7 GROUNDWATER MANAGEMENT PROGRAM

The groundwater management program at the Savannah River Site (SRS) achieves the following objectives:

- Ensuring future groundwater contamination does not occur,
- Monitoring groundwater to identify areas of contamination,
- Remediating groundwater contamination as needed, and
- Conserving groundwater.

This chapter describes the site-wide programs in place at the SRS for protecting, monitoring, remediating, and using groundwater.

2015 Highlights

Drinking Water Standards

The 2015 data show no exceedances of drinking water standards (maximum contaminant limit [MCLs] or regional screening levels [RSLs]) in the SRS Boundary wells near A/M Area.

Removal of Groundwater Contaminants

In 2015, SRS removed 8,775 lbs of volatile organic compounds (VOCs) from groundwater and the vadose zone, and prevented 113 curies of tritium from reaching SRS streams.

Offsite Groundwater Monitoring (GA)

For more than 15 years, detections of tritium in Georgia groundwater monitoring wells have been well below the MCL for tritium (20 pCi/mL). This data supports the conclusions drawn from a groundwater model developed by the U.S. Geological Survey (USGS) that indicates there is no mechanism by which groundwater could flow under the Savannah River and contaminate Georgia wells (Cherry 2006).

7.1 INTRODUCTION

In the past, some Savannah River Site (SRS) operations released chemicals and radionuclides into the soil and contaminated the groundwater around hazardous waste management facilities and waste disposal sites. Because of these past releases, SRS operates extensive groundwater monitoring and groundwater remediation programs.

The SRS groundwater monitoring program consists of wells for sampling and monitoring groundwater contaminants. Wells are monitored regularly to meet sampling requirements in the Federal Facility Agreement (FFA) for the Savannah River Site (FFA 1993) approved monitoring plans and Resource Conservation and Recovery Act (RCRA) permits. SRS uses laboratories certified by the South Carolina Department of Health and Environmental Control (SCDHEC) to analyze groundwater samples.

Chapter 7 Key Terms

Aquifer *is an underground water supply – one found in porous rock, sand, gravel, etc.*

Attenuation *is a reduction of groundwater contaminants over time due to naturally occurring physical, chemical, and biological processes.*

Confining unit *is the opposite of an aquifer. It is a layer of rock or sand that limits the movement of groundwater in and out of an aquifer.*

Contaminants of Concern *are contaminants found at the unit that have undergone detailed analysis and have been found to present a potential threat to human health and the environment.*

Groundwater *is water found underground in cracks and spaces in soil, sand, and rocks.*

Maximum Contaminant Level (MCL) *is the highest level of a contaminant allowed in drinking water.*

Plume *is a volume of contaminated water originating at a waste source (e.g., a hazardous waste disposal site). It extends downward and outward from the waste source.*

Regional Screening Level (RSL) *is the risk-based concentration derived from standardized equations combining exposure assumptions with toxicity data.*

Remediation *is the assessment and cleanup of sites contaminated with waste due to historical activities.*

Surface water *is water found above ground (e.g. streams, lakes, wetlands, reservoirs, and oceans).*

Waste unit *refers to a particular area that is, or may be, posing a threat to human health or the environment. They range in size from a few square feet to tens of acres and include basins, pits, piles, burial grounds, landfills, tank farms, disposal facilities, process facilities, and groundwater contamination.*

The monitoring data show that the majority of contaminated groundwater is located in the central areas of the SRS, and does not extend beyond the SRS boundary. Groundwater contamination at the SRS is primarily limited to the Upper Three Runs/Steed Pond Aquifers and the Gordon/Lost Lake Aquifers (Figure 7-1). SRS submits summaries of groundwater data to regulatory agencies and, if necessary, takes appropriate action (i.e., remediation or removal activities).

SRS uses several technologies to remediate groundwater that exceeds the maximum contaminant levels [MCLs] or the regional screening levels [RSLs]). Remediation strategies include closing waste units to reduce the potential for contaminants to reach groundwater, actively treating contaminated water, and employing passive and natural (attenuation) groundwater remedies. The U.S. Department of Energy (DOE) and the regulatory agencies must agree on the appropriate final disposition of the waste units.

Major groundwater remediation activities at SRS focus on volatile organic compounds (VOCs) and tritium. VOCs in groundwater, mainly trichloroethylene (TCE) and tetrachloroethylene (PCE), originated from use as degreasing agents in industrial operations at SRS. Tritium in groundwater stemmed from reactor operations, which ceased in 1991. Examples of SRS groundwater corrective action operations include surface water management and using trees and plants to remove or break down contaminants (phytoremediation). These operations are successfully removing VOCs from the groundwater and effectively reducing tritium releases into SRS streams and the Savannah River.

7.2 GROUNDWATER AT SRS

The groundwater flow system at SRS consists of four major aquifers separated by confining units: Upper Three Runs/Steed Pond, Gordon/Lost Lake, Crouch Branch, and McQueen Branch. Groundwater flow in recharge areas generally migrates downward and laterally. It eventually flows into the Savannah River and its tributaries, or migrates into the deeper regional flow system. Figure 7-1 is a three-dimensional block diagram of these units at SRS and the generalized groundwater flow patterns within those units.

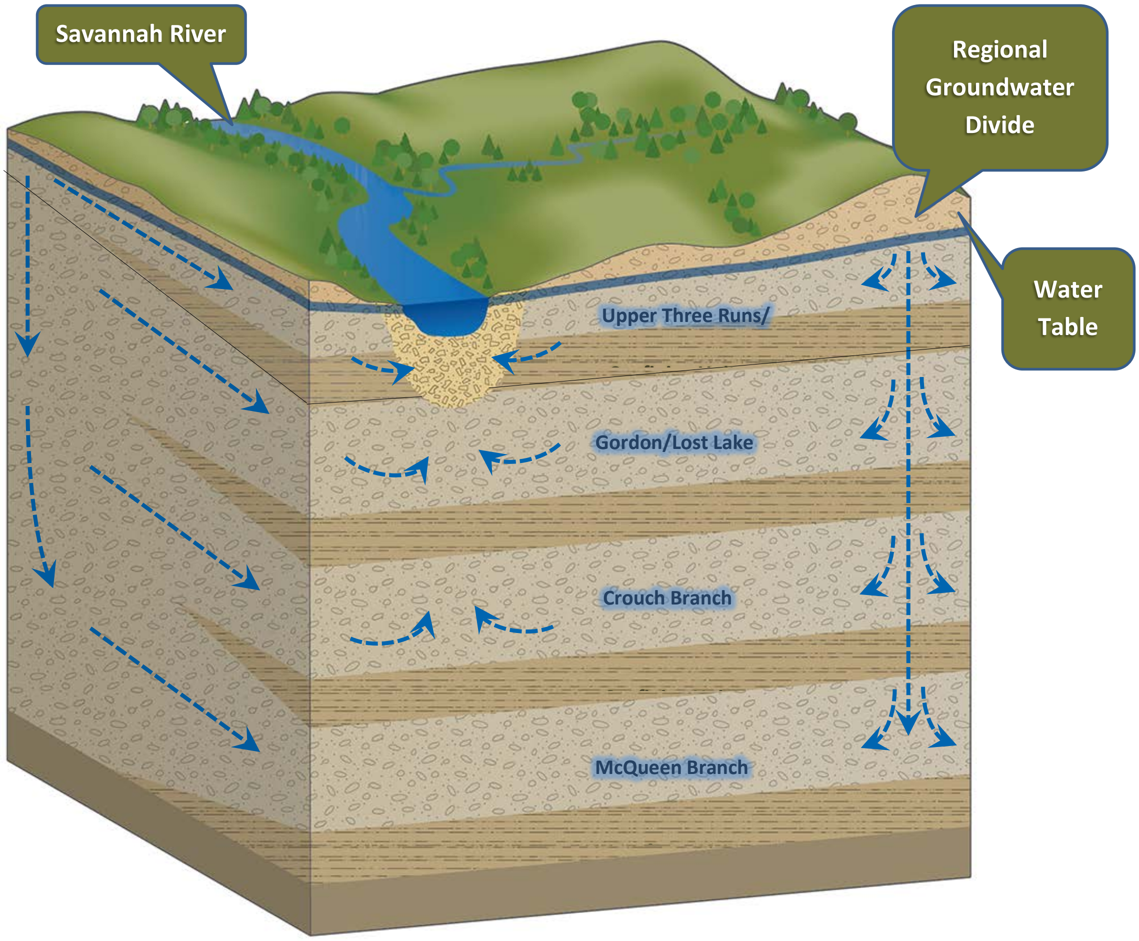

Figure 7-1 Groundwater at SRS

7.3 GROUNDWATER PROTECTION PROGRAM AT SRS

SRS has designed and implemented a groundwater protection program to prevent any new releases to groundwater, and remediate groundwater contamination to meet federal and state laws and regulations, DOE orders, and SRS policies and procedures. It contains the following elements:

- Protecting SRS groundwater,
- Monitoring SRS groundwater,
- Remediating contaminated SRS groundwater, and
- Conserving SRS groundwater.

7.3.1 Protecting SRS Groundwater

SRS groundwater-related activities focus on preventing and monitoring groundwater contamination, protecting the public and environment from contamination, and protecting groundwater quality for future use. Groundwater protection is performed through the following activities:

- Preventing or controlling groundwater contamination sources from construction sites, hazardous waste management facilities, and waste units;
- Monitoring groundwater and surface water to detect contaminants; and
- Reducing contaminants via a groundwater cleanup program.

7.3.2 Monitoring SRS Groundwater

The purpose of monitoring groundwater is to observe and evaluate the changes in the groundwater quality over time, and to establish, as accurately as possible, the baseline quality of the groundwater occurring naturally in the aquifers. The SRS groundwater monitoring program includes two primary components: groundwater contaminant source monitoring, and groundwater surveillance monitoring. SRS evaluates groundwater-monitoring data frequently to identify whether new groundwater contamination exists or if current monitoring programs require modification in order to maintain an optimal monitoring program.

SRS uses groundwater monitoring data to determine the effects of Site operations on groundwater quality. The program supports several critical activities:

- Compliance with environmental regulations and DOE directives,
- Evaluation of the current status of groundwater plumes,
- Evaluation of the suitability of a new facility being located near or within the groundwater plume footprint, and
- Basic and applied research projects to enhance groundwater remediation.

The movement of water from the ground's surface into the aquifers can carry contamination along with it, resulting in underground plumes of contaminated water (Figure 7-2). Monitoring the groundwater around SRS facilities and known waste disposal sites and associated surface waters is the best way to detect and track contaminant migration. Through careful monitoring and analysis, SRS implements appropriate remedial or corrective actions. Figure 7-3 shows the groundwater plumes associated with SRS.

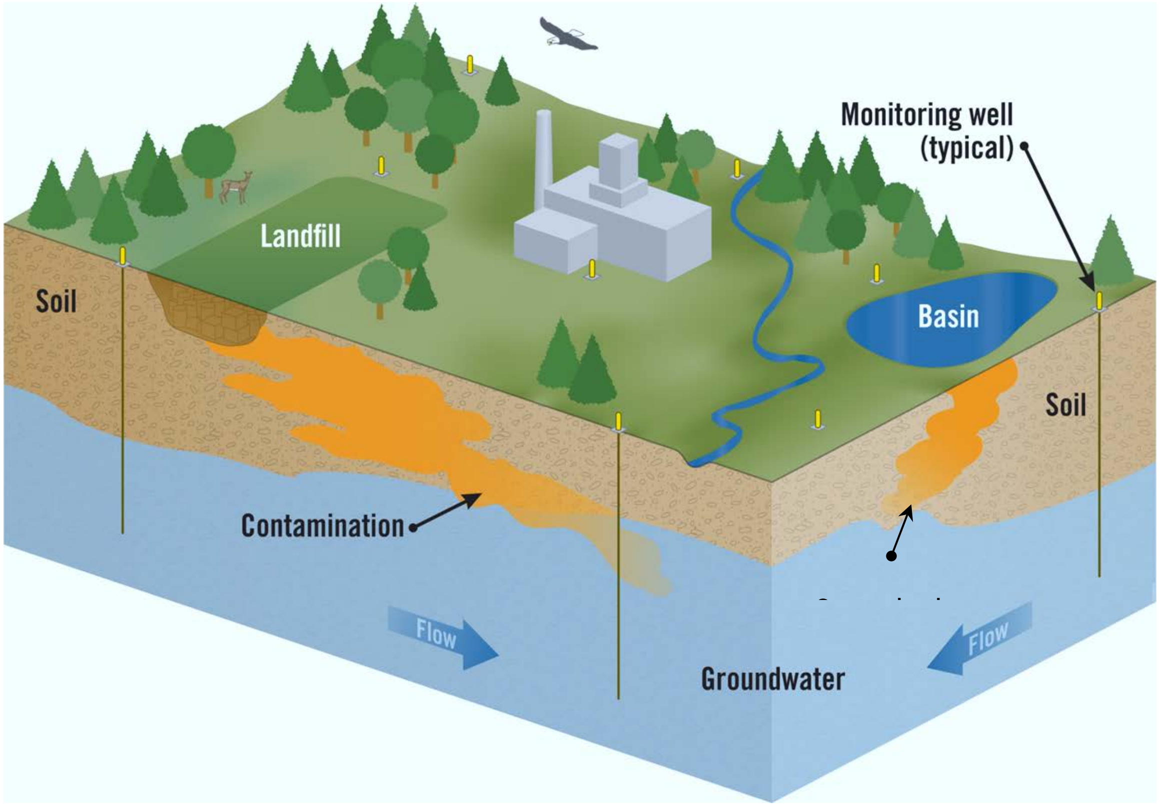

Figure 7-2 How Contamination Gets to Soil and Groundwater

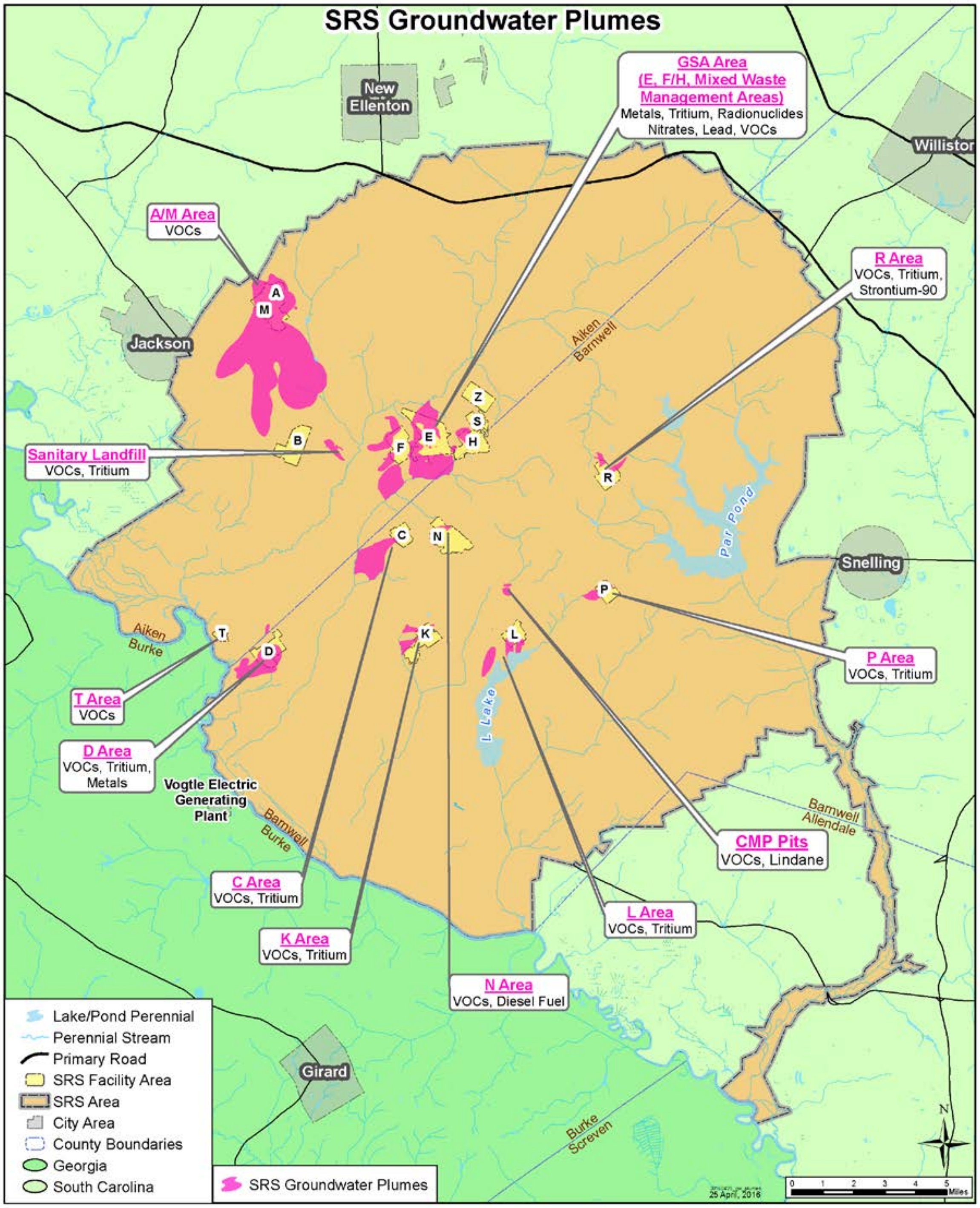

Figure 7-3 Groundwater Plumes at SRS

7.3.2.1 Groundwater Surveillance Monitoring

Surveillance monitoring efforts at SRS focus on the collection and analysis of data to characterize the groundwater flow and the presence or absence of contaminants. Characterization efforts at SRS include the following activities:

- Collecting soil and groundwater samples to determine the extent of contamination;
- Obtaining geologic soil cores or seismic profiles to better determine underground structural features, as warranted;
- Installing wells for periodic collection of water-level measurements and groundwater samples;
- Developing maps to help define groundwater flow;
- Performing calculations based on water elevation data in order to estimate groundwater velocities;
- Analyzing regional groundwater to provide a comprehensive understanding of SRS groundwater movement, and specifically the transport of contaminants near facilities and individual waste units; and
- Characterizing regional surface water flow to assess contaminant risk to perennial streams, which are the receptors of groundwater flow.

7.3.2.2 2015 Groundwater Data Summary

A significant plume exists beneath A/M Areas. SRS uses more than 150 wells to monitor this plume. Some of these monitoring wells lie within a half-mile of the northwestern boundary of SRS. The direction of groundwater flow in the area parallels the Site boundary; however, groundwater flow direction can fluctuate. Because of this pattern, SRS pays particular attention to the groundwater results from these wells located along the Site boundary, as well as between the A/M Areas and the nearest population center, Jackson, South Carolina (Figure 7-4). The 2015 data show no exceedances of drinking water standards (MCLs or RSLs) in the SRS Boundary Wells near A/M Area. In the majority of these SRS boundary wells, no detectable contamination exists.

Although most of the SRS contaminated groundwater plumes do not approach the Site boundary, the potential to affect Site streams does exist when contaminated groundwater flows into nearby streams. SRS monitors and evaluates groundwater contamination that flows into Site streams, and remediates as appropriate. In conjunction with stream monitoring, SRS conducts extensive monitoring near SRS waste units and operating facilities, regardless of their proximity to the boundary. Details concerning groundwater monitoring and conditions at individual sites can be found in the *Savannah River Site Groundwater Management Strategy and Implementation Plan* (SRNS 2011) and the *Environmental Monitoring Program Management Plan*, SRS Manual 3Q1, Procedure 101, Revision 7 (SRS EM Plan 2015).

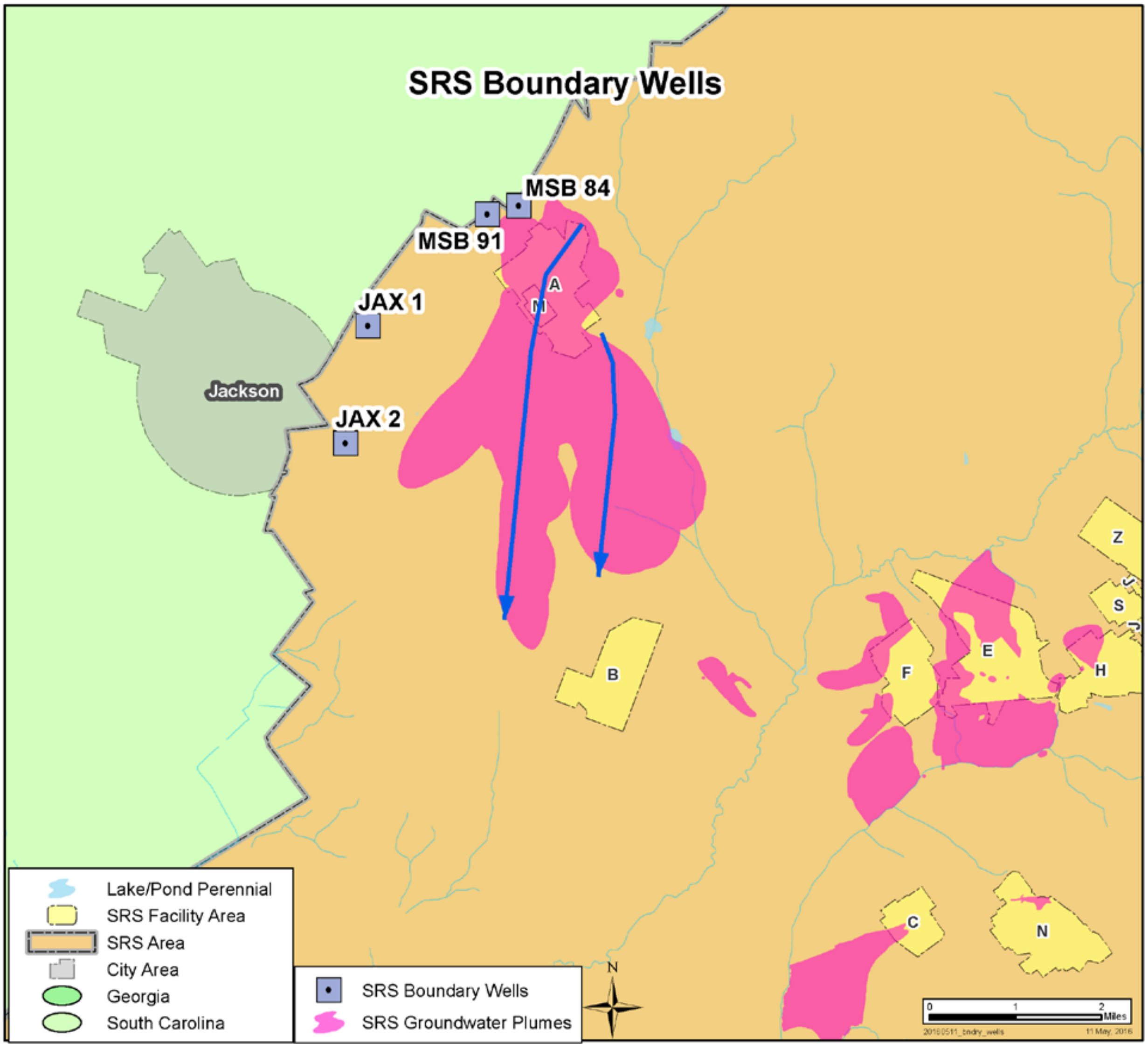

Figure 7-4 Location of Site Boundary Wells at SRS - Between A/M Areas and Jackson, South Carolina

Table 7-1 identifies the typical contaminants of concern (COCs) found in SRS groundwater and their significance. These COCs are a result of SRS operations that released chemicals and radionuclides into the soil and groundwater around hazardous waste management facilities and waste disposal sites. Table 7-2 presents a general summary of the most common contaminants found in groundwater at SRS facility areas, based on 2015 monitoring data, and compares the maximum concentrations to the appropriate drinking water standards. As shown in Table 7-2, major COCs in the groundwater include common degreasers (TCE and PCE) and radionuclides (tritium, gross alpha, and nonvolatile beta emitters).

Since the early 1990s, SRS has directed considerable effort toward assessing the likelihood of flow beneath the Savannah River from South Carolina to Georgia. A groundwater model developed by the U.S. Geological Survey (USGS) indicates there is no mechanism by which groundwater could flow under the Savannah River and contaminate Georgia wells (Cherry 2006). SRS continues to monitor for tritium in groundwater

Table 7-1 Typical Contaminants of Concern at SRS

Contaminants	Sources	Limits and Exposure Pathways
Gross Alpha	Alpha radiation is the emission of positively charged particles from the disintegration (radioactive decay) of certain elements including uranium, thorium, and radium. Alpha radiation in drinking water can be in the form of dissolved minerals, or in the case of radon, as a gas.	MCL is 15 pCi/L. An alpha particle cannot penetrate a piece of paper or human skin. Causes increased risk of cancer through ingestion or inhalation.
Nonvolatile Beta	Beta decay commonly occurs among neutron-rich fission byproducts produced in nuclear reactors.	MCL for beta particles is 4 mrem/yr. Causes increased risk of cancer through ingestion, inhalation, or dermal exposure.
Tritium	Radioactive isotope of hydrogen with a half-life of 12.3 years. It emits a very weak beta particle and behaves like water.	MCL is 20 pCi/mL. It primarily enters the body when people swallow tritiated water. Causes increased risk of cancer through ingestion, inhalation or dermal exposure.
TCE/PCE	VOCs used primarily to remove grease from fabricated metal parts.	MCL is 5 µg/L. Causes increased risk of cancer through ingestion, inhalation, or dermal exposure.
Vinyl Chloride	VOC; degradation product of TCE/PCE.	MCL is 2 µg/L. Causes increased risk of cancer through ingestion, inhalation, or dermal exposure.
1,4-Dioxane	Synthetic industrial chemical used as a stabilizer for VOCs to reduce degradation	RSL for Tap Water is 0.46 µg/L. Causes increased risk of cancer through ingestion, inhalation, or dermal exposure.

Table 7-2 Summary of the Maximum Contaminant Concentrations for Major Areas within SRS

Location	Major Contaminant	Units	2015 Maximum Concentration	Well	MCL or RSL	Likely Stream Endpoints
A/M Area	Tetrachloroethylene	µg/L	99,000	MSB002BR	5	Tims Branch/Upper Three Runs in Swamp in West
	Trichloroethylene	µg/L	35,000	MSB107B	5	
	1,4-Dioxane	µg/L	300	ARP 1A	6.1[c]	
C Area	Tetrachloroethylene	µg/L	7.1	CRP 5C	5	Fourmile Branch and Castor Creek
	Trichloroethylene	µg/L	321	CRW020D	5	
	Vinyl chloride	µg/L	209	CRP 50B	2	
	cis-1,2-Dichloroethne	µg/L	181	CRP 50B	70	
	Tritium	pCi/mL	3,500	CTA003D	20	
CMP Pits (G Area)	Tetrachloroethylene	µg/L	483	CMP 45D	5	Pen Branch
	Trichloroethylene	µg/L	263	CMP 10C	5	
	1,4-Dioxane	µg/L	80	CMP 11D	0.46	
	Lindane	µg/L	4.88	CMP 35D	0.2	
D Area	Tetrachloroethylene	µg/L	16	DOB 11	5	Savannah River Swamp
	Trichloroethylene	µg/L	237	DCB 62	5	
	Vinyl Chloride	µg/L	19	DOB 15	2	
	Tritium	pCi/mL	274	DCB 26AR	20	
E-Area MWMF	Trichloroethylene	µg/L	280	BSW 4D2	5	Upper Three Runs/ Crouch Branch in North; Fourmile Branch in South
	1,4-Dioxane	µg/L	700	BSW 6C3	6.1[c]	
	Tritium	pCi/mL	19,200	BSW 8C1	20	
	Gross Alpha	pCi/L	26.2	BSW 3D2	15	
	Nonvolatile Beta	pCi/L	71.1	HSP-097A	50[a]	

Location	Major Contaminant	Units	2015 Maximum Concentration	Well	MCL or RSL	Likely Stream Endpoints
F-Area HWMF	Trichloroethylene	µg/L	16.3	FSB 95CR	5	Fourmile Branch
	Tritium	pCi/mL	1,990	FSB 94C	20	
	Gross Alpha	pCi/L	388	FSB 94C	15	
	Nonvolatile Beta	pCi/L	1,190	FSB 95DR	50[a]	
F-Area Tank Farm	Tritium	pCi/mL	16.7	FTF030D	20	Fourmile Branch / Upper Three Runs
	Nonvolatile Beta	pCi/L	827	FTF 28	50[a]	
	Manganese	µg/L	395	FTF009R	430	
H Area	Trichloroethylene	µg/L	4.3	HGW 3D	5	Upper Three Runs/Crouch Branch in North; Fourmile Branch in South
	Gross Alpha	pCi/L	12.9	HR3 16DU	15	
	Nonvolatile Beta	pCi/L	50.4	HAA 12A	50[a]	
	Tritium	pCi/mL	29.6	HGW2D	20	
H-Area HWMF	Trichloroethylene	µg/L	86.5	HSB120C	5	Fourmile Branch
	Tritium	pCi/mL	1,650	HSB113DR	20	
	Gross Alpha	pCi/L	78.7	HSB102D	15	
	Nonvolatile Beta	pCi/L	1,080	HSB102D	50[a]	
H-Area Tank Farm	Tritium	pCi/mL	67.4	HAA 12C	20	Fourmile Branch / Upper Three Runs
	Gross Alpha	pCi/L	7.6	HAA 4D	15	
	Manganese	µg/L	539	HAA017C	430	
K Area	Tetrachloroethylene	µg/L	5.4	KRP 9	5	Indian Grave Branch
	Trichloroethylene	µg/L	5.5	KRP 9	5	
	Tritium	pCi/mL	5,420	KRB 19D	20	
L Area	Tetrachloroethylene	µg/L	56	LSW 25DL	5	L-Lake
	Trichloroethylene	µg/L	4	LSW030DL	5	
	Tritium	pCi/mL	645	LSW 25DL	20	
P Area	Trichloroethylene	µg/L	7,100	PGW025B	5	Steel Creek
	Tritium	pCi/mL	16,200	PSB002C	20	
R Area	Trichloroethylene	µg/L	13.2	RAG008B	5	Mill Creek in Northwest; Tributaries of PAR Pond
	Tritium	pCi/mL	575	RPS004C	20	
	1,4 Dioxane	µg/L	3.3	RPS004C	0.46	
	Strontium-90[b]	pCi/L	111	RSE 10	8	
Sanitary Landfill	1,4-Dioxane	µg/L	201	LFW 62C	6.1[c]	Upper Three Runs
	Trichloroethylene	µg/L	7.7	LFW 32	5	
	Mercury	µg/L	3.4	LFW 44D	2	
TNX	Trichloroethylene	µg/L	113	TBG 3	5	Savannah River Swamp
Z Area	Technetium-99	pCi/L	238	ZBG 2	50[a]	Upper Three Runs
	Nonvolatile Beta	pCi/L	158	ZBG 2	50[a]	
	Gross Alpha	pCi/L	23.3	ZBG002D	15	
	Nitrate-Nitrite as Nitrogen	mg/L	9.9	ZBG 2	10	

a The MCL for nonvolatile beta activity (pCi/L or pCi/mL) equivalent to 4 mrem/yr varies according to which specific beta emitters are present in the sample. At SRS this value equates to 50 pCi/L.

b At R Area, strontium-90 is sampled for every five years per agreement with state and federal regulators.

C RCRA Permitted Groundwater Protection Standard (GWPS) for 1,4-Dioxane

Note: MWMF is the Mixed Waste Management Facility; HWMF is the Hazardous Waste Management Facility; TNX is the 678-T facilities, CMP is the Chemicals, Metals and Pesticides Pits wells in Georgia (Figure 7-5) by collecting samples annually during the second half of the year. Detections of tritium in groundwater in these Georgia offsite wells have been below 1.5 pCi/mL since 1999 (Figure 7-6). The MCL, or drinking water standard, for tritium is 20 pCi/mL. The results are consistent with aquifer recharge from rainfall in the Central Savannah River Area. The overall groundwater data trend continues to show a gradual decline in the levels of tritium in the Georgia wells.

SRS collected groundwater samples from 40 of the 44 offsite wells in Georgia during 2015. Three wells could not be sampled because they were dry (i.e., no water available) and one well could not be sampled due to damage to the well casing. All samples collected in 2015 had no detectable concentrations of tritium.

7.3.3 Remediating SRS Groundwater

SRS's environmental remediation program has been in place for more than 20 years. The remediation and monitoring of contaminated groundwater is regulated under RCRA and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as specified in the Federal Facility Agreement (FFA) for the Savannah River Site (FFA 1993). The remediation efforts focus on removing mass, reducing contaminant levels, and reducing exposure to humans and the environment for those contaminants that exceed either MCLs or RSLs as identified in Table 7-2.

For each remediation project, SRS determines the degree and extent of groundwater contamination through characterization. After completing characterization, SRS and the regulatory agencies decide upon a strategy for remediating the groundwater.

SRS often applies remedial actions to the groundwater contamination source. For instance, soil vapor extraction (pulling contaminated soil vapor from the vadose zone), is widely used at SRS to remove VOCs from the unsaturated (vadose) zone above the water table.

SRS implements several groundwater remedial technologies. These technologies manage the rate of contaminant movement and reduce contaminant exposure risk to human health and ecological receptors. Thirty-seven remediation systems are currently operating. Eighteen groundwater treatment systems are no longer in use. In 2015, SRS removed 8,775 lbs of VOCs from the groundwater and the vadose zone, and prevented 113 curies of tritium from reaching SRS streams (SRNS 2016b). SRS has worked to reduce the tritium flux to Fourmile Branch for over two decades. Since 2000, SRS has reduced the tritium flux to Fourmile Branch by almost 70% using groundwater remedial technologies (subsurface barriers and water capture with irrigation). The largest reductions are associated with the MWMF Phytoremediation Project which reduced the release to the Branch by approximately 113 Curies in 2015. Overall, the size, shape, and volume of most SRS groundwater plumes are shrinking since the majority of the contaminant sources have remediation systems in place. You will find additional information concerning the SRS remediation systems in the *Soil and Groundwater Closure Projects Technology Descriptions* (WSRC 2007).

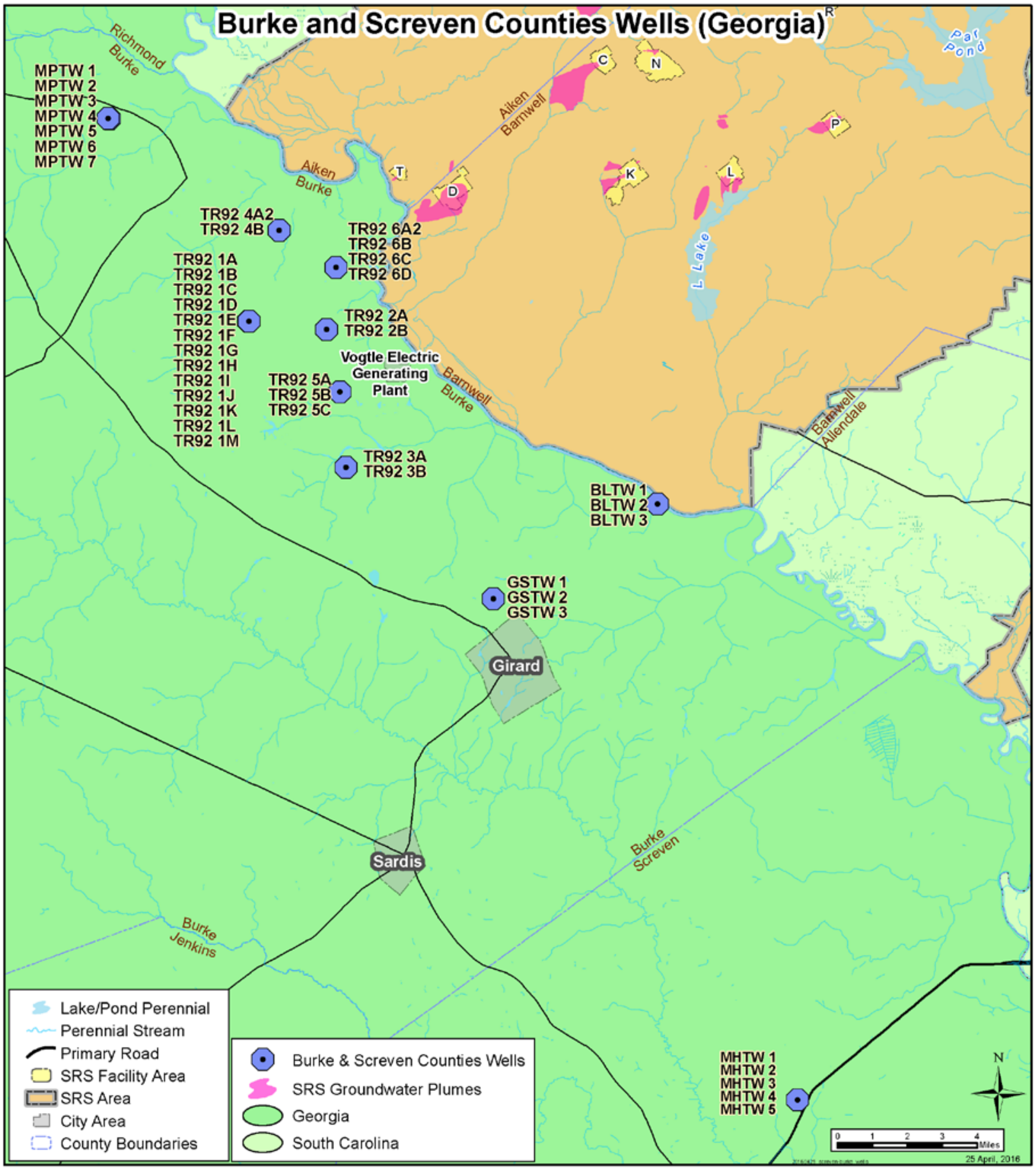

Figure 7-5 Location of Monitoring Wells Sampled for Tritium in Burke and Screven Counties, Georgia

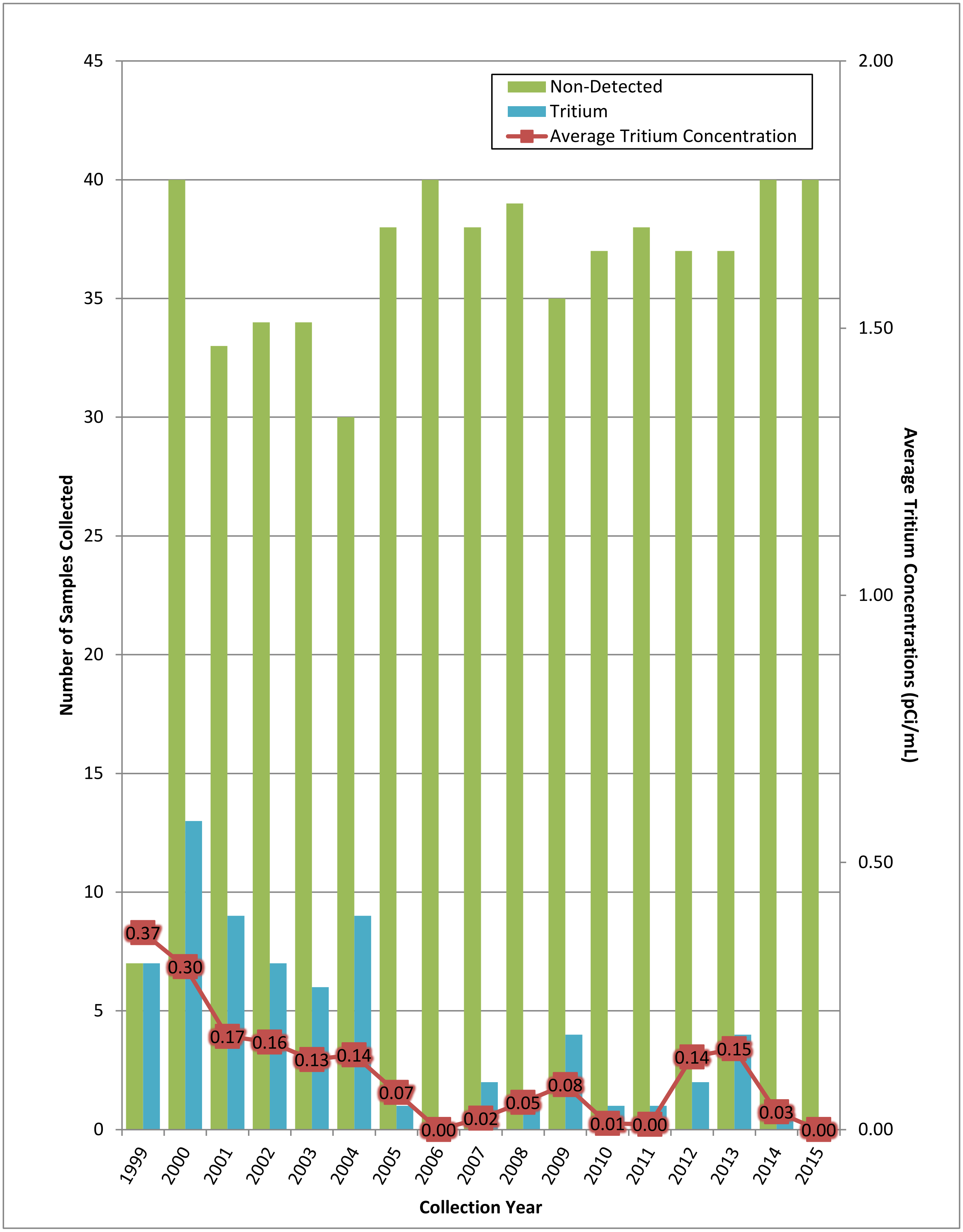

Figure 7-6 Tritium Concentration in Wells Sampled in Burke and Screven Counties, Georgia

7.3.4 Conserving SRS Groundwater

As in the past, SRS continues to report its drinking and process water usage to SCDHEC. In 2015, SRS used 2.65 million gallons of water per day. You will find information on SRS water conservation efforts in Chapter 2, "Environmental Management System."

SRS manages its own drinking and process water supply from groundwater located beneath the SRS. Approximately 40 production wells in widely scattered locations across the Site supply SRS domestic and process water systems. Eight of these wells are domestic water systems that supply drinking water. The other 32 wells provide water for all SRS facility operations. A map of the SRS domestic water system can be found under the "Environmental Maps" heading on the *SRS Environmental Report for 2015* webpage.

The A-Area domestic water system now supplies treated water to most Site areas. The system is comprised of a treatment plant, distribution piping, elevated storage tanks, and a well network. The wells range in capacity from 200 to 1,500 gallons per minute. Remote facilities, such as field laboratories, barricades, and pump houses, utilize small drinking water systems and bottled water. The SRS domestic water systems meet state and federal drinking water quality standards. SCDHEC samples the systems quarterly for chemical analyses. Monitoring the A-Area water system for bacteria occurs monthly. SCDHEC performs sanitary surveys every two years on the A-Area system and inspects the smaller systems every three years. All 2015 water samples complied with SCDHEC and EPA water quality standards.

The process water systems are located in A, F, H, and S Areas. These systems meet the SRS demands for boiler feedwater; equipment cooling water; facility washdown water; and makeup water for cooling towers, fire storage tanks, chilled-water-piping loops, and Site test facilities. Process water wells ranging in capacity from 100 to 1,500 gallons per minute supply water to these systems. In K Area, L Area, and Z Areas, the domestic water system supplies the process water system. At some locations, the process water wells pump to ground level storage tanks, where SRS implements corrosion control measures. At other locations, the wells directly pressurize the process water distribution piping system without supplemental treatment.