological systems.

Also, only four radioactive parameters (gross alpha, nonvolatile beta, iodine-129 and tritium) were above these standards in 1998. This compares with 10 that exceeded the standards during the initial sampling event in 1989 (Table 2C).

Acknowledgments

This section lists the subcontractors and WSRC organizations responsible for conducting specific activities in support of the April 1998 sampling event.

- The primary analytical laboratory was General Engineering Laboratory, GEL.
- GEL subcontracted the radiological analysis to Environmental Physics, EP.
- Recra conducted the split sample analyses for non-radiological analyses. Recra subcontracted the radiological analysis to Thermo Nuclear, TN.
- ES&TD technicians conducted Seepline water sampling.
- The support services for the April 1998 sampling event were coordinated through the Environmental Groundwater Group, EGG, of the Environmental Monitoring Section, EMS, of WSRC.
- Analytical data validation services were performed by Exploration Resources, ExR, through EMS managed subcontracts.
- Science Applications International Corporation, SAIC, as a subcontractor to ExR performed mobilization of this sampling event.

References

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: 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 Fourth Quarter 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. WSRC-TR-93-289. Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, SC.

Dixon, K.L., and 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 (U) WSRC-TR-94-0286-ESS, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, SC.

Dixon, K.L., J.W. Koch, and V.A. Rogers. 1995. Semi-Annual Sampling of Fourmile Branch and Its Seeplines in the F and H Areas of SRS: February 1993, July 1993, April 1994. (U) WSRC-TR-95-0454, Rev. 1, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, SC.

EPD (Environmental Protection Depart-ment), Environmental Monitoring Section. 1998. Data Summary Report for the Assessment of the Fourmile Branch and its F- and H-Area Seeplines, Radionuclides and Appendix IX Metals (U) WSRC-TR-98-00260, Rev 0, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, SC.

Friday, G.P. 1998. Ecological Screening Values for Surface Water, Sediment, and Soil. WSRC-TR-00110, Westinghouse Savannah River Company, Aiken, SC.

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 Seepline Near the F- and H-Area of SRS. WSRC-RP-90-0591, Westinghouse Savannah River Company, Savannah River Laboratory, 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.

Koch, J.W. and K.L. Dixon. 1994. Results of the Quarterly Tritium Survey of Fourmile Branch and its Seeplines in the F and H Areas of SRS: December 1994. (U) WSRC-TR-95-0300, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, SC.

Koch, J.W. and K.L. Dixon. 1995. Results of the Quarterly Tritium Survey of Fourmile Branch and its Seeplines in the F and H Areas of SRS: May 1995. (U) WSRC-TR-95-0369, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, SC.

Koch, J.W. and K.L. Dixon. 1996. Results of the Quarterly Tritium Survey of Fourmile Branch and its Seeplines in the F and H Areas of SRS: March 1996. (U) WSRC-TR-96-0215, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, SC.

Koch, J.W. and K.L. Dixon. 1997a. Results of the Quarterly Tritium Survey of Fourmile Branch and its Seeplines in the F and H Areas of SRS: September 1996 and 1989-1996 Trending. (U) WSRC-TR-97-0109, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, SC.

Koch, J.W. 1998. Tritium Concentrations in the F- and H-Area Seeplines and FourmileBranch at SRS: March and August 1998 Events and 1989-1998 Trending. (U) WSRC-TR-99-00028, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, SC.

Koch, J.W. and K.L. Dixon. 1997b. Tritium Concentrations in the F- and H-Area Seeplines and Fourmile Branch at SRS: March 1997 and 1989-1997 Trending. (U) WSRC-TR-97-00359, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, SC.

Koch, J.W. and K.L. Dixon. 1998. Tritium Concentrations in the F- and H-Area Seeplines and Fourmile Branch at SRS: September 1997 and 1989-1997 Trending. (U) WSRC-TR-98-00365, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, SC.

Leblanc, D. and C. Loehle. 1990. The Effect of Contaminated Groundwater on Tree Growth: A Tree Ring Analysis (U). WSRC-RP-90-552. Savannah River Laboratory, Westinghouse Savannah River Company, Aiken, SC.

Loehle, C. 1990. Recovery of Contaminated Wetland Soils at SRS by Natural Rainfall: An Experimental Toxicological Study. WSRC-RD-90-14. Savannah River Laboratory, Westinghouse Savannah River Company, Aiken, SC.

Looney, B.B., J.E. Cantrell, and J.R. Cook. 1988. Sampling and Analysis of Surface Water in the Vicinity of the F- and H-Area Seepage Basins. DPST-88-229, 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, and 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.

Rogers, V.A., K.L. Dixon, and B.B. Looney. 1994a. Results of the Quarterly Tritium Survey of Fourmile Branch and its Seeplines in the F and H Areas of SRS: December 1993. (U) WSRC-TR-94-0342, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, SC.

Rogers, V.A., K.L. Dixon, and B.B. Looney. 1994b. Results of the Quarterly Tritium Survey of Fourmile Branch and its Seeplines in the F and H Areas of SRS: March 1994. (U) WSRC-TR-94-0408, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, SC.

Rogers, V.A., K.L. Dixon, and B.B. Looney. 1994c. Results of the Quarterly Tritium Survey of Fourmile Branch and its Seeplines in the F and H Areas of SRS: June 1994. (U) WSRC-TR-94-0441, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, SC.

U.S. Department of Energy. (DOE) 1992. Environmental Measurements Laboratory of the U.S. DOE, 376 Hudson St., New York, NY.

U.S. Environmental Protection Agency (EPA). 1977. National Interim Primary Drinking Water Regulations. EPA-570/9-76-003, Washington, D.C.

U.S. Environmental Protection Agency (EPA). 1980. Prescribed Procedures for Measurement of Radioactivity in Drinking Water. EPA-600/4-80-32. Cincinnati, OH.

U.S. Environmental Protection Agency (EPA). 1983. Methods for Chemical Analysis of Water and Wastes. PB84-128677. Cincinnati, OH.

U.S. Environmental Protection Agency (EPA). 1986a. Water Pollution Control; National Primary Drinking Water Regulations; Radionuclides; Proposed. Federal Register, September 30, 1986, pp. 34835-34862, Washington, D.C.

U.S. Environmental Protection Agency (EPA). 1991. National Primary Drinking Water Regulations; Radionuclides; Proposed; Federal Register, July 18, 1991, pp. 33052-33127, Washington, D.C.

U.S. Environmental Protection Agency (EPA). 1994. Drinking Water Regulations and Health Advisories. EPA 822-R-94-001, Washington, D.C.

WSRC. 1999a. Aquatic Toxicity Reference Values (TRV's). Draft, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC.

WSRC. 1999b. Assessment and Measurement Endpoint Selection Process. Draft, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC.

WSRC. 1999c. Bioaccumulation and Bioconcentration Screening. Final, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC.

WSRC. 1999d. Ecological Constituents of Potential Concern Selection Process. Final, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC.

WSRC. 1999f. Terrestrial Toxicity Reference Values (TRV's). Final, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC.

Appendix A

Water Analytical Methods and Detection Limits for General Engineering/Environmental Physics and Recra Analytical/Thermo Nuclear

In the following tables of analytical methods and detection limits, the MDL column reports the matrix-specific method detection limit (MDL). The MDL takes into account the reagents, sample matrix, and preparation steps of a specific analytical method, and is defined as the minimum concentration that can be measured and reported with 99% confidence that the analyte concentration is greater than zero.

Table 1A. Water Analytical Methods and Detection Limits for GE.

Analyte (Specified Analyses)	Method	MDL	Units
Chloride	EPA300.0	7	µg/L
Cyanide	EPA335.3	3.34	µg/L
Hardness as CACO3	EPA130.2	1000	µg/L
Nitrate as nitrogen	EPA300.0	6	µg/L
Nitrate-nitrite as nitrogen	EPA353.1	7	µg/L
Metals (total recoverable)			
Aluminum	EPA6010A	37.6	µg/L
Antimony	EPA6010A	1.64	µg/L
Arsenic	EPA6010A	2.98	µg/L
Barium	EPA6010A	0.332	µg/L
Beryllium	EPA6010A	0.223	µg/L
Cadmium	EPA6010A	0.208	µg/L
Calcium	EPA6010A	15.4	µg/L
Chromium	EPA6010A	0.729	µg/L
Cobalt	EPA6010A	0.671	µg/L
Copper	EPA6010A	1.32	µg/L
Iron	EPA6010A	8.63	µg/L
Lead	EPA6010A	0.678	µg/L
Magnesium	EPA6010A	3.33	µg/L
Manganese	EPA6010A	0.903	µg/L
Mercury	EPA7470	0.104	µg/L
Nickel	EPA6010A	2.27	µg/L
Potassium	EPA6010A	5.87	µg/L
Selenium	EPA6010A	1.4	µg/L
Silver	EPA6010A	0.62	µg/L
Sodium	EPA6010A	29.1	µg/L
Thallium	EPA6010A	2.63	µg/L
Tin	EPA6010A	2.94	µg/L
Vanadium	EPA6010A	0.427	µg/L
Zinc	EPA6010A	0.966	µg/L

Table 2A. Water Analytical Methods and Detection Limits for Recra.

Analyte (Specified Analyses)	Method	MDL	Units
Chloride	EPA9056	21	µg/L
Cyanide	EPA9010A	1.52	µg/L
Hardness as CACO3	EPA130.2	960	µg/L
Nitrate as nitrogen	EPA353.2	2	µg/L
Nitrate-nitrite as nitrogen	EPA353.2	2	µg/L
Metals (total recoverable)			
Aluminum	EPA6010	14.6	µg/L
Antimony	EPA6010	2.7	µg/L
Arsenic	EPA6010	4	µg/L
Barium	EPA6010	0.18	µg/L
Beryllium	EPA6010	0.16	µg/L
Cadmium	EPA6010	0.47	µg/L
Calcium	EPA6010	47.1	µg/L
Chromium	EPA6010	0.7	µg/L
Cobalt	EPA6010	0.45	µg/L
Copper	EPA6010	1.5	µg/L
Iron	EPA6010	7.4	µg/L
Lead	EPA6010	4.7	µg/L
Magnesium	EPA6010	7.4	µg/L
Manganese	EPA6010	0.78	µg/L
Mercury	EPA7470	0.045	µg/L
Nickel	EPA6010	2.6	µg/L
Potassium	EPA6010	18.7	µg/L
Selenium	EPA6010	6.6	µg/L
Silver	EPA6010	0.5	µg/L
Sodium	EPA6010	28.5	µg/L
Thallium	EPA6010	5.5	µg/L
Tin	EPA6010	7	µg/L
Vanadium	EPA6010	0.69	µg/L
Zinc	EPA6010	5.3	µg/L

In the following tables of analytical methods and minimum detectable activities, the MDA column reports the mean matrix-specific minimum detectable activity. The MDA takes into account the reagents, sample matrix, and preparation steps of a specific analytical method, and is defined as the smallest quantity of a radionuclide that can be detected in a sample with a 95% confidence level.

Table 3A. Water Analytical Methods and Minimum Detectable Activities for EP.

Analyte Radionuclides	Method	MDA	Units
Actinium-228	EPIA-013	18.9	pCi/L
Americium-241	EPIA-011	0.132	pCi/L
Antimony-124	EPIA-013	4.99	pCi/L
Antimony-125	EPIA-013	11.1	pCi/L
Barium-133	EPIA-013	5.13	pCi/L
Cerium-144	EPIA-013	25.5	pCi/L
Cesium-134	EPIA-013	4.12	pCi/L
Cesium-137	EPIA-013	4.44	pCi/L
Cobalt-57	EPIA-013	3.23	pCi/L
Cobalt-58	EPIA-013	4.57	pCi/L
Cobalt-60	EPIA-013	4.76	pCi/L
Curium-242	EPIA-011	0.152	pCi/L
Curium-243/244	EPIA-011	0.145	pCi/L
Curium-245/246	EPIA-011	0.0613	pCi/L
Europium-152	EPIA-013	11.5	pCi/L
Europium-154	EPIA-013	12.7	pCi/L
Europium-155	EPIA-013	13.8	pCi/L
Gross alpha	EPIA-001	1.1	pCi/L
Iodine-129	EPIA-006	1.04	pCi/L
Lead-212	EPIA-013	7.89	pCi/L
Manganese-54	EPIA-013	4.32	pCi/L
Neptunium-237	EPIA-032	0.106	pCi/L
Neptunium-239	EPIA-013	23.9	pCi/L
Nickel-63	EPIA-022	242	pCi/L
Nonvolatile beta	EPIA-001	1.76	pCi/L
Potassium-40	EPIA-013	51.9	pCi/L
Promethium-144	EPIA-013	4.27	pCi/L
Promethium-146	EPIA-013	5.29	pCi/L
Radium-226	EPIA-008	0.486	pCi/L
Radium-228	EPIA-009	0.84	pCi/L
Ruthenium-106	EPIA-013	38.8	pCi/L
Sodium-22	EPIA-013	4.52	pCi/L
Tin-113	EPIA-013	5.42	pCi/L

Table 4A. Water Analytical Methods and Minimum Detectable Activities for TNU.

Analyte (Radionuclides)	Method	MDA	Units
Actinium-228	EPA901.1MOD	14.2	pCi/L
Antimony-124	EPA901.1MOD	4.85	pCi/L
Antimony-125	EPA901.1MOD	8.33	pCi/L
Barium-133	EPA901.1MOD	4.02	pCi/L
Cerium-144	EPA901.1MOD	17.2	pCi/L
Cesium-134	EPA901.1MOD	3.58	pCi/L
Cesium-137	EPA901.1MOD	3.92	pCi/L
Cobalt-57	EPA901.1MOD	2.27	pCi/L
Cobalt-58	EPA901.1MOD	4.48	pCi/L
Cobalt-60	EPA901.1MOD	3.67	pCi/L
Europium-152	EPA901.1MOD	27.6	pCi/L
Europium-154	EPA901.1MOD	12.1	pCi/L
Europium-155	EPA901.1MOD	6.99	pCi/L
Gross alpha	EPA900.0MOD	1.51	pCi/L
Iodine-129	EPA902.0MOD	10.5	pCi/L
Lead-212	EPA901.1MOD	4.95	pCi/L
Manganese-54	EPA901.1MOD	3.85	pCi/L
Nickel-63	3500NIEMOD	12.6	pCi/L
Nonvolatile beta	EPA900.0MOD	2.14	pCi/L
Potassium-40	EPA901.1MOD	37.3	pCi/L
Promethium-144	EPA901.1MOD	3.88	pCi/L
Promethium-146	EPA901.1MOD	6.17	pCi/L
Radium-228	EPA904.0MOD	6.76	pCi/L
Ruthenium-106	EPA901.1MOD	33.5	pCi/L
Sodium-22	EPA901.1MOD	4.36	pCi/L
Strontium-90	EMLSR02MOD	1.84	pCi/L
Tin-113	EPA901.1MOD	4.65	pCi/L
Tritium	EPA906.0MOD	0.623	pCi/mL
Yttrium-88	EPA901.1MOD	4.34	pCi/L
Zinc-65	EPA901.1MOD	7.59	pCi/L
Zirconium-95	EPA901.1MOD	8.72	pCi/L

Appendix B

1998 Non-Radionuclide comparisons: to region IV standards, to background concentrations, and to 1989 concentrations.

Table 1B. Constituents in surface water whose 95% UCI exceeded background measurements at one or more location along the F- and H-Area seeplines and FMB, 1992-1997*.

Sample Date	1992			Feb 1993			July 1993			1994			1996			1997		
Constituent	**F**	**H**	**FMB**	**F**	**H**	**FMB**	**F**	**H**	**FMB**	**F**	**H**	**FMB**	**F**	**H**	**FMB**	**F**	**H**	**FMB**
Alkalinity	X	X																
Aluminum		X		N	N	N	N	N	N			N		N	N			N
Ammonia as N				O	O	O	O	O	O			O		O	O			O
Antimony				N	N	N	N	N	N			N		N	N			N
Arsenic				E	E	E	E	E	E			E		E	E			E
Barium																		
Beryllium																		
Cadmium																		
Calcium	X	X								X								
Chloride																		
Chromium																		
Cobalt																		
Copper																	X	
Cyanide																		
Hardness																		
Iron																		
Lead																		
Magnesium													X			X	X	
Manganese	X																	
Mercury																		
Nickel				N	N	N	N	N	N			N		N	N			N
Nitrate				O	O	O	O	O	O			O		O	O			O
Nitrate/Nitrite				N	N	N	N	N	N			N		N	N			N
Potassium				E	E	E	E	E	E			E		E	E			E
Selenium																		
Silver																		
Sodium		X									X							
Thallium																		
Tin																		
Vanadium																		
Zinc																		

***Note: This comparison was not made for April 1998 due to the insufficient sample size.**

Table 2B. Constituents in surface water whose 95% UCI exceeded PDWS, SDWS, or MCL at one or more location along the F- and H-Area seeplines and FMB, 1989-1998.

Sample Date	1989			1992			Feb 1993			July 1993			1994			1996			1997			1998		
Constituent	**F**	**H**	**FMB**	**F**	**H**	**FMB**	**F**	**H**	**FHB**	**F**	**H**	**FMB**	**F**	**H**	**FMB**	**F**	**H**	**FMB**	**F**	**H**	**FMB**	**F**	**H**	**FMB**
Aluminum																			X	X	X	X	X	X
Ammonia as N			N			N												N						
Antimony			O			O												O						
Arsenic			N			N												N						
Barium			E			E												E						
Beryllium																								
Cadmium	X						X				X	X	X	X	X				X					
Chloride																						X	X	X
Chromium																								
Cobalt																								
Copper																								
Cyanide																								
Hardness																								
Iron																						X	X	X
Lead																								
Magnesium																								
Manganese																			X	X	X	X		
Mercury																								
Nickel																								
Nitrate	X	X		X	X		X				X		X	X		X	X					X	X	
Nitrate/Nitrite			N			N												N						
Potassium			O			O												O						
Selenium			N			N												N						
Silver			E			E												E						
Sodium																								
Thallium																								
Tin																								
Vanadium																								
Zinc																								

Table 3B. Constituents in surface water whose 95% UCI exceeded 1989 measurements at one or more location along the F- and H-Area seeplines and FMB, 1989-1998.

Sample Date	1992			Feb 1993			July 1993			1994			1996			1997			1998		
Constituent	**F**	**H**	**FMB**	**F**	**H**	**FMB**				**F**	**H**	**FMB**	**F**	**H**	**FMB**	**F**	**H**	**FMB**	**F**	**H**	**FMB**
Alkalinity			X																		
Aluminum	X	X		X	X	X					N		X		X		X	N	X	X	N
Ammonia as N											O							O			O
Antimony											N							N			N
Arsenic											E							E			E
Barium																					
Beryllium																					
Cadmium				X						X			X								
Chloride	X	X	X	X	X					X									X	X	
Chromium																					
Cobalt																					
Copper				X						X											
Cyanide																					
Hardness				X																	
Iron																					
Lead																					
Magnesium		X								X											
Manganese																					
Mercury	X	X	X																		
Nickel																					
Nitrate											N							N			N
Nitrate/Nitrite											O							O			O
Potassium											N							N			N
Selenium											E							E			E
Silver																					
Sodium		X	X		X							X			X						
Thallium																					
Tin																					
Vanadium																					
Zinc		X			X					X						X					

Appendix C

1998 Radionuclide comparisons: to region IV standards, to background concentrations and to 1989 concentrations.

Table 1C. Radionuclides, alpha and beta emitters in surface water whose 95% UCI exceeded background measurements at one or more location along the F- and H-Area seeplines and FMB, 1989-1997.

Sample Date	1992			Feb 1993			July 1993			1994			1996			1997		
Constituent	F	H	FMB	F	H	FMB	F	H	FMB	F	H	FMB	F	H	FMB	F	H	FMB
Americium-249																		
Cecium-137																	N	
Cobalt-60														X			O	
Gross alpha														X		X	N	
Iodine-129																	E	
Nonvolatile beta							X						X	X				
Radium-226		X																
Radium-228				X														
Strontium-89																		
Strontium-90																		
Technicium-99																		
Tritium	X	X		X	X		X	X		X	X							
Uranium-233/234																		
Uranium 238																		

Note: FMB is N/A for this table since the comparison was not made.

Table 2C. Radionuclides, alpha and beta emitters in surface water whose 95% UCI exceeded PDWS, SDWS, or MCL at one or more location along the F- and H-Area seeplines and FMB, 1989-1998.

Sample Date	1989			1992			Feb 1993			July 1993			1994			1996			1997			1998		
Constituent	F	H	FMB	F	H	FMB	F	H	FMB	f	H	FMB	F	H	FMB	F	H	FMB	F	H	FMB	F	H	FMB
Americium-249	X																							
Cecium-137												N												
Cobalt-60												O												
Gross alpha	X	X			X							N								X		X	X	
Iodine-129	X			X	X	X						E										X	X	
Nonvolatile beta	X	X	X	X	X	X							X						X	X		X	X	
Radium-226	X	X																						
Radium-228				X	X	X	X																	
Strontium-89	X	X																						
Strontium-90	X	X		X	X	X													X	X				
Technicium-99																								
Tritium	X	X	X	X	X	X	X				X		X	X		X	X	X	X	X	X	X	X	X
Uranium-233/234	X																							
Uranium 238	X																							

Table 3C. Radionuclides, alpha and beta emitters in surface water whose 95% UCI exceeded 1992 measurements at one or more location along the F- and H-Area seeplines and FMB, 1992-1998.

Sample Date	1992			Feb 1993			July 1993			1994			1996			1997			1998		
Constituent	F	H	FMB	F	H	FMB	F	H	FMB	F	H	FMB	F	H	FMB	F	H	FMB	F	H	FMB
Americium-249																					
Cecium-137			X		N				X	N	N	N		N	N	N	N	X		N	N
Cobalt-60					O					O	O	O		O	O	O	O			O	O
Gross alpha				X	N					N	N	N	X	N	N	N	N			N	N
Iodine-129	X	X			E		X			E	E	E		E	E	E	E			E	E
Neptunium-237						X															
Nonvolatile beta																					
Radium-226			X																		
Radium-228																					
Strontium-89																					
Strontium-90			X			X			X												
Technicium-99																					
Tritium																					
Uranium-233/234																					
Uranium 238																			X		