The Brookhaven National Laboratory Groundwater Protection Management Program is made up of four elements: prevention, monitoring, restoration, and communication. In addition to implementing aggressive pollution prevention measures to protect groundwater resources, BNL has established an extensive groundwater monitoring well network to verify that prevention and restoration activities are effective. In 2000, BNL collected groundwater samples from 683 monitoring wells during 2,530 individual sampling events. Six volatile organic compound plumes and eight radionuclide plumes were tracked. During 2000, five onsite and one offsite groundwater remediation systems removed approximately 700 pounds (318 kg) of volatile organic compounds and returned approximately one billion gallons (3.8 billion liters) of treated water to the Upper Glacial aquifer.

Chapter 7

Groundwater Protection

7.1 THE BNL GROUNDWATER PROTECTION MANAGEMENT PROGRAM

U.S. Department of Energy (DOE) Order 5400.1 (1988), *General Environmental Protection Program,* requires development and implementation of a groundwater protection program. The primary goal of the BNL Groundwater Protection Management Program is to ensure that plans for groundwater protection, management, monitoring, and restoration are fully defined, integrated, and managed in a cost-effective manner that is consistent with federal, state, and local regulations. This program is described in the *BNL Groundwater Protection Program Description* document (Paquette *et al.* 1998). The BNL Groundwater Protection Program consists of four interconnecting elements: (1) preventing pollution of the groundwater, (2) monitoring the effectiveness of engineered/administrative controls at operating facilities, and groundwater treatment systems, (3) restoration of the environment by cleaning up contaminated soil and groundwater, and (4) communicating with interested parties on groundwater protection issues (Figure 7-1). BNL's goal is to identify, track, and remediate, as necessary, existing contamination and ensure that new contamination does not occur.

Figure 7-1. Elements of BNL's Groundwater Program.

♦ *Prevention*

BNL has conducted a three-phased project to: (1) identify past or current activities with the potential to affect environmental quality, (2) conduct a Laboratory-wide review of all experiments and industrial-type operations to determine the potential impacts of those activities on the environment and to integrate pollution prevention/waste minimization, resource conservation, and compliance into planning, decision-making, and implementation, and (3) develop and implement an Environmental Management System. These activities are designed to prevent further pollution of the sole source aquifer underlying the BNL site, and are described in Chapter 2. In addition, as described in Chapter 3, efforts are being made to achieve or maintain compliance with regulatory requirements and to implement best management practices designed to protect groundwater. Examples include upgrading underground storage tanks, closing cesspools, adding engineered controls (e.g., barriers to prevent rainwater infiltration that could move contaminants out of the soil and into groundwater), and administrative controls (e.g., reducing the toxicity and volume of chemicals in use or storage).

♦ *Monitoring*

BNL has an extensive groundwater monitoring network designed to evaluate the impacts of groundwater contamination from historical and current operations and to track cleanup progress. Groundwater monitoring is a means of verifying that protection and restoration efforts are working. Groundwater monitoring is focused in two general areas: (1) Environmental Surveillance (ES) designed to satisfy DOE and New York State monitoring requirements for active research and support facilities, and (2) Environmental Restoration (ER) monitoring related to BNL's obligations under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). This monitoring is coordinated to ensure completeness and to prevent any duplication of effort in the installation, monitoring, and abandonment of wells. Furthermore, data quality objectives, plans and procedures, sampling and analysis, quality assurance, data management, and well installation, maintenance and abandonment programs have been integrated to (1) create a cost-effective monitoring system and (2) to ensure that water quality data are available for review and interpretation in a timely manner.

♦ *Restoration*

BNL was added to the National Priorities List in 1989 (see Chapter 2 for a discussion of the BNL's ER Program). To help manage the restoration effort, thirty separate Areas of Concern (AOC) were grouped into six Operable Units (OU) (see Figure 2-13). Remedial Investigation/Feasibility Studies have been conducted for each OU, and focus is now shifting to design and implementation of cleanup systems. Contaminant sources (e.g., contaminated soil, underground tanks) are being removed or remediated to prevent further contamination of groundwater. All remediation work is carried out under the Interagency Agreement (IAG) among the U.S. Environmental Protection Agency (EPA), New York State Department of Environmental Conservation (NYSDEC), and DOE.

♦ *Communication*

BNL has a community involvement, government and public affairs program to ensure that BNL communicates with the community in a consistent, timely and accurate manner. A number of communication mechanisms are in place, such as web pages, mailings, public meetings, briefings, and roundtable discussions. Specific examples include the Community Advisory Council and the Brookhaven Executive Roundtable. In addition, BNL has developed a *Groundwater Protection Contingency Plan* (BNL 2000) that provides a formal process to communicate off normal or unusual monitoring results to BNL's management, DOE, regulatory agencies, and other stakeholders in a timely manner.

7.2 GROUNDWATER PROTECTION PERFORMANCE

Since 1998 the BNL Groundwater Protection Management Program has been tracking progress towards eliminating new contamination of the aquifer system. While the Laboratory has made significant investments in environmental and groundwater protection since 1998, it has not yet eliminated all new groundwater impacts. BNL is currently in a transition period, and it is expected to take several more years before the recent investments in environmental and groundwater protection allow BNL to reach its "zero" groundwater impact goal. A new groundwater impact is defined as the detection of unusual or off normal groundwater monitoring results. During 1999-2000, BNL developed a *Groundwater Protection Contingency Plan* (BNL 2000) that is designed to ensure that appropriate and timely actions are taken if unusual or off normal results are observed. The contingency plan provides guidelines for evaluating the source of the problem, stakeholder notifications, and implementing appropriate corrective actions.

From 1998 through 2000, BNL installed hundreds of new permanent and temporary monitoring wells as a result of a comprehensive evaluation of known or potential contaminant source areas. During this period, BNL has identified nine new groundwater impacts using this enhanced monitoring system (Figure 7-2). It is important to note, however, that four of these were determined to be from historical (or legacy) contaminant releases. These legacy issues include the discovery of low level petroleum hydrocarbon contamination in groundwater near the BNL Service Station, the discovery of tritium near the former U-Line target area at the AGS, the discovery of 1,1,1-trichloroethane (TCA) near Building 830 and the BNL Motor Pool. In addition, the improved groundwater surveillance program detected three small tritium plumes that originated from active experimental areas at the AGS (the g-2 and E-20 Catcher areas) and the BLIP facility. In two cases, activities associated with the Laboratory's environmental restoration program resulted in new groundwater impacts. One was the inadvertent release of carbon tetrachloride during the removal of an underground storage tank, and the second was caused by an unex-

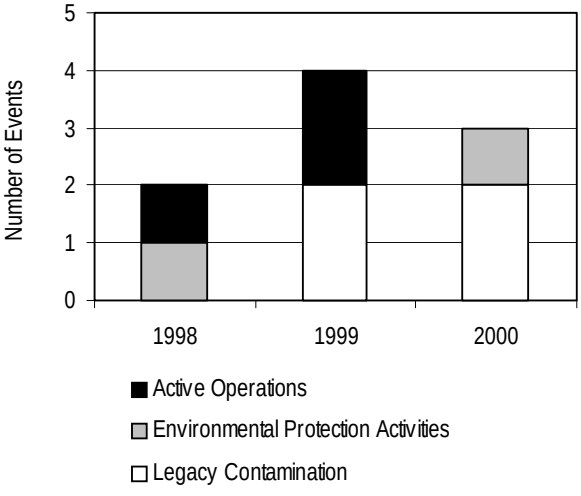


Figure 7-2. Groundwater Impact Events (1998-2000).

Figure 7-3. Sampling a Groundwater Monitoring Well.

pected displacement of tritium during an innovative grout injection process designed to protect groundwater quality by stabilizing activated soils at the BLIP facility. In all nine cases, BNL thoroughly investigated the cause of the contamination and took corrective actions as necessary to eliminate or limit the scale of these impacts.

BNL will continue the efforts to prevent new groundwater impacts, and is vigilant in measuring performance and improving upon environmental and efforts.

7.3 GROUNDWATER MONITORING

Groundwater monitoring program elements include installing monitoring wells, planning and scheduling, quality assurance, sample collection (see Figure 7-3), sample analysis, data verification, validation and interpretation, and reporting. Monitoring wells are generally used to evaluate BNL's progress in restoring groundwater quality, to comply with regulatory permit requirements, monitor active research and support facilities, assess the quality of groundwater entering or leaving the BNL site, and ensure that corrective measures designed to protect and restore groundwater are, in fact, working.

The groundwater beneath the BNL site is classified by New York State as Class GA groundwater. Class GA groundwater is defined as a source of potable water supply and suitable for drinking. As such, federal drinking water standards, New York State Drinking Water Standards (NYS DWS), and New York State Ambient Water Quality Standards (NYS AWQS) for Class GA groundwater are used as groundwater protection and remediation goals. The BNL groundwater surveillance program uses monitoring wells (which are not utilized for drinking water supply) to monitor research and support facilities where there is a potential for environmental impact, and areas where past waste handling practices or accidental spills have already degraded groundwater quality. BNL evaluates the potential impact of radiological and nonradiological levels of contamination by comparing analytical results to New York State and DOE reference levels and background water quality levels. Nonradiological analytical results from groundwater samples collected from surveillance wells are usually compared to NYS AWQS. Radiological data are compared to NYS DWS (for tritium, gross beta, and strontium-90), NYS AWQS (for gross alpha and radium-226/228), and Safe Drinking Water Act (SDWA)/DOE Derived Concentration Guides (for determining the 4 mrem dose for other beta/gamma-emitting radionuclides). Contaminant concentrations that are below these standards are also compared to background values to evaluate the potential effects from facility operations. The detection of low

concentrations of facility-specific volatile organic compounds (VOCs) or radionuclides may provide important early indications of a contaminant release and allow for the timely investigation into the identification and remediation of the source.

Groundwater quality at BNL is routinely monitored through a network of approximately 680 onsite and offsite surveillance wells (see Figure 7-4). In addition to groundwater quality assessments, water levels are routinely measured in over 650 onsite and offsite wells to assess variations in directions and velocities of groundwater flow. Groundwater flow directions in the vicinity of BNL are shown on Figure 7-5.

Active and inactive facilities that have groundwater monitoring programs include the Sewage Treatment Plant/Peconic River area, Biology Agricultural Fields, Former Hazardous Waste Management Facility (HWMF), new Waste Management Facility (WMF), two former landfill areas, Central Steam Facility/Major Petroleum Facility (CSF/MPF), Alternating Gradient Synchrotron (AGS), Waste Concentration Facility (WCF), Supply and Materiel, and several other smaller facilities. As the result of detailed groundwater investigations conducted over the past fifteen years, six significant VOC plumes and eight radionuclide plumes have been identified (Figures 7-6 and 7-7).

7.4 SUPPLEMENTAL MONITORING PROGRAM FOR POTABLE AND PROCESS SUPPLY WELLS

As discussed in Chapter 3, BNL is a public water purveyor and maintains six potable water supply wells and associated treatment facilities for the distribution of potable water on the site. The quality of the BNL potable water supply is monitored as required by the Safe Drinking Water Act, and the analytical results are reported to the Suffolk County Department of Health Services. Groundwater quality is also routinely monitored at all active process supply wells. All supply wells are screened within the Upper Glacial aquifer. Because of the proximity of BNL's potable supply wells to known or suspected groundwater contamination plumes and source areas, BNL conducts a supplemental potable supply well monitoring program. The BNL supply well network consists of six potable water supply wells (Wells 4, 6, 7, 10, 11, and 12) and two secondary cooling/process water supply wells (Wells 9 and 105) (Figure 7-5). In 2000, Well 9 supplied process water to a facility where biological research on fish is conducted. Secondary cooling water for the Brookhaven Medical Research Reactor was supplied from Well 105.

Monitoring of the potable and process supply wells in 2000 included VOCs, inorganics (anions and metals), and radiological parameters. During 2000, the BNL potable water system fully complied with all drinking water requirements. Furthermore, as required by 1996 amendments to the Safe Drinking Water Act, BNL prepared a *Source Water Assessment for Drinking Water Supply Wells* (Bennett *et al*. 2000). The source water assessment is designed to serve as a management tool in further protecting the sole source aquifer system underlying the BNL site.

7.4.1 RADIOLOGICAL RESULTS

Potable well water was sampled and analyzed for gross alpha and gross beta activity, tritium, and strontium-90; the results are listed in Table 7-1. In addition, tap water samples were collected daily from Building 490 (Analytical Services Laboratory) and analyzed for gross alpha and beta activity and tritium. Nuclide-specific gamma spectroscopy was also performed for potable well samples, supplementing the requirements of the SDWA which does not require this analysis unless gross beta activity exceeds 50 pCi/L (1.8 Bq/L). Average gross activity and tritium levels in the potable water wells were consistent with those of typical background water samples. Neither strontium-90 nor any man-made gamma-emitting radionuclides were observed above the minimum detection limit (MDL) in any of the potable water samples.

7.4.2 NONRADIOLOGICAL RESULTS

7.4.2.1 VOLATILE ORGANIC COMPOUNDS (VOCS)

Samples collected from supply Wells 4, 6, 9, and 105 were analyzed for VOCs following EPA Standard Method 624. This method tests for 38 organic compounds, including halogenated and aromatic hydrocarbons. The only parameters detected above the MDL were chloroform and 1,1,1-trichloroethane (TCA). TCA was detected in Well 9 at 2.5 micrograms per liter (µg/L). Well 9 is located within a known area of contamination and is included

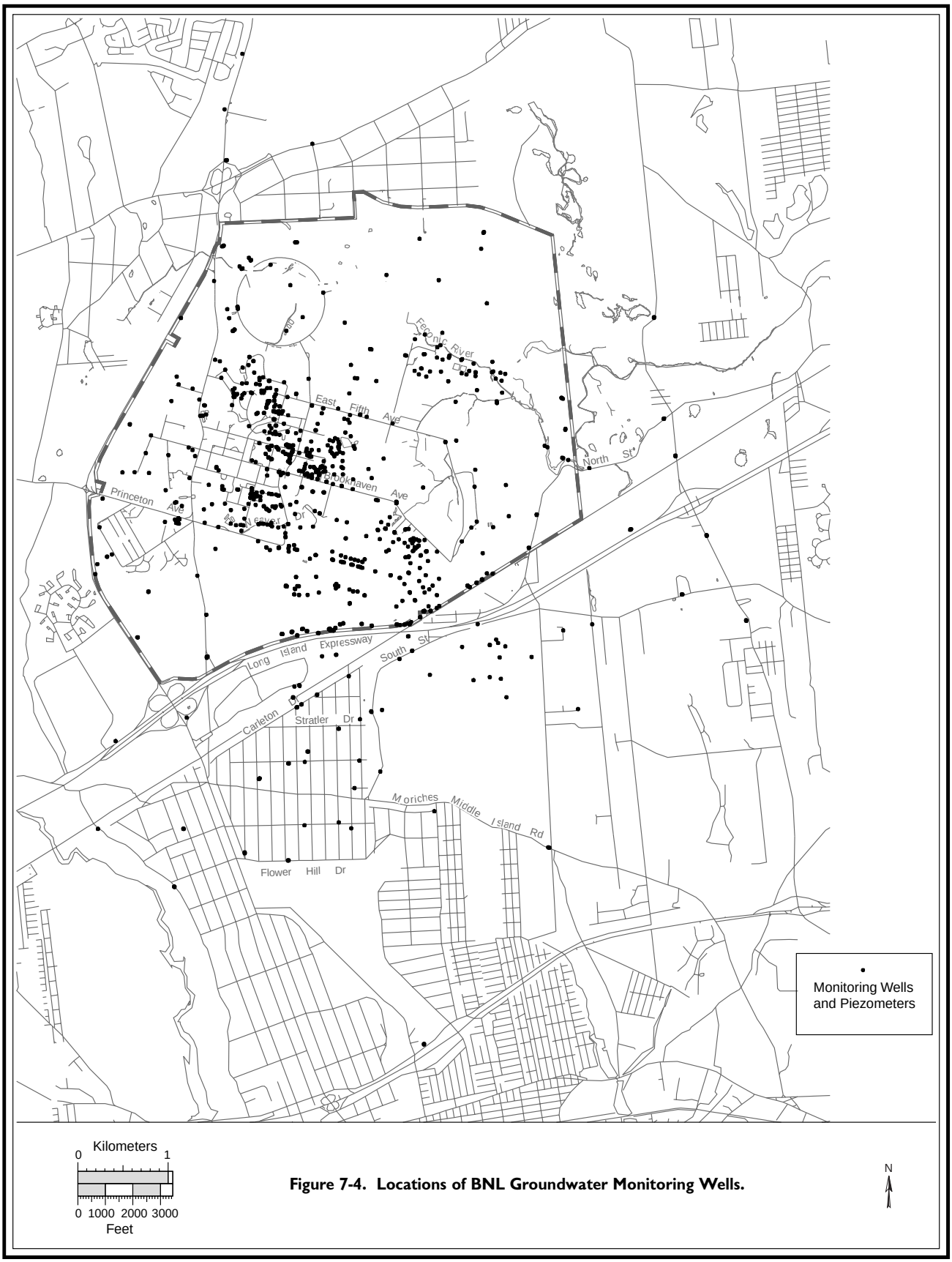


Figure 7-4. Locations of BNL Groundwater Monitoring Wells.

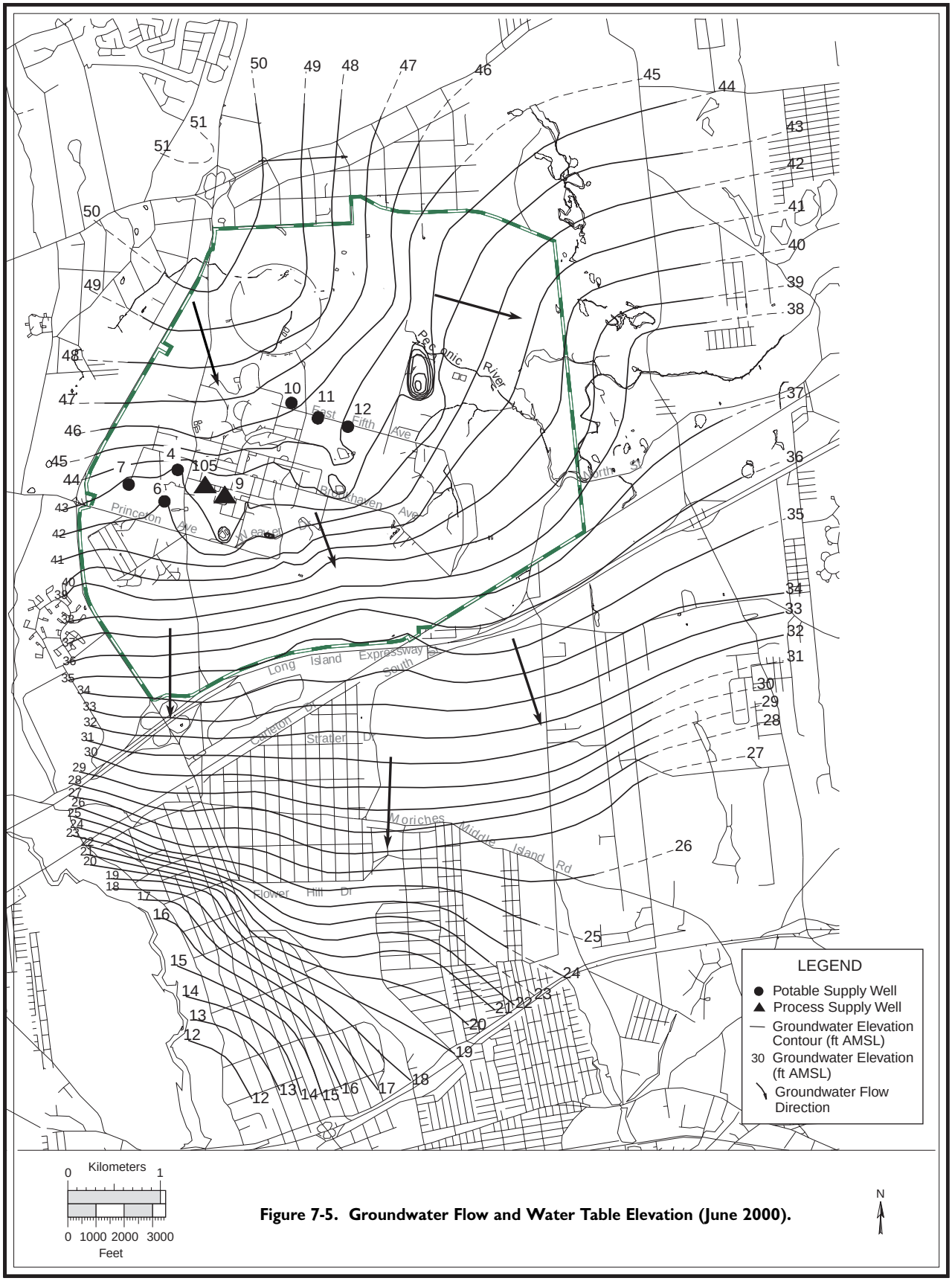


Figure 7-5. Groundwater Flow and Water Table Elevation (June 2000).

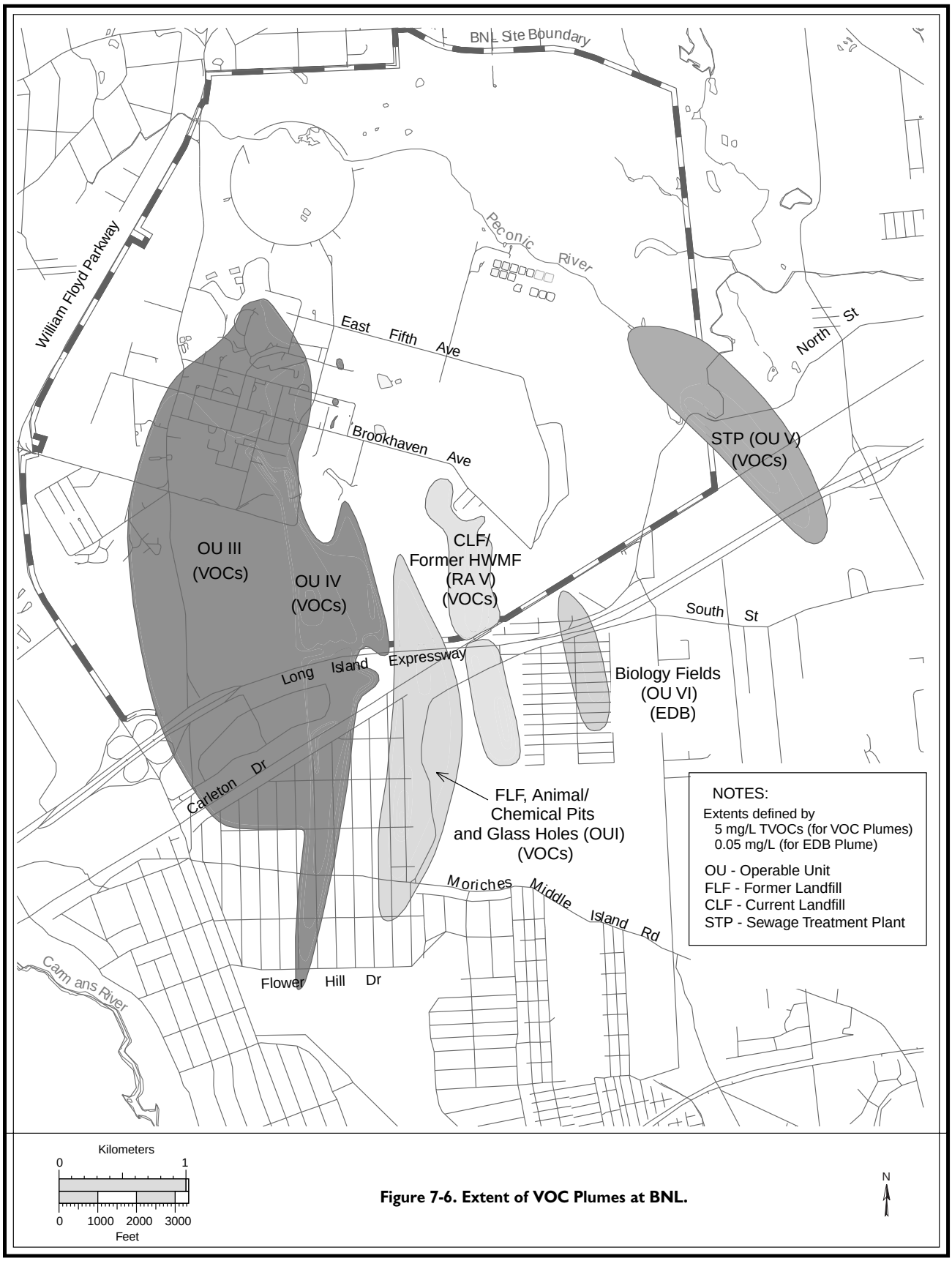


Figure 7-6. Extent of VOC Plumes at BNL.

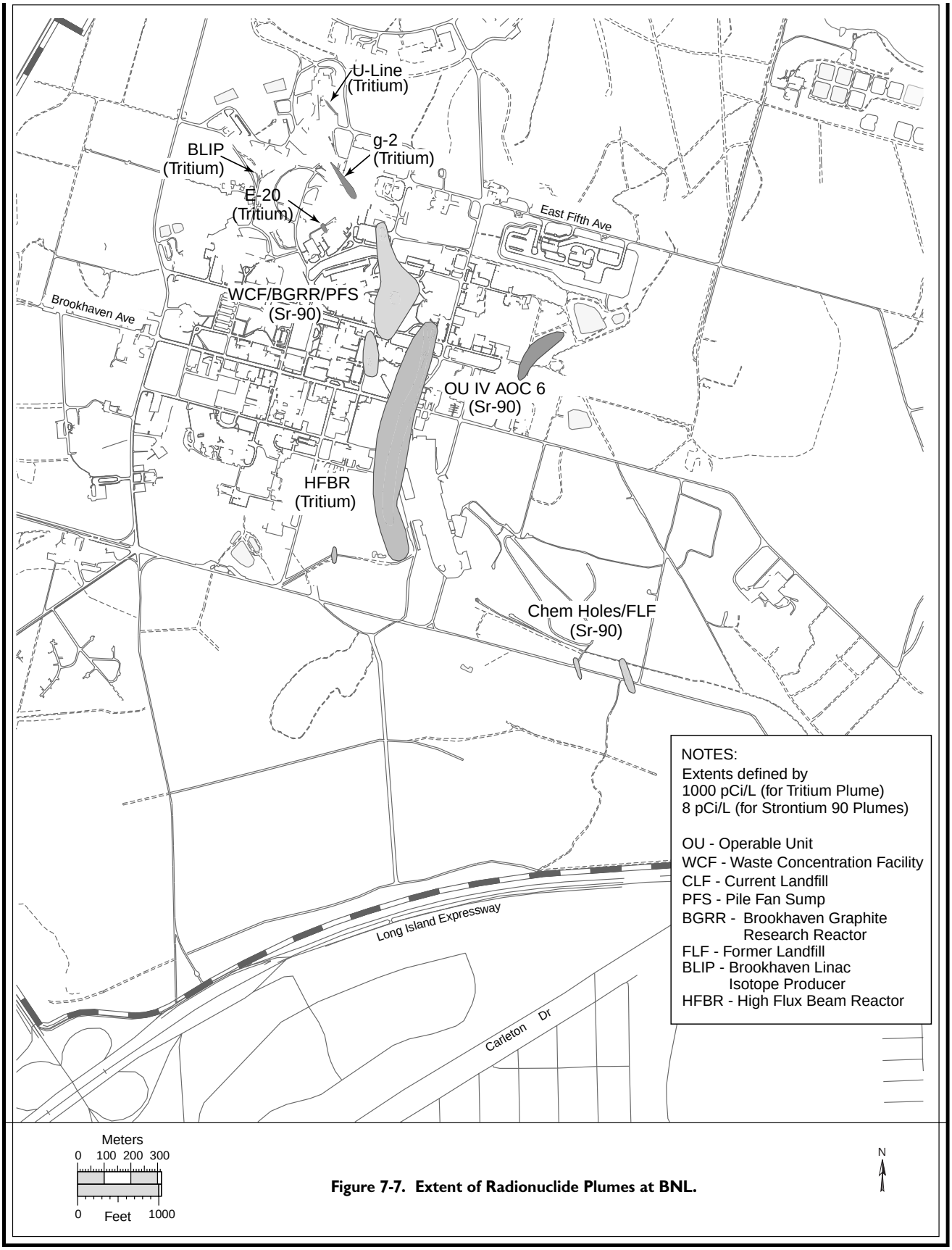


Figure 7-7. Extent of Radionuclide Plumes at BNL.

Table 7-1. Potable Water Supply Radiological Analytical Results (CY 2000).

Potable Well ID[a]		Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Tritium (pCi/L)	Sr-90 (pCi/L)
4 (FD)	N	4	4	4	3
	Max.	1.1 ± 0.6	13.1 ± 1.6	< 320	< 0.55
	Avg.	0.8 ± 0.3	4.5 ± 5.2	-36 ± 123	-0.1092 ± 0.09
6 (FF)	N	5	5	5	2
	Max.	1.3 ± 0.8	6.1 ± 1.4	< 315 ± < 0.58	
	Avg.	0.7 ± 0.3	3.8 ± 1.4	-5 ± 70	0.25 ± 0.29
7 (FG)	N	6	6	6	2
	Max.	< 0.7	3.5 ± 1.4	< 289	< 0.68
	Avg.	0.1 ± 0.2	2.1 ± 1.1	26 ± 77	0.38 ± 0.285
10 (FO)	N	3.0	3	3	1
	Max.	1.0 ± 0.6	2.8 ± 1.32	< 304	< 0.41
	Avg.	-0.1 ± 0.8	1.7 ± 0.8	-26 ± 23	NA
11 (FP)	N	6	6	6	2
	Max.	< 0.8	5.2 ± 1.4	< 304	< 0.70
	Avg.	0.1 ± 0.3	2.6 ± 1.3	73 ± 90	0.28 ± 0.38
12 (FQ)	N	5	5	5	2
	Max.	< 0.8	5.2 ± 1.4	< 315	< 0.61
	Avg.	-0.0 ± 0.5	3.1 ± 1.0	55 ± 110	-0.08 ± 0.01
Tap Water[b]	N	247	247	248	NS
Bldg. 490	Max.	7.7 ± 3.0	16.6 ± 6.1	307 ± 189	
(FN)	Avg.	2.5 ± 0.2	5.0 ± 0.4	-30 ± 14	
SDWA Limit		15[c]	50[d]	20,000	8

Notes:
See Figure 7-5 for well locations.
All values shown with 95% confidence interval.
No anthropogenic gamma-emitting radionuclides were detected in samples collected from these wells in 2000.
N=Number of samples collected
NS=Not sampled for this analyte
NA=Not applicable to one value
SDWA=Safe Drinking Water Act
[a]Historic ID shown in parentheses.
[b]The gross activity values for FN are elevated compared with the other potable wells due to differences in the analytical procedure (smaller sample volumes and shorter counting times) used to obtain the activity values.
[c]Excluding radon and uranium.
[d]Screening level above which analysis for individual radionuclides is required.

in the Operable Unit III study area. At these concentrations, the TCA does not interfere with the fish experiments for which the water is used.

Chloroform was found in most wells, with concentrations ranging from trace levels (< 2 µg/L) to a maximum of 4.2 µg/L. All chloroform concentrations were equal to or below the ambient water quality standard of 7 µg/L and well below the drinking water standard of 80 µg/L.

7.4.2.2 METALS AND ANIONS

Samples collected at Supply Wells 4, 6, 7, 10, and 11 were analyzed for metals and anions. The results are summarized in Tables 7-2 (anions) and 7-3 (metals). Review of these data shows that the water obtained from Wells 10 and 11 fully comply with drinking water requirements. Iron is present in Wells 4, 6, and 7. Water collected from these wells is treated for iron removal at the Water Treatment Plant prior to site distribution.

7.5 ENVIRONMENTAL SURVEILLANCE PROGRAM (NON-CERCLA)

BNL's Environmental Surveillance Program includes groundwater monitoring at active research facilities (e.g., research reactor areas, accelerator beam stop and target areas, greenhouse areas) and support facilities (e.g., fuel storage facilities and water treatment facilities).

In September 1998, BNL finalized a *Groundwater Monitoring Improvements Plan* (Paquette 1998) that identified active research and support facilities requiring improved groundwater monitoring programs. As a result of this evaluation, 84 new, permanent groundwater monitoring wells were installed on a prioritized basis during 1999 and 2000. During 2000, 120 groundwater surveillance wells were monitored during 350 individual sampling events. All wells sampled during 2000 are listed in Appendix E. Results for these programs are summarized below. For detailed descriptions and maps related to groundwater monitoring in the Environmental Surveillance Monitoring Program, refer to the *BNL CY 2000 Groundwater Status Report* (BNL 2001).

7.5.1 SURVEILLANCE MONITORING OF RESEARCH FACILITIES

7.5.1.1 ALTERNATING GRADIENT SYNCHROTRON (AGS) COMPLEX

Activated soils have been created near a number of AGS experimental areas as the result of secondary particles (primarily neutrons) produced at beam targets and beam stops. Radionuclides, such as tritium and sodium-22, have been produced by the interaction of these secondary particles with the soils that surround the experimental areas. Furthermore, historical surface spills and discharges of solvents to cesspools and recharge basins near the AGS have contaminated soils and groundwater with VOCs. VOC contamination is monitored under the ER Program's OU III Central Areas Project (see Section 7.6.3).

During 2000, 41 groundwater monitoring wells were used to evaluate groundwater quality near potential soil activation areas within the AGS Complex (e.g., Building 912, AGS Booster Beam Stop, 914 Transfer Tunnel, g-2 experimental area, E-20 Catcher, former U-Line Target, and the new J-10 Beam Stop). Thirty-nine of these wells were installed as part of the Groundwater Monitoring Improvements project during 1999 and 2000. Since 1999, the enhanced groundwater monitoring program detected three tritium plumes that are associated with activated soil shielding.

These plumes originated from the g-2 experimental area, former U-Line area, and the Former E-20 Catcher region of the AGS Complex (see Figure 7-8).

Table 7-2. Potable Water Supply Wells Water Quality Data (CY 2000).

Potable Well ID.*		Chlorides	Sulfates	Nitrate as N
		mg/L		
	N	1	1	1
4 (FD)	Value	14.8	10	< 1
	N	1	1	1
6 (FF)	Value	14.2	10	< 1
	N	1	1	1
7 (FG)	Value	20.2	11.6	< 1
	N	1	1	1
10 (FO)	Value	11.6	9.6	< 1
	N	1	1	1
11 (FP)	Value	22.5	12.9	< 1
NYS DWS		250	250	10
Typical MDL		4	4	1

Notes:
See Figure 7-5 for location of wells.
*Historic ID shown in parentheses.
N = Number of Samples
NYSDWS = New York State Drinking Water Standard
MDL = Minimum Detection Limit

7.5.1.1.1 g-2 EXPERIMENT AREA

In November 1999, monitoring wells located approximately 250 feet (76 m) downgradient of the g-2 experimental area detected the presence of tritium and sodium-22 in groundwater. A sample from Well 054-67 collected in October 1999 had a tritium concentration of 41,700 pCi/L (1,543 Bq/L). (Note: The drinking water standard for tritium is 20,000 pCi/L or 740 Bq/L.) A groundwater investigation conducted during November-December 1999 revealed a narrow tritium plume of approximately 20-30 feet (6-9m) wide and 250-300 feet (76-91 m) long. The maximum radionuclide concentrations were detected in temporary Well 054-116, located approximately 70 feet (21 m) downgradient of the g-2 beam line, with a tritium concentration of 1,800,000 pCi/L (66,600 Bq/L) and sodium-22 concentration of 60 pCi/L (2.2 Bq/L). (Note: The drinking water standard for sodium-22 is 400 pCi/L or 14.8 Bq/L.) Following the discovery, an investigation into the source of the contamination revealed that the tritium originated from activated soil shielding located adjacent to the g-2 experiment's VQ-12 Magnet. In December 1999, an impermeable (Gunite™) cap was installed over the soil activation area to

Table 7-3. Total Metals Concentration Data for Potable Water Supply Well Samples (CY 2000).

Potable Well ID.*	No. of Samples	Ag µg/L	Al µg/L	As µg/L	Ba µg/L	Be µg/L	Cd µg/L	Co µg/L	Cr µg/L	Cu µg/L	Fe mg/L	Hg µg/L	Mn µg/L	Mo µg/L	Ni µg/L	Na µg/L	Pb µg/L	Sb µg/L	Se µg/L	Tl µg/L	V µg/L	Zn µg/L
4 (FD)	1	7.7	7.9	< 3	23.8	< 0.7	< 1.1	0.7	1.1	45.1	2.2	< 0.2	0.2	< 5.0	< 1.1	10.2	< 1.3	< 0.9	12	< 0.7	< 5.5	< 4
6 (FF)	1	< 1	12.4	3.4	22.2	< 0.7	< 1.1	0.7	2	15.1	4	< 0.2	0.08	< 5.0	3.8	9.1	< 1.3	< 0.9	12	< 0.7	< 5.5	10.7
7 (FG)	1	< 1.0	6.6	3.6	24.8	< 0.7	< 1.1	0.6	1.1	3.7	1.7	< 0.2	0.07	< 5.0	1.2	13.1	< 1.3	< 0.9	12	< 0.7	< 5.5	20.7
10 (FO)	1	< 1.0	4.1	< 3.0	13.5	< 0.7	< 1.1	< 0.1	1.1	18.1	0.1	< 0.2	0.01	< 5.0	< 1.1	9.6	< 1.3	< 0.9	12	< 0.7	< 5.5	16
11(FP)	1	< 1.0	4.1	< 3.0	32.9	< 0.7	< 1.1	< 0.1	1.2	7.1	< 0.0	< 0.2	< 0.00	< 5.0	< 1.1	15.5	< 1.3	< 0.9	12	< 0.7	< 5.5	28
NYS DWS		100	SNS	6	2000	4	5	SNS	100	1300	0.3	2	0.3	SNS	100	SNS	15	6	50	2	SNS	5000
Typical MDL		1	2.2	3	1.8	0.7	1.1	0.1	1	2	0.075	0.2	2	5	1.1	1	1.3	0.9	5	0.7	5.5	4

Notes:
See Figure 7-5 for well locations.
*Historic ID shown in parentheses.
NYSDWS = New York State Drinking Water Standard
MDL = Minimum Detection Limit
SNS = Drinking Water Standard Not Specified.

prevent rainwater infiltration and the continued leaching of the radionuclides out of the soils and into groundwater. In September 2000, the activated soil shielding and the associated tritium plume were designated as sub-Area of Concern 16T. Following this designation, DOE agreed to prepare an Engineering Evaluation/Cost Analysis (EE/CA) to evaluate the adequacy of the corrective actions taken to date, and the need for further actions. During 2000, eight permanent monitoring wells in the g-2 area were sampled on a quarterly basis. Samples were collected for tritium analysis and gamma spectroscopy. Due to a significant reduction in pumpage from potable supply Well 10 in early 2000, groundwater flow directions in the eastern section of the AGS facility changed from east-southeast to a more southeasterly direction. As a result, the tritium plume shifted slightly away from most of the established monitoring well network. As the flow direction of the plume shifted to the southeast, tritium concentrations in Well 054-07 increased from approximately 3,300 pCi/L (122 Bq/L) in November 1999 to 293,000 pCi/L (10,841 Bq/L) in July 2000. By October 2000, tritium concentrations in Well 054-07 decreased to 74,000 pCi/L (2,738 Bq/L). Time of travel from the VQ-12 source area to Well 054-07 is approximately six to seven months. The decrease in tritium concentration in Well 054-07 is probably an indication that the Gunite™ cap that was installed in December 1999 has been effective in preventing rainwater infiltration through the activated soils. Alternatively, the concentration fluctuations observed in Well 054-07 could be due to the well being located on the margin of a more concentrated tritium plume. In early 2001, a series of temporary wells will be installed as part of the g-2 EE/CA to verify the position of the plume in this area and evaluate the effectiveness of the cap.

Based upon available monitoring well data and groundwater flow direction and rates, it is likely that the leading edge of the plume is now located east of Building 912 (Figure 7-8). Shallow Wells 065-123, 065-124 and 065-125 were originally installed to monitor soil activation areas located below the Building 912 floor. For the first three quarters of 2000, tritium concentrations in

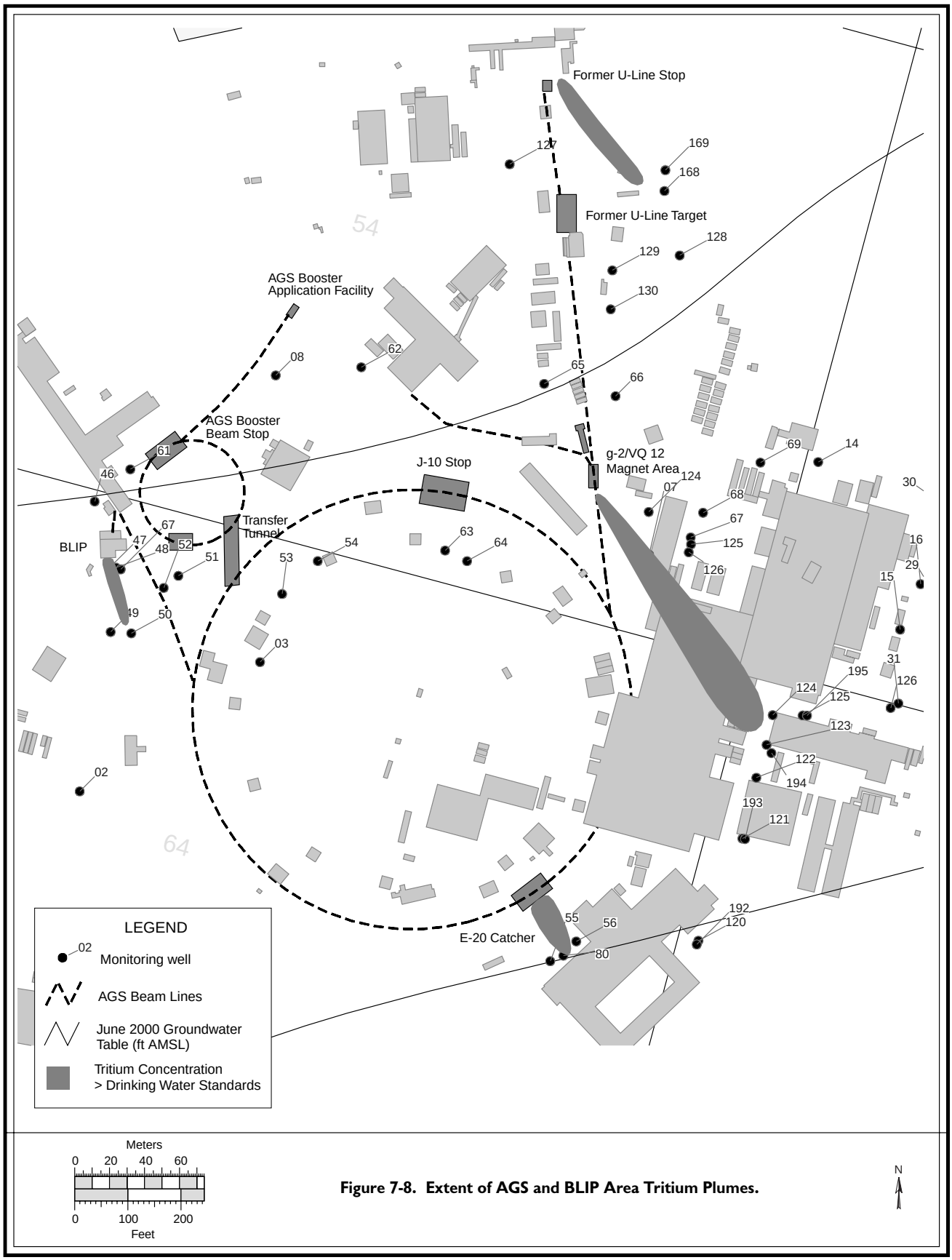


Figure 7-8. Extent of AGS and BLIP Area Tritium Plumes.

these wells ranged between nondetectable (i.e., below the typical MDL of approximately 350 pCi/L or 13 Bq/L) to 528 pCi/L (20 Bq/L). Sodium-22 was also detected at concentrations up to 18 pCi/L (0.67 Bq/L). Significant increases in tritium concentrations were observed in samples collected in October 2000, with a maximum tritium concentration of 3,690 pCi/L (136 Bq/L) observed in Well 065-124. This increase may be an indication that the leading edge of the g-2 tritium plume has emerged from beneath Building 912. This is a reasonable interpretation considering distance from the source (approximately 600 feet [183m]) and an average groundwater flow rate of approximately 0.6 feet per day. During the g-2 EE/CA, temporary Geoprobe™ wells will be used to verify the vertical distribution of tritium in areas east of Building 912.

7.5.1.1.2 FORMER E-20 CATCHER AREA

In late 1999, tritium and sodium-22 were detected in wells located approximately 100 feet (30 m) downgradient of the former E-20 Catcher (Figure 7-8). The highest levels of tritium and sodium-22 were detected in Well 064-56 at concentrations of 5,800 pCi/L (215 Bq/L) and 219 pCi/L (8 Bq/L), respectively. To further evaluate the extent of contamination, four temporary wells were installed in January 2000. The highest levels of tritium and sodium-22 were found in Geoprobe™ Well 064-065 with concentrations of 40,400 pCi/L (1,495 Bq/L) and 704 pCi/L (26 Bq/L), respectively. This well was installed approximately 12 feet southwest of permanent Well 064-56. These data indicate that at a distance of approximately 100 feet (30.5 meters) downgradient of the E-20 Catcher, the zone of elevated tritium and sodium-22 is estimated to be approximately 20 to 30 feet wide (9.15 meters) and situated within 10 feet (3 m) of the water table (approximately 30 to 40 feet [9-12 m] below land surface). In April 2000, a temporary impermeable cap was installed over the E-20 Catcher soil activation area to prevent rainwater infiltration and the continued leaching of the radionuclides out of the soils and into groundwater. A permanent (geomembrane) cap was constructed by October 2000, and one additional well (Well 064-80) was installed for improved long-term monitoring of the source area.

7.5.1.1.3 FORMER U-LINE TARGET AND STOP AREAS

Low levels of tritium and sodium-22 have been frequently detected in wells located downgradient of the former U-Line target (Figure 7-8). The tritium and sodium-22 concentrations are well below the applicable drinking water standards. The highest tritium concentration was 6,110 pCi/L (226 Bq/L) detected in Well 055-14 which is located approximately 500 feet (152 m) downgradient of the former U-Line target. The highest sodium-22 concentration was 20.9 pCi/L (0.8 Bq/L) in Well 054-129 located approximately 200 feet (61 m) downgradient of the target area. Low-level contamination from the former U-Line area can be traced to Well 055-29, located approximately 1,000 feet (305 m) downgradient of the target area. The maximum tritium and sodium-22 concentrations detected in this well were 4,710 pCi/L (174 Bq/L) and 15.2 pCi/L (0.6 Bq/L), respectively.

In March and April 2000, four temporary wells were installed approximately 200 feet (61 m) downgradient of the former U-Line beam stop (Figure 7-8). The highest tritium concentrations were detected in temporary Well 054-133, with a tritium concentration of 71,600 pCi/L (2,649 Bq/L) at a depth of 35-39 feet (11-12 m) below land surface (approximately 12 to 16 feet [4-5 m] below the water table). Sodium-22 was not detected in any of the samples collected from the four temporary wells. The tritium plume (as defined by concentrations greater than 20,000 pCi/L) appears to be very narrow — only 20 to 25 feet wide. In May 2000, a temporary impermeable cap was installed over the U-Line beam stop soil activation area to prevent rainwater infiltration and leaching of the radionuclides out of the soils and into groundwater. By October 2000, a permanent (geomembrane) cap was constructed over the former beam stop area, and two additional permanent wells (054-168 and 054-169) were installed to provide long-term monitoring.

7.5.1.2 BROOKHAVEN LINAC ISOTOPE PRODUCER (BLIP)

The BLIP facility is located at the southern end of the Linear Accelerator (Figure 7-8). When the BLIP is operating, the Linear Accelerator delivers a beam of protons that impinges on a series of eight targets located within the BLIP target vessel. During irradiation, activation of the soils immediately

outside of the vessel occurs due to the creation of secondary particles produced at the target. In February 1998, elevated levels of tritium and sodium-22 were detected in wells located downgradient of BLIP. The subsequent installation of temporary wells approximately 40 feet (12.1 m) downgradient of the BLIP target detected tritium and sodium-22 concentrations of 52,000 pCi/L (1,924 Bq/L) and 151 pCi/L (5.6 Bq/L), respectively. To prevent rainwater from infiltrating the activated soils below the building, the BLIP building's roof drains were redirected away from the building, paved areas were resealed, and an extensive Gunite™ (cement) cap was installed on three sides of the building. In June 2000, BNL took an additional protective measure by using an innovative silica grouting technique to reduce the permeability of the activated soils.

Groundwater monitoring data collected from January 1999 to July 2000 indicated that the corrective actions taken during 1998 (i.e., Gunite™ cap, sealed pavement and rerouted roof gutters) were highly effective in preventing the release of tritium and sodium-22 from the activated soils surrounding the BLIP target vessel. Tritium and sodium-22 were not detected in samples collected in April 2000. However, significant increases in tritium and sodium-22 concentrations were observed in groundwater samples collected soon after the activated soils were treated with the silica grout injection process. Groundwater samples collected in early July indicated tritium and sodium-22 concentrations of 5,700 pCi/L (210 Bq/L) and 57 pCi/L (2 Bq/L), respectively. Samples collected in early October 2000 indicated tritium concentrations that exceeded the drinking water standard of 20,000 pCi/L (740 Bq/L). The maximum tritium concentration was 56,500 pCi/L (2,090 Bq/L) in samples from monitoring well 064-67, located approximately 40 feet (12 m) downgradient of the BLIP vessel. In accordance with the *BNL Groundwater Protection Contingency Plan*, BNL and DOE notified the regulatory agencies of this situation and increased the sampling frequency for the wells. The maximum sodium-22 concentration was 299 pCi/L (11 Bq/L) detected in Well 064-67 on December 1, 2000. By December 21, 2000, tritium concentrations dropped to below the 20,000 pCi/L (740 Bq/L) drinking water standard in wells located approximately 40 feet (12 m) downgradient of BLIP. Concurrently, as the slug of tritium continued to migrate downgradient of the BLIP, concentrations in Well 064-50 increased to 20,000 pCi/L (740 Bq/L) by December 28, 2000. Well 064-50 is located approximately 150 feet (46 m) downgradient of BLIP.

Following the detection of elevated tritium concentrations in October 2000, BNL, DOE, and external experts conducted a review of the grouting process. Findings of this review suggest that grout displaced residual vadose-zone soil pore water that was contaminated with tritium. The pattern of decreasing tritium concentrations in wells directly downgradient of BLIP indicated a short-term (pulsed) tritium release and that the plume has dissipated quickly in the aquifer. Although the grouting process had a short-term impact on groundwater quality, it is believed that the process will provide long-term benefits in reducing the permeability of the contaminated soil shielding. Information on the potential for displacing residual pore water will be used to improve this innovative grouting technology.

7.5.1.3 RELATIVISTIC HEAVY ION COLLIDER (RHIC)

Within the RHIC facility, there are two areas where low levels of radionuclides could be produced in the soils outside of the collider tunnel. The first area contains two beam stops that are located at the 10 o'clock position of the ring, and the second contains two collimators that are located at the 8 o'clock region. Secondary particles created at the internal beam stop and collimator areas have the potential to activate the soils immediately surrounding those areas. During 1999, twelve wells were installed to provide a means of verifying that the engineered (i.e., impermeable caps) and operational controls designed into the RHIC beam stops and collimators are effective in protecting groundwater quality. Six monitoring wells were installed in the beam stop area and six wells were installed in the collimator area.

Groundwater samples were collected from the twelve RHIC monitoring wells on a semiannual schedule during 2000. Surface water samples were also collected from the Peconic River both upstream and downstream of the beam stop area. No tritium or

sodium-22 was detected in any of the groundwater or surface water samples.

7.5.1.4 BROOKHAVEN MEDICAL RESEARCH REACTOR (BMRR)

During a 1997 evaluation of groundwater quality near the BMRR, low levels of tritium were detected in the groundwater downgradient of the reactor building. The maximum tritium concentration was 11,800 pCi/L (44 Bq/L) in wells installed directly downgradient (within 30 feet [9.15 m]) of the facility. Based upon inspection of the facility and review of historical records, the tritium is believed to have originated from the historical discharge of small amounts of BMRR primary cooling water to a basement floor drain and sump system that may have leaked. Although the last discharge of primary cooling water to the floor drain system occurred in 1987, the floor drains continued to be used for secondary (nonradioactive) cooling water until 1997. The infiltration of this water may have promoted the movement of residual tritium from the soils surrounding the floor drain piping system to the groundwater. The floor drains were permanently sealed in 1998 to prevent any accidental future releases to underlying soils.

Monitoring results for 2000 indicate that tritium concentrations continued to be below the drinking water standard of 20,000 pCi/L (740 Bq/L). Detectable levels of tritium were observed in all three downgradient wells, with the maximum value of 7,870 pCi/L (291 Bq/L) in Well 084-27. Slightly elevated gross beta concentrations (up to 38.6 pCi/L or 1.4 Bq/L) were detected in several samples from downgradient Well 084-13. As in past years, no other reactor-related radionuclides, including strontium-90, were detected during 2000. The elevated gross beta values are probably due to naturally occurring potassium-40, which was detected in BMRR groundwater samples at concentrations up to 105 pCi/L (3.9 Bq/L).

7.5.2 SURVEILLANCE MONITORING OF SUPPORT FACILITIES

7.5.2.1 SEWAGE TREATMENT PLANT (STP) AREA

As described in Chapters 1 and 3, the STP processes sanitary sewage from BNL facilities. Approximately 15% of the treated effluent released to the STP's sand filter beds either evaporates or directly recharges to groundwater; the remaining water is discharged to the Peconic River.

The STP groundwater surveillance program is designed to evaluate whether current operations are impacting groundwater quality. During 2000, six wells were used to monitor groundwater quality in the filter bed area and three wells were monitored in the holding pond area. Groundwater quality impacts resulting from historical STP discharges are currently being monitored as part of the OU V monitoring program using wells that are located at the site boundary and offsite areas (see Section 7.6.5).

Radionuclides

Radioactivity levels in samples collected from the STP wells were generally typical of ambient (background) levels. Tritium was not detected in wells located in the immediate filter bed area. However, low levels of tritium were detected in Wells 039-88 (up to 2,500 pCi/L or 92 Bq/L) and 039-89 (up to 799 pCi/L or 29 Bq/L), which are located downgradient of the holding ponds. Because the ponds have not been used recently to hold tritiated wastewater and the wells are located downgradient of the filter bed area, it is likely that the tritium originated from past wastewater releases to the filter beds. An elevated gross alpha concentration of 94.7 pCi/L (3.5 Bq/L) was detected in the June 2000 sample from Well 039-88. This value exceeds the 15 pCi/L (0.6 Bq/L) drinking water standard. However, gross alpha was not detected in the sample collected from this same well in December. Historical gross alpha measurements in groundwater at the STP have generally been less than 3 pCi/L (<0.1 Bq/L), well below the 15 pCi/L (0.5 Bq/L) standard. It is likely that the elevated gross alpha concentration in the June sample is due to an erroneous measurement or sample cross contamination. If future STP groundwater samples indicate elevated gross alpha, BNL will conduct radionuclide-specific analyses to identify possible alpha emitting radionuclides.

Volatile Organic Compounds, Metals, and Anions

During 2000, all water quality and most metals concentrations in wells monitoring

the STP were below applicable New York State Ambient Water Quality Standards (NYS AWQS). Sodium was detected at concentrations slightly above the standard of 20 mg/L in three filter bed area wells. Wells 039-07, 039-08, and 039-86 had maximum sodium concentrations of 22.3 mg/L, 30 mg/L, and 29.2 mg/L, respectively. Nitrates were detected in most STP area wells; however, all samples were below the standard of 10 mg/L. The maximum concentration of 9.9 mg/L was detected in filter bed area monitoring Well 039-08. Volatile organic compounds were not detected in any of the monitoring well samples.

7.5.2.2 WATER TREATMENT PLANT (WTP)

At the direction of the New York State Department of Environmental Conservation, five shallow Upper Glacial aquifer surveillance wells were installed at the WTP in 1993 to assess potential leaching of iron from the plant's recharge basin (Basin HX) into the groundwater. Naturally high levels of iron in the groundwater pumped for potable and process supply is removed at the WTP, and the precipitated iron is discharged to the recharge basin during filter back flushing operations.

Metals and Anions

The groundwater monitoring wells in the WTP recharge basin area were sampled in June 2000. Analytical results indicate that anions and metals (including iron) concentrations were below the applicable NYS AWQS and were consistent with established background levels for Long Island. Since the beginning of the groundwater monitoring program in 1992, iron has rarely been detected above the typical detection limit of 0.075 mg/L in groundwater near Basin HX, and has never exceeded the 0.3 mg/L water quality standard.

7.5.2.3 MOTOR POOL

Building 423 serves as the site Motor Pool, where BNL's fleet vehicles are repaired and refueled. Gasoline is stored in two 8,000-gallon (32,280 liter) capacity underground storage tanks, and waste oil is stored in one 500-gallon (1,892 liter) capacity underground storage tank. Although the underground storage tanks and associated distribution lines meet Suffolk County Article 12 requirements for secondary containment, leak detection, and high level alarms, BNL initiated a groundwater monitoring program in 1996 as a means of verifying that groundwater quality is not being impacted by current operations. Following a 1998 discovery of a hydraulic oil spill in Building 423 and a 1996 discovery of a historical oil spill immediately south of the nearby Site Maintenance Facility Building 326, BNL entered into a spill response (stipulation) agreement with NYSDEC. As part of this agreement, BNL installed six new groundwater surveillance wells in early 1999. Monitoring of these wells confirmed that these spills had not impacted groundwater quality, and these sites were removed from the NYSDEC's Active Spills List in early 2000.

Volatile and Semivolatile Organic Compounds

Two wells (102-05 and 102-06) are used to monitor for potential contaminant releases from the underground storage tank (UST) area. Except for low levels of the gasoline additive methyl tertiary butyl ether (MTBE) (up to 5 µg/L), no other chemicals related to gasoline products (e.g., benzene, ethylbenzene, toluene, or xylenes) were detected in groundwater. (Note: A NYS AWQS has not been established for MTBE.) MTBE has been used as a gasoline additive since 1977, and has been detected at low levels in the Motor Pool wells since the monitoring program began in 1996. The presence of MTBE in groundwater downgradient of the UST and pump island area is likely due to small-scale spillage during gasoline dispensing operations. No semivolatile compounds were detected in the groundwater samples. The solvent TCA was detected in Well 102-06 at a concentration of 6.9 µg/L. The NYS AWQS for TCA is 5 µg/L. The TCA contamination is probably due to historical parts degreasing operations. Wells 102-05 and 102-06 were also tested for the presence of floating petroleum hydrocarbons. As in previous years, no floating petroleum product was observed.

Groundwater quality downgradient of Building 423 and Building 326 is monitored using four wells (102-10, 102-11, 102-12, and 102-13). The program is designed to periodically assess existing solvent contamination that resulted from historical vehicle maintenance operations, and to confirm that the current engineered and institutional controls

are effective in preventing additional contamination of the aquifer.

During CY 2000, TCA was detected in Wells 102-10, 102-11, 102-12, and 102-13 at concentrations ranging from 7.4 µg/L to 79 µg/L. 1,1-dichloroethane (DCA) was detected in Well 102-12 at concentrations up to 10.6 µg/L. The NYS AWQS for TCA and DCA is 5 µg/L. Consistent with 1999 monitoring results, no semivolatile compounds were detected in the groundwater samples.

7.5.2.4 UPTON SERVICE STATION

Building 630 is a commercial automobile repair and gasoline station for the BNL site. Gasoline is stored in two 8,000-gallon (30,280 liter) capacity and one 6,000-gallon (22,710 liter) capacity underground storage tanks, and waste oil is stored in one, 500-gallon (1,892 liter) capacity underground storage tank. Although the storage tanks and associated distribution lines meet Suffolk County Article 12 requirements for secondary containment, leak detection, and high level alarms, BNL initiated a groundwater monitoring program in 1996 as a means of verifying that groundwater quality is not being impacted by current operations. This program was enhanced in early 2000, by the installation of three new monitoring wells.

Volatile and Semivolatile Organic Compounds

Prior to 1999, low levels (<20 µg/L) of carbon tetrachloride were detected in Service Station Well 085-17. Approximately one year after the April 1998 removal of a carbon tetrachloride tank located 200 feet (61 m) northeast of the Service Station, higher levels of carbon tetrachloride started to be detected in Service Station area wells. (Note: The carbon tetrachloride tank was associated with an experiment conducted in the 1950s and is not related to service station operations.) In 1999, carbon tetrachloride concentrations in Well 085-17 was 503 µg/L, and by January 2000 carbon tetrachloride concentrations reached 2,000 µg/L. By June 2000, carbon tetrachloride concentrations in Well 085-17 were 4,400 µg/L. The NYS AWQS for carbon tetrachloride is 5 µg/L. BNL started to remediate the carbon tetrachloride plume in October 1999. Following the detection of high levels of carbon tetrachloride in January 2000, the Service Station area wells were temporarily incorporated into the ER Program's carbon tetrachloride plume monitoring program and placed on a monthly sampling schedule (see Section 7.6.3).

Petroleum hydrocarbon-related compounds were detected in two of the new wells (085-236 and 085-237) installed in January 2000 directly downgradient of the Service Station. These compounds were not detected in upgradient wells. Therefore, the source of the contamination is located close to or beneath the Service Station. No floating petroleum product was detected in the monitoring wells.

Primary petroleum hydrocarbon related compounds detected in samples collected from Wells 085-236 and 085-237 during January-May 2000 included: xylenes (up to 420 µg/L), ethylbenzene (up to 77 µg/L), 1,2,4-trimethylbenzene (up to 47 µg/L), 1,3,5-trimethylbenzene (up to 31 µg/L), and naphthalene (up to 32 µg/L). Trace amounts of the gasoline additive MTBE (<5 µg/L) were detected in downgradient Wells 085-236 and 085-237. MTBE was also detected in a sample from upgradient Well 085-235. Tetrachloroethylene (PCE) (up to 37 µg/L) was also detected in a number of Service Station area wells, and is probably related to historical degreasing operations. In June 2000, BNL implemented the *Groundwater Protection Contingency Plan* and formed a technical team to identify the source of the contamination. An evaluation of current operations indicates that the underground storage tanks and associated distribution lines are not leaking and that all waste oils and used solvents are being properly stored and recycled. Therefore, it is believed that the petroleum hydrocarbons and PCE detected in groundwater are from historical vehicle maintenance and fuel dispensing operations.

Between June and October 2000, concentrations of petroleum hydrocarbon related compounds in samples collected from Well 085-236 and 085-237 decreased to nearly nondetectable levels. During this same period however, levels of petroleum hydrocarbon related compounds increased in Well 085-17 from near nondetectable levels to concentrations well above NYS AWQS. By October 2000, samples from Well 085-17 had total xylene concentrations of 120 µg/L, 1,2,4-trimethylbenzene concentrations at 21.6 µg/L,

1,3,5-trimethylbenzene at 12.7 µg/L, and naphthalene at 4.0 µg/L. The shift in the detection of petroleum hydrocarbon related contaminants from Well 085-236 to Well 085-17 corresponds to a change in groundwater flow direction from southeast to south that began in June-July 2000. This change in flow direction was caused by the operation of the nearby carbon tetrachloride extraction wells.

In April 2000, the Environmental Restoration Program installed two additional wells (085-238 and 095-183) approximately 200 feet (61 m) downgradient of the Service Station in an effort to better characterize the extent of carbon tetrachloride contamination. Results from the initial sampling of these wells in early June indicated carbon tetrachloride up to 2,080 µg/L and tetrachloroethylene up to 12.6 µg/L. The lack of petroleum hydrocarbon compounds at this distance away from the Service Station is consistent with the findings of numerous studies on petroleum hydrocarbon spills, where it has been found that compounds such as xylenes, ethylbenzene, 1,2,4-trimethylbenzene, and naphthalene degrade rapidly and, therefore, do not migrate great distances from source areas.

7.5.2.5 MAJOR PETROLEUM FACILITY (MPF)

The Central Steam Facility supplies steam for heating to all major facilities of the Laboratory through an underground distribution system. The MPF is the storage area for most fuels used at the Central Steam Facility. Five shallow Upper Glacial aquifer wells monitoring the MPF were initially installed as part of the licensing requirements for this facility, and are screened across the water table so that potential free product (i.e., oil floating on top of the groundwater) can be detected. As part of the Laboratory's Groundwater Monitoring Improvements Project, three additional surveillance wells were installed in early 2000 to improve monitoring of the MPF area. Additional surveillance wells are located in the CSF area. These wells are used to monitor groundwater contamination resulting from a 1977 leak of approximately 25,000 gallons (94,625 liters) of Alternative Liquid Fuel (a fuel oil/spent solvent mixture). Contaminated soils and groundwater near the 1977 spill site have been undergoing active remediation since the winter of 1997 (see Section 7.6.4.1).

Volatile and Semivolatile Organic Compounds

In accordance with the Special License Conditions for the MPF, groundwater samples are analyzed semiannually for the Polynuclear Aromatic and Base Neutral Compounds contained in EPA test Method 625. During 2000, none of these compounds were detected. The MPF wells were tested monthly for the presence of floating petroleum hydrocarbons. As in previous years, no floating petroleum product was observed.

In addition to the required testing for semi-VOCs, BNL also analyzed samples collected in October for the presence of VOCs. TCA was detected in upgradient Well 076-25 at concentrations of 25 µg/L. Low levels (up to 2 µg/L) of tetrachloroethylene and 1,1-dichloroethylene were also detected in several wells. The NYS AWQS for these compounds is 5 µg/L. The detection of TCA in upgradient Well 076-25 is consistent with historical monitoring results and it is believed that the TCA originates from contaminated soils associated with historical operations at Building 650.

7.5.2.6 WASTE MANAGEMENT FACILITY (WMF)

In 1997, BNL began operating a new WMF. The new WMF is designed and operated in a manner that meets all applicable federal, state, and local environmental protection requirements. Nevertheless, BNL established a voluntary groundwater monitoring program as a secondary means of verifying the effectiveness of the facility's administrative and engineered controls. The new WMF is monitored by eight shallow Upper Glacial aquifer wells.

Volatile Organic Compounds, Metals, and Anions

Groundwater quality in the WMF area is monitored using eight wells. During 2000, all water quality and most metals concentrations were below the applicable NYS AWQS. Sodium was detected at concentrations above the NYS AWQS of 20 mg/L in upgradient Wells 055-03 and 066-07 at maximum concentrations of 47.4 mg/L and 22.7 mg/L, respectively. The detection of low levels of sodium is not uncommon in wells located within the developed area of the site and could be related to road salting operations. These low levels of sodium have not impacted the operation of nearby drinking water Wells 11 and 12. 1,1,1-Trichloroethane (TCA) and 1,1-Dichloroethylene (DCE) were detected in

upgradient Well 066-07 at concentrations up to 153 µg/L and 35 µg/L, respectively. The NYS AWQS for TCA and DCE is 5 µg/L. It is believed that the TCA and DCE contamination detected in Well 066-07 is due to historical releases from Building 830. Historically, the operations of nearby drinking water Wells 11 and 12 have been impacted by low level TCA contamination. Water pumped from these wells is treated by activated carbon filters prior to distribution. In December 2000, BNL initiated an investigation to verify the source of the VOC release.

Radionuclides

During 2000, no radionuclides related to Laboratory operations were detected in WMF area wells. Gross radioactivity levels in samples collected from the WMF wells were generally typical of background levels. However, one sample from upgradient Well 066-83 had a gross beta concentration of 61 pCi/L (2.3 Bq/L), which exceeded the 50 pCi/L (1.8 Bq/L) drinking water standard. It is likely that the elevated gross beta concentration is due to naturally occurring radionuclides such as potassium-40. Compared to previous years results, low levels of cobalt-60 (<10 pCi/L or <0.4 Bq/L) were not detected in samples collected from upgradient Well 066-07 during 2000. The source of the cobalt-60 was historical releases that occurred at Building 830.

7.5.2.7 BIOLOGY DEPARTMENT GREENHOUSE AREA

The Biology Department facility includes 11 greenhouses where various types of plants are grown for biological research. Eight of the greenhouses have dirt floors and three have concrete floors. Pesticides and fertilizers have been routinely used in the greenhouses. Records also indicate that copper sulfate was applied to the dirt floors on an annual basis until the mid-1980s. The pesticide Endosulphan II was detected in soil samples collected from a dry well located within Greenhouse 10.

Metals, Anions and Pesticides

Two wells are used to monitor groundwater quality in the greenhouse area. The wells were sampled in May and September 2000, and tested for pesticides, metals, and anions. Groundwater monitoring results for 2000 indicate that current greenhouse operations are not impacting groundwater quality. Pesticides were not detected in any of the samples and all water quality and most metals concentrations were below the applicable NYS AWQS. Sodium was detected at concentrations slightly above the standard of 20 mg/L in the samples collected from both wells in May. The detection of low levels of sodium is not uncommon in wells located within the developed area of the site and could be related to road salting operations.

7.5.2.8 SHOTGUN RANGE

The BNL Shotgun Range is used for trap and skeet target shooting by the Brookhaven Employees Recreation Association. The shotgun range is located in an isolated, wooded area north of the new Waste Management Facility. The range was established in 1974. Clay targets are thrown south from the trap house into an open field that is approximately 205 feet (62 m) east-west by 410 feet (125 m) north-south. Although most of the shot falls within the cleared range, shooting from several of the trap line positions results in the deposition of some of the shot into the nearby wooded areas.

From 1974 until 2000, the shotgun shells used at the facility typically contained lead pellets. It is estimated that as many as 30,000 shotgun rounds per year have been used at the range. At an average of 1.125 oz. per round, as much as 2,100 pounds (954 kg) of lead may have been deposited on the surface of the range annually. To prevent additional deposition of lead, in early 2000 BNL implemented a rule that allows only steel shot to be used at the range.

Metals and Anions

The three Shotgun Range groundwater monitoring wells were sampled in May and September 2000. All water quality (e.g., chlorides, sulfates and nitrate) and metals concentrations were below the applicable NYS AWQS and were consistent with established background levels for Long Island. Lead was not detected in any of the groundwater samples.

7.5.2.9 LIVE-FIRE RANGE

The BNL Live-Fire Range consists of a six-position, 100-yard (91 m), bermed out door small arms and grenade range. The primary use of the current facility is to allow members of the BNL Safeguards and Security group to

practice and qualify in the use of firearms and to gain experience in the use of smoke and tear gas grenades. Federal law enforcement agencies and the Brookhaven Employees Recreation Association also occasionally use the range.

The Live-Fire Range was constructed in 1986 and is located immediately to the north of the BNL Sewage Treatment Plant. The eastern half of the range is located within 200 feet (61 m) of the Peconic River. The small arms and grenade ranges are co-located, side-by-side. The bullet stop at the range is an earthen berm, and bullets are known to have a typical penetration depth of approximately two to three inches into the berm. The soil of the rear berm is periodically screened to a depth of approximately one foot (0.305 m). The lead shot recovered during the screening process and the spent brass cartridges are disposed of offsite via a commercial waste handler as scrap metal. The grenade range is essentially an open field surrounded by earthen berms.

Metals and Anions

The two Live-Fire Range wells were sampled in May and September 2000. All water quality and metals concentrations were below the applicable NYS AWQS and were consistent with established background levels for Long Island. Lead was not detected in any of the samples.

7.6 ENVIRONMENTAL RESTORATION (ER) GROUNDWATER MONITORING PROGRAM

The mission of the ER groundwater monitoring program is to monitor the various contaminant plumes located onsite and offsite, as well as to monitor the progress that the groundwater treatment systems are making on plume remediation. The groundwater monitoring information described below provides an overview of ER groundwater monitoring and remediation activities for 2000. During this period, a total of 563 groundwater surveillance wells were monitored during approximately 2,180 individual sampling events. All wells sampled during 2000 are listed in Appendix E. Detailed analytical results for the ER Program are provided in the *BNL CY 2000 Groundwater Status Report* (BNL 2001).

Maps showing the main VOC and radionuclide plumes are provided as Figures 7-6 and 7-7. For each significant contaminant source area and plume described below, specific groundwater contaminant distribution maps are provided. These maps depict the areal extent of contamination, and were created by selecting the highest contaminant concentration observed for a given set of wells during a selected sampling period. Associated cross sections showing the vertical distribution/extent of contamination, as well as the hydrogeology for the BNL site and surrounding areas are described in the *BNL CY 2000 Groundwater Status Report* (BNL 2001).

7.6.1 BACKGROUND MONITORING

Background groundwater quality for the BNL site is monitored through a network of 13 wells located in the northern portion of the site and in offsite areas to the north. The site background wells provide information on the chemical and radiological composition of groundwater that has not been affected by activities at BNL. These background data are a valuable reference for comparison with groundwater quality data from areas that have been affected. This well network can also provide warning of any contaminants originating from potential sources of contamination that may be located upgradient of the BNL site.

There were no significant detections of VOCs in background wells. The highest concentration detected was chloroform at 2.2 µg/L in Well 000-120, which is a shallow Upper Glacial aquifer well, located immediately north of the northwest corner of the site. The NYS AWQS for chloroform is 7 µg/L. Historically, low concentrations of VOCs have been detected in some background wells. All radionuclide concentrations were consistent with natural levels.

7.6.2 OPERABLE UNIT I

7.6.2.1 FORMER LANDFILL, ANIMAL/CHEMICAL PITS AND GLASS HOLES

The Former Landfill area was initially used by the U.S. Army as a landfill area during World Wars I and II. Then BNL used the southeast corner of the landfill from 1947 through 1966 for disposal of construction and demolition debris, sewage sludge, chemical and low-level radioactive waste, used equipment, and animal carcasses. From 1960 through 1966, BNL waste, glassware containing chemical and radioactive waste, and animal

carcasses containing radioactive tracers were disposed of in shallow pits in an area directly east of the Former Landfill. From 1966 through 1981, BNL disposed of used glassware in shallow pits located directly north of these chemical/animal pits. The Former Landfill was capped in 1996 and the Animal/Chemical Pits and Glass Holes were excavated in 1997.

A network of eight monitoring wells is used to monitor the Former Landfill area. The monitoring program for the Former Landfill is designed in accordance with post-closure operation and maintenance requirements specified in 6 NYCRR Part 360, "Solid Waste Management Facilities." These requirements specify that the well network be monitored quarterly for a minimum of five years, after which time BNL may petition NYSDEC to modify the frequency and types of analyses based on supporting data. The objective of this program is to monitor radiological and nonradiological contamination in the shallow Upper Glacial aquifer immediately downgradient of the landfill. The program was initiated following the capping of the Former Landfill in November 1996, to verify whether the cap effectively prevents the continued leaching of contaminants from the landfill, and to document anticipated long-term improvements to groundwater quality. In addition to these wells, BNL established a separate network of 24 wells to monitor the Animal/Chemical Pits and Glass Holes areas, and the downgradient portions of the Former Landfill plume. The downgradient portions of these plumes are currently being monitored as part of the OU I/IV Pre-Record of Decision Monitoring Program.

Volatile Organic Compounds

The areal extent of VOC contamination from the Former Landfill - Animal/Chemical Pits and Glass Holes area is shown on Figure 7-9. The primary chemical contaminants observed in the Former Landfill - Animal/Chemical Pits and Glass Holes plume are carbon tetrachloride (CT), TCA, 1,1-dichlroethylene (DCE), trichloroethylene (TCE), tetrachloroethylene (PCE) and chloroform. The plume is approximately 9,700 feet (2,956 m) in length from the Former Landfill source areas to just south of Crestwood Drive in North Shirley. The plume is defined by areas having total volatile organic compound (TVOC) concentrations greater than 5 µg/L. (Note: The NYS AWQS for most of the compounds listed is 5 µg/L. A TVOC concentration is the sum of all individual VOC concentrations detected in a given sample.) The area of the plume showing the highest TVOC concentration is located offsite near Sleepy Hollow Drive in North Shirley, and is composed primarily of CT and PCE, with a maximum TVOC concentration of 151 µg/L detected in Well 000-154. In general, VOCs are found in the shallow Upper Glacial aquifer in the vicinity of the Former Landfill, Animal/Chemical Pits and Glass Holes area, in the middle Upper Glacial aquifer at the southern site boundary, and in the deep Upper Glacial aquifer south of BNL. For a more detailed discussion on the vertical distribution of VOC contamination, see the *BNL CY 2000 Groundwater Status Report* (BNL 2001).

A comparison of the TVOC plume distribution from 1997 through 2000 is shown on Figure 7-9. Comparison of the groundwater data indicates that the capping of the Former Landfill in November 1996 and the excavation of the Chemical/Animal Pits and Glass Holes in September 1997 have contributed to the decline of TVOC concentrations to below 5 µg/L in shallow wells located near the source areas. Since 1997, TVOC concentrations greater than 1,000 µg/L that were observed in the vicinity of Stratler Drive, Shirley, have declined to less than 250 µg/L. Construction of the North Street Groundwater Remediation System is planned for late 2001, and will focus on reducing the high concentration VOC contamination in this area (see Figure 7-17).

Radionuclides

Strontium-90 has been routinely detected in groundwater in the Former Landfill, Animal/Chemical Pits and Glass Holes areas at concentrations above the drinking water standard of 8 pCi/L (0.3 Bq/L); specifically in Wells 106-16, 106-13, 097-03, and 097-64. There are two strontium-90 plumes (as defined by the 8 pCi/L standard) that are located close to the source areas. One plume originates from the Former Landfill and the second originates from the Animal/Chemical Pits area (Figure 7-10).

Comparison of the groundwater data indicates that the capping of the Former Landfill in November 1996 has contributed to

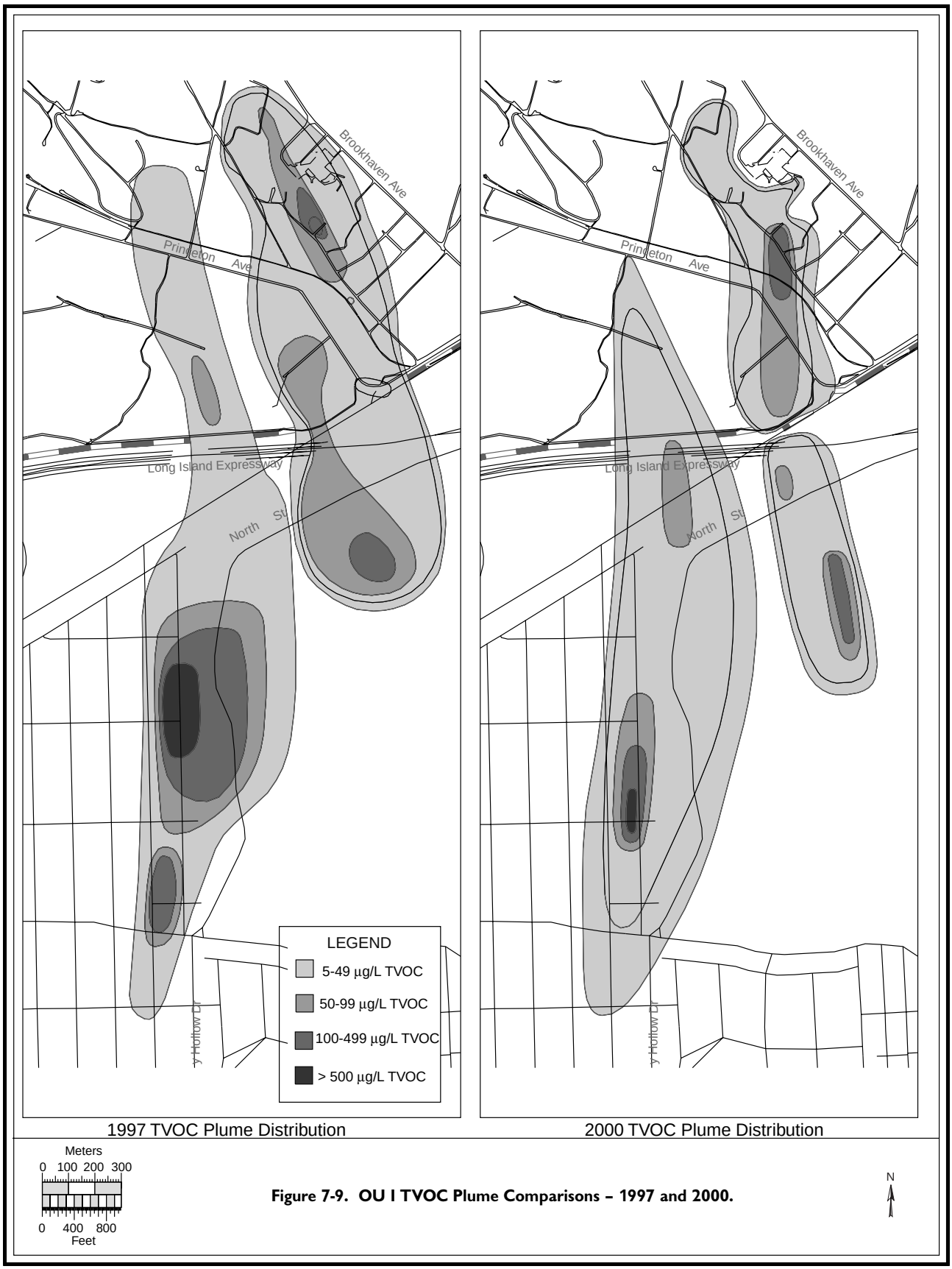


Figure 7-9. OU I TVOC Plume Comparisons – 1997 and 2000.

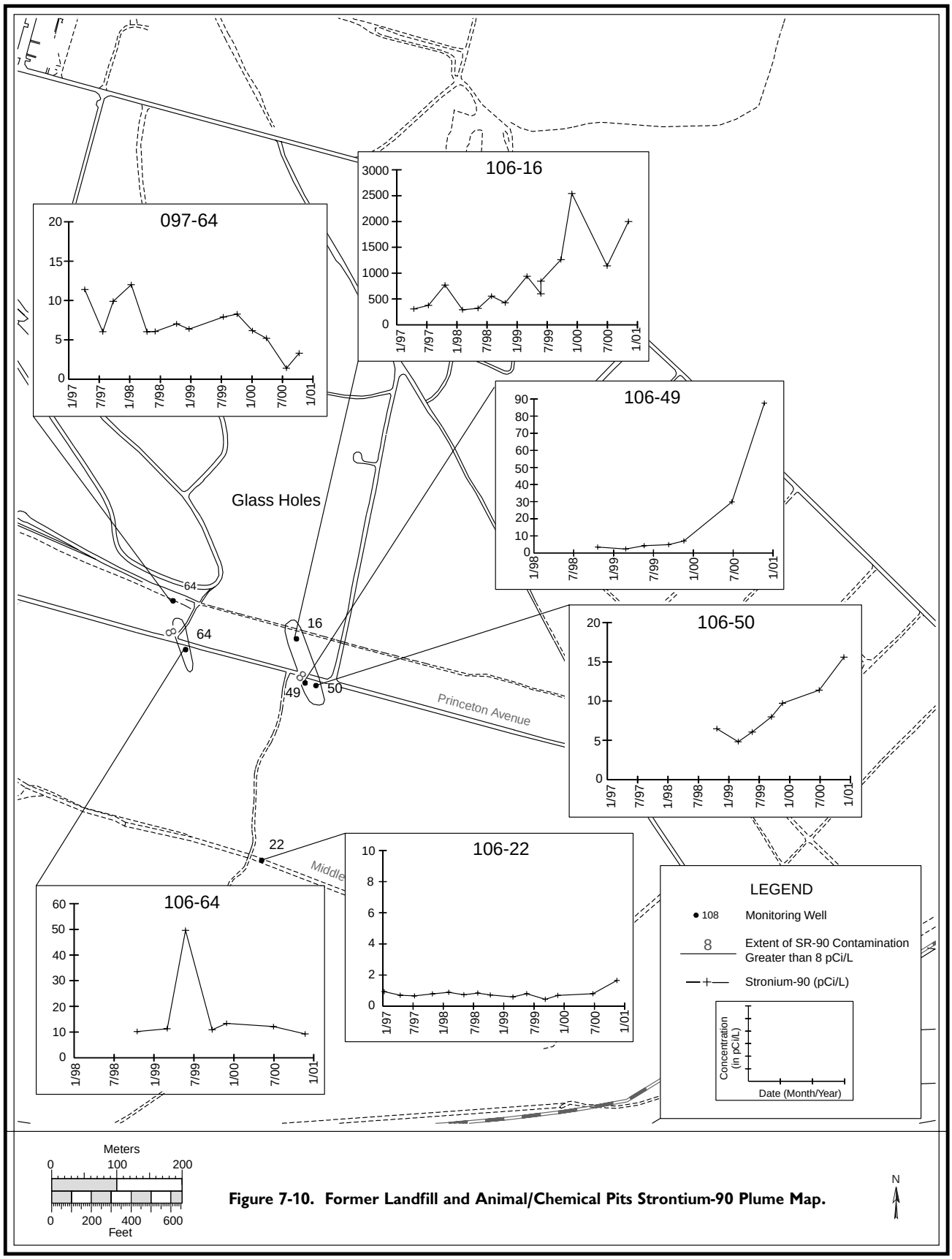


Figure 7-10. Former Landfill and Animal/Chemical Pits Strontium-90 Plume Map.

the decline of strontium-90 concentrations to below 8 pCi/L (0.3 Bq/L) in shallow wells located near the source areas. The highest strontium-90 concentration was 9.3 pCi/L (0.34 Bq/L) detected in Well 106-64, which is located approximately 350 feet (107 m) downgradient of the Former Landfill. Much higher strontium-90 concentrations were detected in areas downgradient of the Animal/Chemical Pits and Glass Holes area. Well 106-16, located immediately downgradient of the Animal/Chemical pits area, showed a maximum concentration of 2,000 pCi/L (74 Bq/L) in November 2000. Historical trends in strontium-90 concentration for key wells are presented in Figure 7-10. The leading edge of the Animal/Chemical Pits strontium-90 plume has migrated towards Wells 106-49 and 106-50 (located approximately 450 feet [137 m] downgradient) as evidenced by increasing strontium-90 concentrations in these wells during 2000.

7.6.2.2 CURRENT LANDFILL

The Current Landfill operated from 1967 through 1990. (Note: This landfill is called the Current Landfill to distinguish it from the older [Former] landfill that closed in 1966.) It was used for disposal of putrescible waste, sludge containing precipitated iron from the Water Treatment Plant, and anaerobic digester sludge from the Sewage Treatment Plant. The latter contained low concentrations of radionuclides, and possibly metals and organic compounds. BNL also disposed of limited quantities of laboratory wastes containing radioactive and chemical material at the landfill. As a result, the Current Landfill is a source of groundwater contamination. Permanent closure (capping) of this landfill was completed in November 1995 as part of the ER Program.

The Current Landfill post-closure groundwater monitoring program consists of a network of 11 monitoring wells situated adjacent to the landfill, in both upgradient and downgradient locations. These wells are monitored quarterly to determine the cap's effectiveness in preventing the continued leaching of contaminants from the landfill, and to document the anticipated long-term improvements to groundwater quality. The monitoring well network was designed in accordance with New York State specified landfill post-closure Operation and Maintenance requirements.

Volatile Organic Compounds

Although VOCs continue to be routinely detected in wells located immediately downgradient of the landfill, their concentrations have decreased in response to the capping of the landfill. The highest TVOC concentration observed during 2000 was 36 µg/L, detected in Well 88-109. Well 88-109 is a shallow water table well located at the southeast corner of the landfill. A detailed discussion of the groundwater monitoring results for the Current Landfill area are included in the *BNL CY 2000 Groundwater Status Report* (BNL 2001).

Radionuclides

As in previous years, low levels of tritium and strontium-90 were detected in Current Landfill monitoring wells during 2000, but at concentrations well below their applicable drinking water standards of 20,000 pCi/L (740 Bq/L) and 8 pCi/L (0.3 Bq/L), respectively. The highest tritium value was 1,950 pCi/L (72 Bq/L) in Well 088-11, and the highest strontium-90 value was 4.9 pCi/L (0.2 Bq/L) detected in Well 088-21.

7.6.2.3 FORMER HAZARDOUS WASTE MANAGEMENT FACILITY (HWMF) AND DOWNGRADIENT SECTION OF CURRENT LANDFILL PLUME

Groundwater contamination originating from the former HWMF and the downgradient section of the Current Landfill plume is being monitored under the Removal Action V (RA V) program. Until 1997, the former HWMF was BNL's central facility for processing, neutralizing, and storing hazardous and radioactive wastes before offsite disposal. As the result of past waste handling and storage practices, groundwater at the former HWMF is contaminated with both chemicals and radionuclides at concentrations that exceed NYS AWQS or DWS.

The Current Landfill and former HWMF plumes become commingled south of the HWMF due, at least partially, to historical pumping and recharge effects of the former Spray Aeration System, which operated from 1985 to 1990. The Spray Aeration System was designed to treat VOC-contaminated groundwater originating from the HWMF. The Current Landfill/HWMF plume is currently being remediated using a groundwater extraction and treatment system consisting of two wells screened in the deep portion of the

Upper Glacial aquifer at the site boundary (the RA V Treatment System is described in Section 7.7.3). This system provides hydraulic containment of those onsite portions of the plume that have TVOC concentrations greater than 50 µg/L.

The RA V monitoring program uses a network of 54 monitoring wells located in areas downgradient of the Current Landfill and HWMF. For a detailed description of the RA V remediation system and its effects on the VOC plume, refer to the *BNL CY 2000 Groundwater Status Report* (BNL 2001).

Volatile Organic Compounds

TVOC concentration distributions for the Current Landfill/HWMF plume are shown in Figure 7-9. The primary VOCs found onsite include chloroethane and DCA; whereas TCA, DCE, TCE, and chloroethane are found in the offsite portion of the plume. The Current Landfill/HWMF plume, as defined by TVOC concentrations greater than 5 µg/L, extends from the Current Landfill south to an area south of North Street, a distance of approximately 7,150 feet (2,180 m). Chloroethane, TCA, and DCA are detected in the shallow Upper Glacial aquifer near the source areas, and in the deep Upper Glacial aquifer at the site boundary and offsite. The maximum TVOC level detected onsite was in Well 098-59, at a concentration of 145 µg/L. TCA, DCE, TCE, and chloroform are found in the middle to deep Upper Glacial aquifer offsite south of North Street, with TVOC concentrations up to 129 µg/L detected in Well 000-124. Cross sectional views of the plume are presented in the *BNL CY 2000 Groundwater Status Report* (BNL 2001).

There have been several distinct changes in the distribution of the plume from 1997 through 2000 as shown on Figure 7-9. In general, the width of the plume has significantly decreased. The onsite reduction in plume width can be attributed to the effects of the groundwater extraction system located at the site boundary. Hydraulic control of the plume at the site boundary has been achieved as evidenced by the groundwater flow patterns in this area, and the decrease in contaminant concentrations (less than 20 µg/L) in Well 000-138 located downgradient of the extraction wells. A new groundwater treatment system (North Street East) is scheduled to be constructed in 2003. This treatment system is designed to remediate the high concentration portion of the VOC plume located offsite (see Figure 7-17).

Radionuclides

During 2000, tritium was detected in several wells, but at concentrations well below the 20,000 pCi/L (740 Bq/L) drinking water standard. The maximum observed tritium concentration during 2000 was detected in Well 088-26, at a concentration of 1,260 pCi/L (47 Bq/L). Well 088-26 is located within the former HWMF. Low levels of strontium-90 were detected in three wells located within or immediately downgradient of the HWMF. Strontium-90 concentrations exceeded the 8 pCi/L (0.3 Bq/L) standard in Well 088-26, with a maximum concentration of 10 pCi/L (0.4 Bq/L) detected in August 2000.

7.6.3 OPERABLE UNIT (OU) III

The monitoring well network established to monitor the OU III VOC and radionuclide source areas and associated contaminant plumes is composed of approximately 180 monitoring wells positioned from the north-central portion of the site to the southern site boundary and offsite. The OU III groundwater monitoring program is specifically designed to address the following groundwater contamination and plume remediation issues:

- Monitor VOC plumes with identified or suspected sources in the AGS Complex, Paint Shop, former carbon tetrachloride (CT) underground storage tank area, former Building 96 area, and the Supply and Material area.
- Monitor the tritium plume associated with the High Flux Beam Reactor (HFBR) and strontium-90 plumes associated with the Waste Concentration Facility and the formerly operated Brookhaven Graphite Research Reactor (BGRR).
- Evaluate the effectiveness of the OU III south boundary groundwater pump-and-treat system initiated in June 1997. This monitoring program characterizes the effects of the pumping on the contaminant plume and provides the data necessary for making decisions on the future operations of the extraction wells (See Section 7.7.1).
- Monitor the offsite segment of the OU III plume and "outpost" wells located to the south (downgradient) of the defined extent

of the offsite VOC plume to provide data on future downgradient migration of the plume. Outpost wells are also situated in the southwestern portion of BNL, directly upgradient of the Suffolk County Water Authority's Parr Village Well Field located near the William Floyd Parkway. These wells provide an early warning if contaminants from BNL were to migrate toward the Suffolk County Water Authority wells.

7.6.3.1 VOLATILE ORGANIC COMPOUND PLUMES

Figure 7-11 shows the areal extent of the OU III VOC plume and the OU IV VOC plume. The two plumes are so close to each other that it is difficult to represent them as distinct, separate plumes. The OU III VOC plume extends from the AGS Complex area in the central part of the site south to the vicinity of Flower Hill Drive in North Shirley, a distance of approximately 17,600 feet (5,360 m). The plume is approximately 5,000 feet (1,525 m) at its maximum width, as defined by TVOC concentrations greater than 5 µg/L. The higher concentration portion of the plume (i.e., containing concentrations greater than 50 µg/L) is approximately 1,900 feet (580 m) wide near the BNL southern boundary.

The OU III VOC plume is actually comprised of multiple commingled plumes originating from several sources. To determine the extent of VOC contamination, monitoring well data from 11 separate ER and Environmental Surveillance monitoring programs are evaluated. These monitoring programs include the OU III Central area, Southern Boundary area, Carbon Tetrachloride Plume, former Building 96 area, AS-Industrial Park area, Offsite Program, select downgradient wells from the HFBR tritium monitoring program, Alternating Gradient Synchrotron Complex area, and the Motor Pool and Service Station areas. The primary VOCs detected in onsite monitoring wells include TCA, PCE, and carbon tetrachloride (CT); whereas CT and PCE are the primary VOCs detected in offsite groundwater. In general, PCE, TCA, and CT are observed in the shallow portions of the Upper Glacial aquifer in the central portion of BNL and in the deep Upper Glacial aquifer and uppermost Magothy aquifer at the southern boundary and offsite areas.

During 2000, wells displaying the highest TVOC concentrations (i.e., greater than 1,000 µg/L) include the former Building 96 area, the former CT underground storage tank area, areas near the South Boundary Treatment System, and the offsite Industrial Park Treatment System area. A comparison of the OU III plume distribution from 1997 and 2000 is provided on Figure 7-11.

7.6.3.1.1 FORMER BUILDING 96 AREA

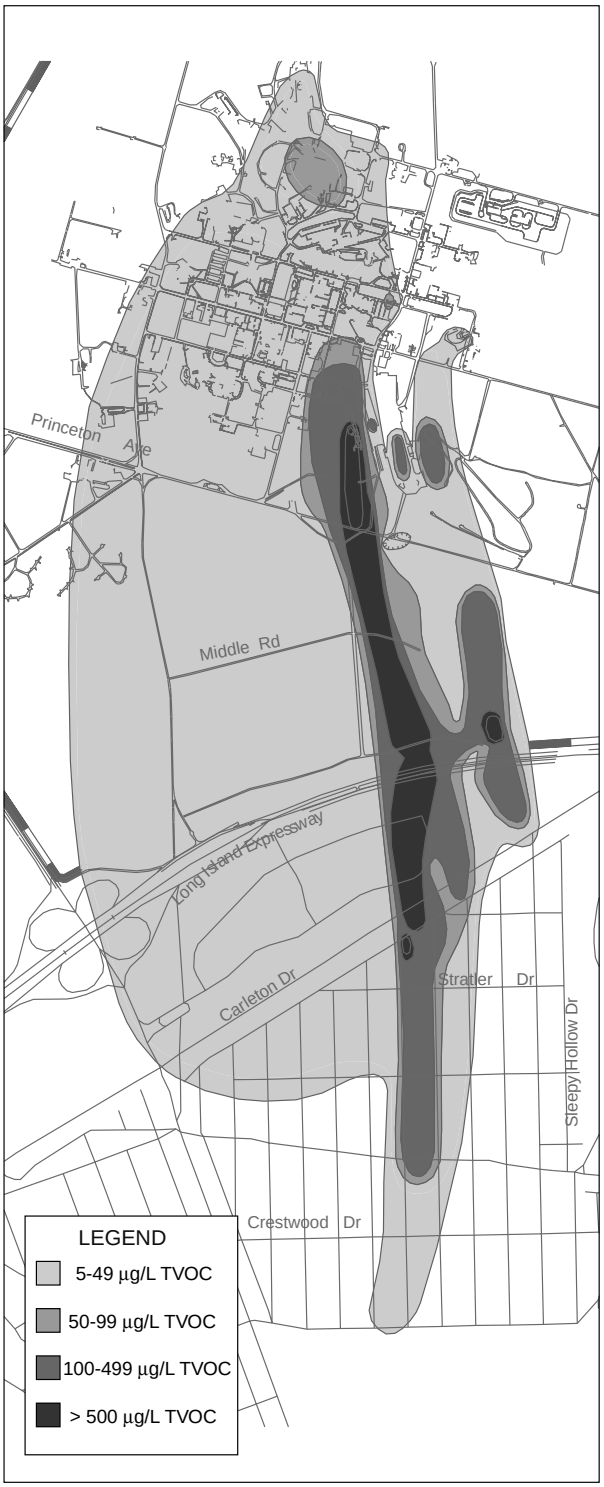
The VOC plume in the former Building 96 area consists primarily of PCE, and lower concentrations of TCA, with TVOC concentrations up to 2,066 µg/L detected in Well 095-84. The NYS AWQS for each of these compounds is 5 µg/L. During 2000, construction began on an in-well air sparging system to remediate the Building 96 source area (Figure 7-17). This groundwater treatment system is expected to be operational in early 2001.

7.6.3.1.2 FORMER CARBON TETRACHLORIDE TANK AREA

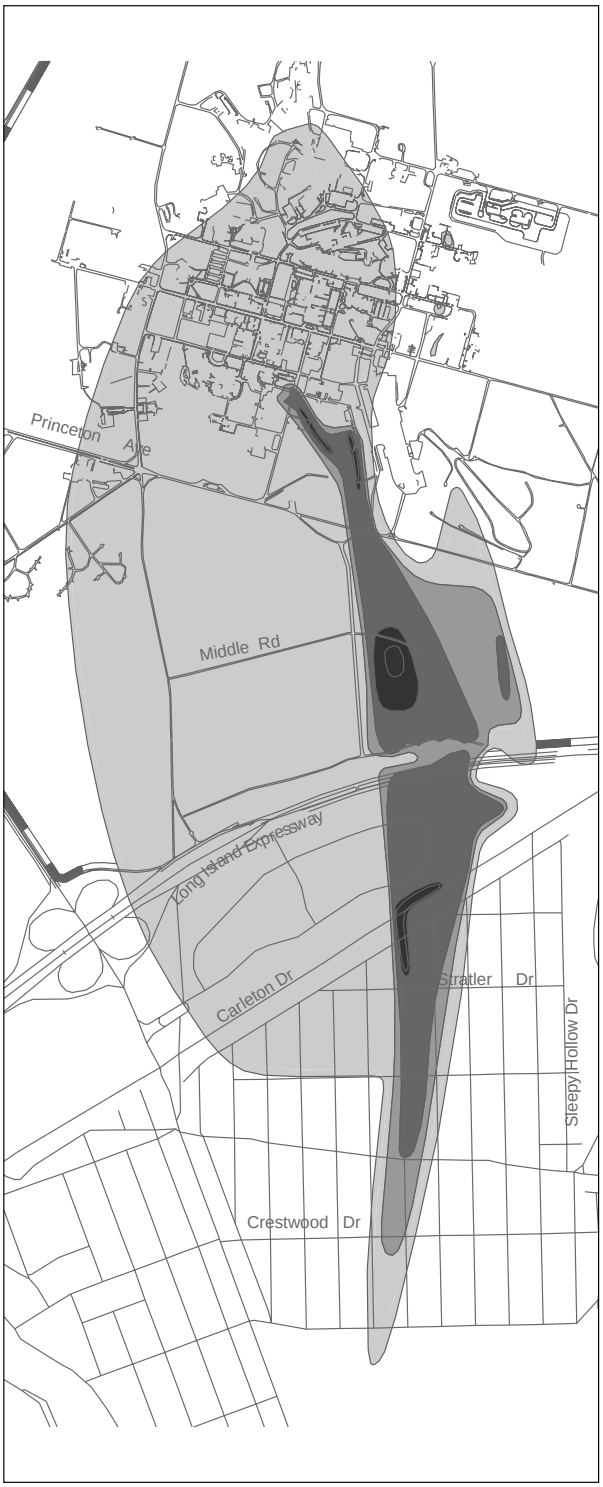
In April 1998, an inactive underground storage tank used for the storage of CT was excavated and removed. This tank was located approximately 200 feet (61 m) northeast of the Upton Service Station. Although groundwater samples collected from a nearby well had shown low-level concentrations of CT since 1995, samples collected in June 1998 revealed levels approaching 100,000 µg/L. The NYS AWQS for CT is 5 µg/L. It is now apparent that the increase in contaminant concentration was probably due to the spillage of residual CT during removal of the underground storage tank. A groundwater remediation system consisting of two extraction wells screened in the shallow Upper Glacial aquifer began operation in October 1999. The effects of the pump-and-treat system on the source area are apparent in the sharp decline in CT concentrations in wells near the former UST area (see Section 7.7.4 for a description of the treatment system). The leading edge of the CT plume appears to be located in the vicinity of onsite Recharge Basin HW located near Weaver Drive. During 2000, the highest CT concentrations (up to 4,400 µg/L) were detected in Well 085-17 located approximately 250 feet (76 m) downgradient of the former UST area.

7.6.3.1.3 SOUTHERN BOUNDARY AREA

Hydraulic control of the OU III plume at the site boundary has been attained as can be



1997 TVOC Plume Distribution



2000 TVOC Plume Distribution

Meters
0 200 400
0 1000
Feet

Figure 7-11. OU III and OU IV TVOC Plume Comparisons – 1997 and 2000.

N

seen in Figure 7-11. The OU III South Boundary treatment system consists of seven extraction wells, which pump water from the deep portions of the Upper Glacial aquifer to an air stripper for treatment (see Section 7.7.1). TVOC concentrations in monitoring wells located near the extraction well system are generally less than 100 µg/L. Several wells located immediately downgradient of the extraction wells show TVOC concentrations in the range of 50 µg/L to 150 µg/L. Groundwater modeling indicates that these wells are located within the stagnation zone (i.e., a zone where there is little groundwater movement) created by the extraction wells. The *BNL CY 2000 Groundwater Status Report* (BNL 2001) contains detailed information on the OU III South Boundary system operations and progress on the remediation effort.

7.6.3.1.4 INDUSTRIAL PARK TREATMENT SYSTEM AREA

The portion of the OU III TVOC plume with concentrations greater than 1,000 µg/L extends from the offsite Industrial Park area to Carleton Drive in North Shirley. This plume, which consists primarily of CT, is located in the deep portions of the Upper Glacial aquifer and upper portion of the Magothy aquifer. A groundwater treatment system, consisting of seven in-well air stripping treatment wells, was installed in the industrial park located south of BNL in 1999 (see Section 7.7.2). The purpose of the in-well air stripping wells is to treat VOC contamination located in the deep Upper Glacial aquifer. Thirty-six monitoring wells were also installed in this area to monitor the effects of the system (i.e., hydraulic control and changes in VOC concentrations). Samples from deep wells located near the offsite Industrial Park indicate that there is significant CT and PCE contamination in the deep Upper Glacial aquifer and uppermost Magothy aquifer in that area. Deep Upper Glacial aquifer Well 000-253 and Magothy aquifer Well 000-130 had maximum TVOC concentrations of 9,780 µg/L and 3,169 µg/L, respectively. Additional characterization of VOC contamination in the Magothy aquifer began in 2000 and will be completed by the end of 2001.

A new groundwater remediation system is being planned for the remediation of the southern extent of the OU III plume. The treatment system will be located along the northern edge of the Town of Brookhaven Airport and is scheduled to be constructed by 2003 (see Figure 7-17).

7.6.3.2 RADIONUCLIDE PLUMES

7.6.3.2.1 HFBR TRITIUM PLUME

Following the January 1997 discovery of tritium in wells south of the HFBR, it was determined that the HFBR's spent fuel pool was leaking tritiated water at a rate of approximately six to nine gallons per day. To prevent additional release of tritiated water, the HFBR's spent-fuel pool was completely emptied in December 1997. During 1997, an extensive groundwater investigation demonstrated that the tritium plume remained completely onsite, and an interim remediation system was constructed to control the leading edge of the plume.

The HFBR tritium plume (defined by concentrations greater than 1,000 pCi/L [37 Bq/L]; one-twentieth of the drinking water standard) extends from the HFBR to an area immediately north of Weaver Drive, a length of approximately 3,000 feet (915 m) (Figure 7-12). The portion of the plume with concentrations exceeding the 20,000 pCi/L (740 Bq/L) drinking water standard extends from the HFBR approximately 2,500 feet (760 m) to the south. Additional groundwater characterization was conducted during 2000 to increase the definition of the high concentration segment of the tritium plume (concentrations greater than 500,000 pCi/L [18,500 Bq/L]). This high concentration portion of the plume extends in a narrow band from Temple Place to approximately 250 feet (975 m) south. During 2000, the highest tritium concentrations were detected in Wells 075-291 and 075-294 located near Temple Place, where tritium concentrations exceeded 1,000,000 pCi/L. In an effort to remediate the high concentration portion of the plume, a low-flow pumping program was conducted using temporary wells. During 2000, approximately 65,000 gallons (246,025 liters) of water was extracted and then transported to an approved offsite disposal facility.

Because tritium concentrations dropped to nondetectable levels, the HFBR Pump and Recharge System extraction wells were shut down and placed in a stand-by mode in September 2000 (see Section 7.7.5). The system will be restarted if tritium concentrations increase to

Figure 7-12. HFBR Tritium Plume Comparisons – 1997 and 2000.

greater than 20,000 pCi/L in wells located near Weaver Drive. A detailed analysis of monitoring and remediation efforts is presented in the *BNL CY 2000 Groundwater Status Report* (BNL, 2001).

7.6.3.2.2 WASTE CONCENTRATION FACILITY (WCF) AND BROOKHAVEN GRAPHITE RESEARCH REACTOR (BGRR)/PILE FAN SUMP AREAS STRONTIUM-90 PLUMES

Historical waste handling operations at the WCF and operations at the former BGRR,

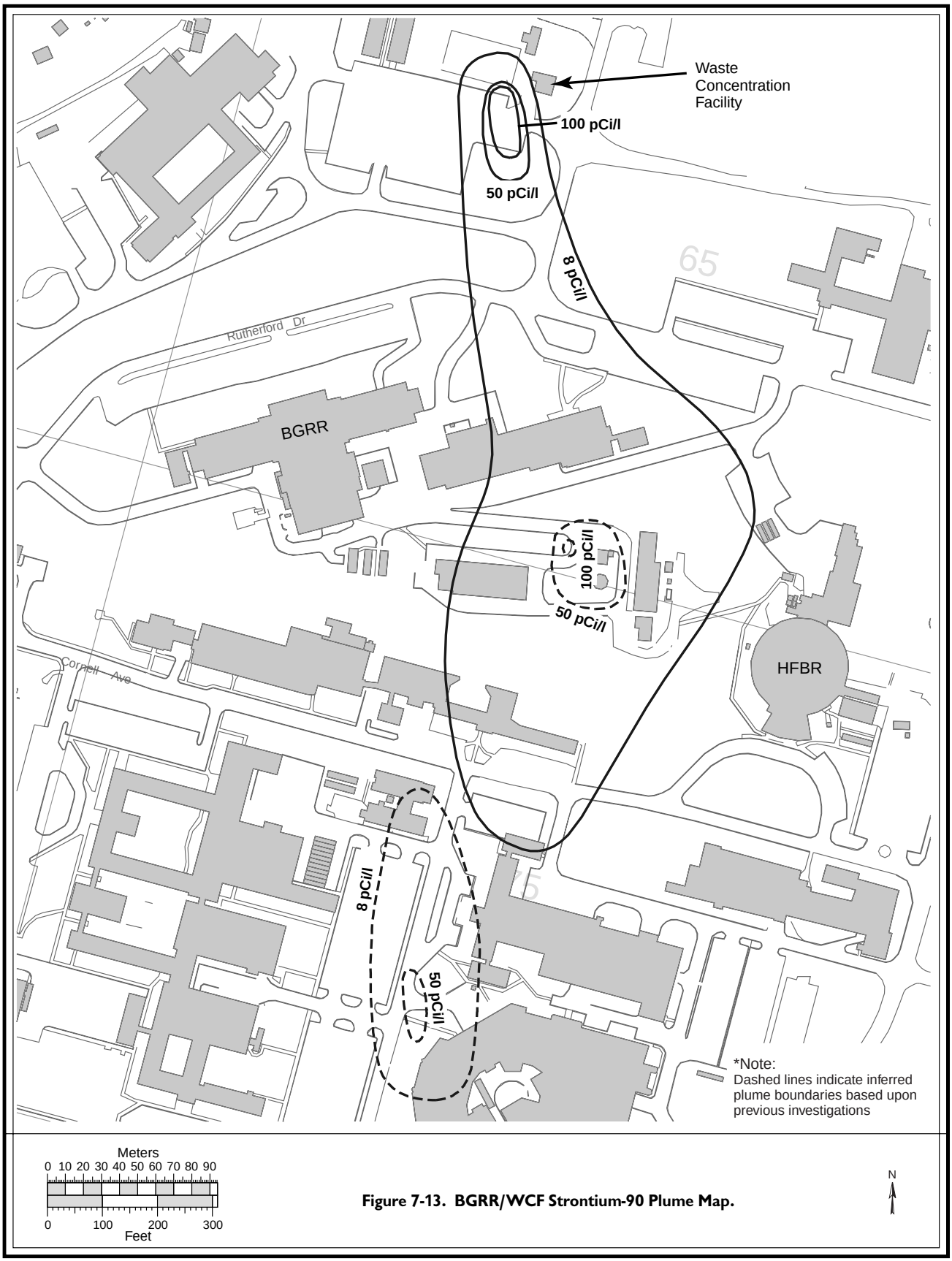


Figure 7-13. BGRR/WCF Strontium-90 Plume Map.

and its associated Pile Fan Sump, resulted in the release of strontium-90 to the groundwater below these facilities.
Two separate and distinct areas of strontium-90 contamination are recognized (Figure 7-13). The more significant of the two areas can be traced from the WCF area south to the area just north of Cornell Avenue, a distance of approximately 1,400 feet (425 m). The width of this plume, as defined by strontium-90 concentrations that exceed the 8 pCi/L (0.3 Bq/L) drinking water standard, is approximately 500 feet (150 m). The vertical extent of contamination is confined to the shallow and middle portion of the Upper Glacial aquifer. The highest concentration associated with the WCF plume is in shallow Well 065-175, at a concentration of 821 pCi/L (30 Bq/L). This well is located immediately downgradient of the WCF and is screened in the shallow portion of the Upper Glacial aquifer. A portion of this plume is composed of strontium-90 that was released in the Building 801 and nearby Pile Fan Sump area. This contamination is detected in shallow Upper Glacial aquifer wells located directly downgradient of the Building 801/ Pile Fan Sump area. The highest concentration associated with the Building 801/Pile Fan Sump portion of the plume is in shallow Well 065-172, at a concentration of 104 pCi/L (3.8 Bq/L).

The second area of strontium-90 contamination is located approximately 500 feet (150 m) south of the BGRR near Cornell Avenue. This plume, defined by strontium-90 concentrations greater than 8 pCi/L (0.3 Bq/L), extends approximately 550 feet (170 m) to an area just north of Brookhaven Avenue and is approximately 200 feet (60 m) wide. The highest concentration associated with the BGRR plume was detected in Well 075-199, at a concentration of 56 pCi/L (2 Bq/L).

In 2003, BNL will conduct additional characterization of the strontium-90 plumes to support the design of a new groundwater remediation system.

7.6.4 OPERABLE UNIT (OU) IV

The Operable Unit IV area contains two significant source areas: the 1977 fuel oil/ solvent spill site (AOC 5) and the Building 650 Sump and Sump Outfall area (AOC 6).

7.6.4.1 1977 OIL-SOLVENT SPILL SITE (AOC 5)

In 1977, approximately 25,000 gallons (94,625 liters) of a mixture of Number 6 fuel oil and mineral spirits were released from a ruptured pipe used to transfer the contents from an underground storage tank to aboveground storage tanks at the Central Steam Facility (CSF). The OU IV plume is composed of the solvents TCA, PCE, DCE, and TCE, and oil products (consisting of toluene, ethylbenzene, and xylene). Although the main source area appears to be in the vicinity of the 1977 spill, the detection of low levels of TCA and PCE in several upgradient wells indicates that some of the contamination originates from historical spills that occurred in the nearby CSF and Building 650 areas. Whereas TCA, PCE, DEC, and TCE have migrated considerable distances, the presence of toluene, ethylbenzene, and xylene is highly localized to the source area.

An air sparging/soil vapor extraction system (AS/SVE) has been in operation since November 1997 to remediate VOC and semi-VOC contamination of soils and groundwater near the spill site (see Section 7.7.6). Compared to pre-November 1997 monitoring results (when TVOC concentrations were typically greater than 1,000 µg/L), VOC concentrations in most wells located within the spill area dropped to below the 5 µg/L remediation goal. However, in October 2000, TVOC concentrations rebounded to 361 µg/L in one well (076-04) located in the immediate vicinity of the 1977 spill. This rebound effect was expected, as it is typical during late stages of remediation.

Monitoring of wells downgradient of the 1977 spill site indicates that the OU IV plume is now cut off from the source area. The OU IV plume, as defined by TVOC concentrations greater than 5 µg/L, now extends from an area just west of the Former Landfill to an offsite area just south of the Long Island Expressway, a distance of approximately 4,000 feet (1,219 m) (Figure 7-11). In the downgradient portion of the OU IV plume, the highest VOC concentrations during 2000 were found in the area between Princeton Avenue and the southern site boundary, with TVOC concentrations up to 180 µg/L in Well 106-54. VOCs were also detected in the upper Magothy aquifer Wells 122-05 and 122-24 at 85 µg/L and 286 µg/L, respectively.

Extraction Well EW-12, of the OU III Southern Boundary treatment system, provides hydraulic control for the downgradient portion of the OU IV plume. The changes in the OU IV plume distribution from 1997 through 2000 are shown on Figure 7-11, which depicts the combined OU III and OU IV plumes. The *BNL CY 2000 Groundwater Status Report* (BNL 2001) contains detailed information on system operations and remediation progress.

7.6.4.2 BUILDING 650 AND 650 SUMP OUTFALL AREAS (AOC 6)

During 2000, strontium-90 was not detected above the 8 pCi/L (0.3 Bq/L) drinking water standard in wells located downgradient of Building 650 (Figure 7-14). A strontium-90 concentration of 6.8 pCi/L (0.25 Bq/L) was detected in Well 76-28, which is located adjacent to the Building 650 sump/decontamination pad and downgradient of a former underground storage tank area. The strontium-90 detected in Well 076-28 probably originates from contaminated soils associated with decontamination pad and storage tank operations. Only a trace level of strontium-90 (0.5 pCi/L or 0.02 Bq/L) was detected in one of three wells located downgradient of Building 650.

Soil and groundwater contamination at the Building 650 Sump Outfall is due to the historical discharge of radionuclides to the Building 650 sump. The strontium-90 plume (defined by concentrations greater than 8 pCi/L [0.3 Bq/L] drinking water standard) extends from the 650 Outfall to Well 076-24, a distance of approximately 800 feet (240 m). During 2000, strontium-90 concentrations exceeded the drinking water standard in three downgradient wells, with the highest concentration observed in Well 076-169 at a concentration of 30.9 pCi/L (1.1 Bq/L).

7.6.5 OPERABLE UNIT V, EASTERN PLUME

The OU V monitoring program uses 34 monitoring wells located downgradient of the Sewage Treatment Plant (STP). These wells monitor VOC and tritium contamination resulting from historical releases at the STP. Surveillance of present groundwater quality at the STP is performed as part of the BNL Environmental Surveillance Program (see Section 7.5).

Volatile Organic Compounds, Metals, and Pesticides

The areal extent of VOC contamination is shown on Figure 7-15. The primary chemical contaminants found in the OU V Eastern VOC plume are TCE and TCA. The ambient water quality standard for both of these compounds is 5 μg/L. The Eastern VOC plume, defined by TVOC concentrations greater than 5 μg/L, extends from a location southeast of the STP to the Long Island Expressway offsite, a distance of approximately 5,300 feet (1,600 m). During 2000, the highest TVOC concentration was 33 μg/L, detected in Well 061-05 located at the site boundary near North Street (Figure 7-15). Vertically, the VOCs are present in the deep portions of the Upper Glacial aquifer. Monitored natural attenuation is the recommended remedial alternative for the VOC contamination at this time. A long-term remedy will be selected as part of the OU V Record of Decision.

Samples from key OU V wells were analyzed for Target Analyte List Metals, and samples from offsite wells were analyzed for pesticides/PCBs. None of the inorganic contaminants of concern initially identified during the OU V Remedial Investigation/Feasibility Study, including mercury and hexavalent chromium, were detected in 2000. Although trace amounts of the pesticides 4,4′-DDD and 4,4′-DDT were detected in several offsite wells during 1998, all samples collected during 2000 were nondetectable for these compounds.

Radionuclides

Detectable levels of tritium were found in a number of wells located near BNL's southeastern site boundary and several offsite wells. However, the concentrations were well below the drinking water standard of 20,000 pCi/L (740 Bq/L). In wells located near the southeastern site boundary, the maximum tritium concentration was detected in Well 50-02, at a concentration of 2,430 pCi/L (90 Bq/L). In offsite wells monitored during 2000, tritium was either nondetectable or just slightly above detection limits. (Note: The typical detection limit for tritium is 350 pCi/L [13 Bq/L].) A detailed discussion on the distribution of tritium within the OU V plume is provided in the CY *2000 Groundwater Status Report* (BNL 2001).

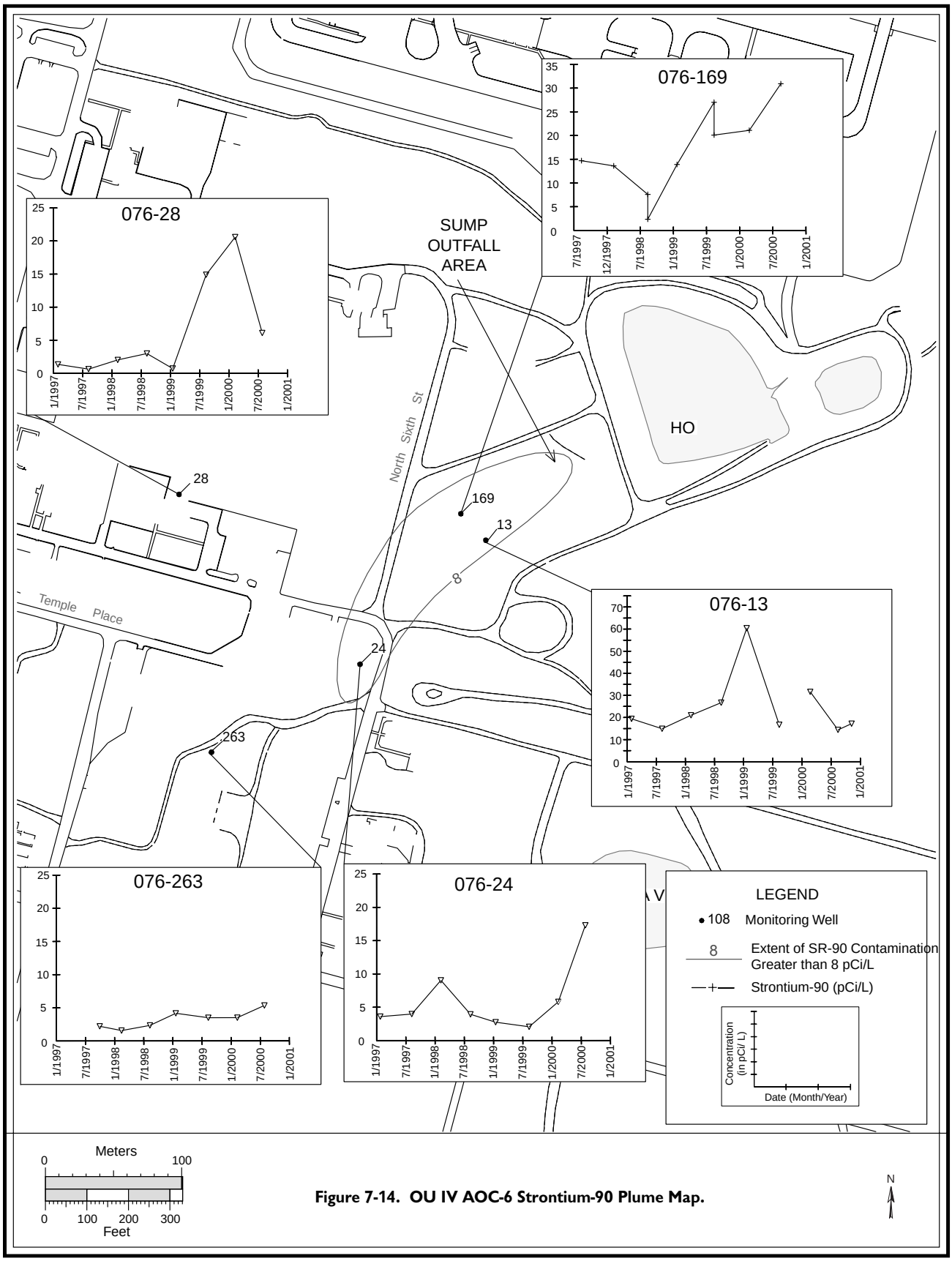


Figure 7-14. OU IV AOC-6 Strontium-90 Plume Map.

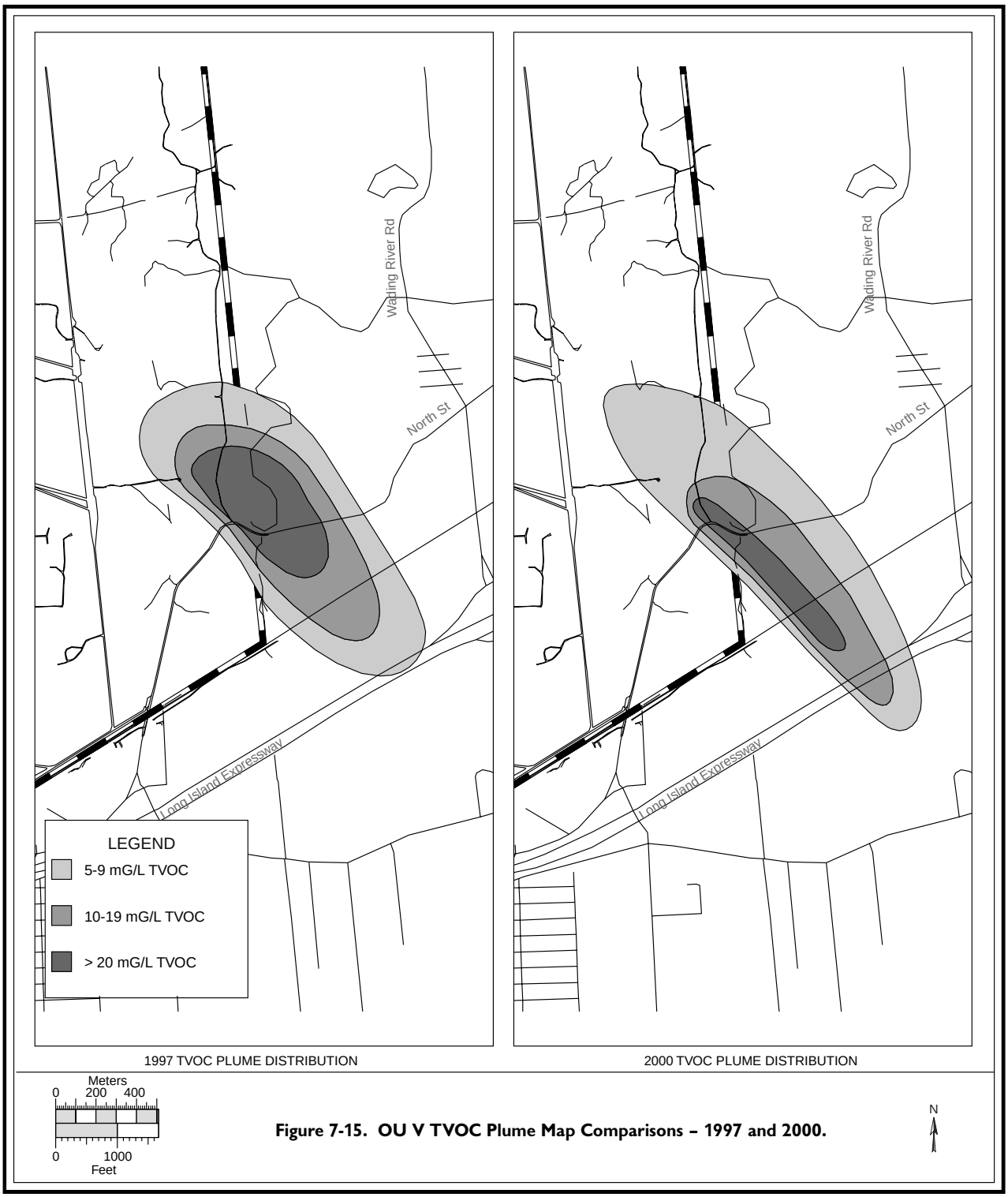


Figure 7-15. OU V TVOC Plume Map Comparisons – 1997 and 2000.

7.6.6 OPERABLE UNIT VI, BIOLOGY FIELDS

Ethylene dibromide (EDB) was used as a fumigant in the BNL Biology Department's agricultural fields located in the southeast portion of the site. Available records indicate that the application of EDB in this area took place in the 1970s. As the result of these historical releases of EDB, a contaminant plume (as defined by concentrations greater than the 0.05 μg/L drinking water standard for

Figure 7-16. OU VI EDB Plume Comparison – 1997 and 2000.

EDB) extends approximately 3,900 feet (1,190 m), from near BNL's southeastern site boundary to an area south of the Long Island Expressway (see Figure 7-16). EDB is the only contaminant of concern for the Biology Fields plume.

During 2000, the highest EDB concentration was found in offsite Well 000-175 (located south of North Street) at 2.8 µg/L. Vertically, EDB is found in the deep Upper Glacial aquifer at the southern site boundary and in offsite areas. Figure 7-16 shows a comparison

of the EDB plume from 1997 and 2000. The important changes in the plume are the downgradient migration of both the trailing edge of the plume and the area of highest EDB concentrations. A remediation system for this plume will be constructed by 2003.

7.7 GROUNDWATER TREATMENT SYSTEMS

The primary mission of BNL's Environmental Restoration Program is remediating soil and groundwater contamination, and preventing additional contamination from migrating off the BNL site. To that end, seven groundwater treatment systems are presently operating at BNL, and an eighth system (Former Building 97 Area) will be operational in 2001. Figure 7-17 shows the locations of these treatment systems. The following is a brief description of the groundwater treatment systems that were operational during 2000 along with a summary of their performance. Table 7-4 provides a summary of pounds of VOCs removed and gallons of water treated since the first treatment system became operational in 1997. During 2000, approximately 700 pounds (318 kg) of VOCs were removed from the groundwater, and more than one billion gallons (3.8 billion liters) of treated groundwater were returned to the aquifer. Detailed information on these treatment systems can be found in the *CY 2000 Groundwater Status Report* (BNL 2001).

7.7.1 OU III SOUTH BOUNDARY REMEDIATION SYSTEM

Construction of the OU III pump-and-treat system was completed in June 1997. The system uses seven wells to extract VOC-contaminated groundwater that originated from a number of sources located in the developed central portion of the BNL site. The water is pumped approximately one mile (1.6 km) north to an air-stripping tower located near the Medical Department complex, where air from a powerful blower separates the VOCs from the water. The removal efficiency is close to 100%. No VOCs were detected above the minimum detection limit (typically 0.5 μg/L) in treated water samples. The clean water is discharged to a nearby recharge basin, and the VOCs stripped from the water are released into the air at concentrations below state and federal emissions standards. The system processes approximately 600 gallons (2,271 liters) of water per minute. During 2000, approximately 325 pounds (148 kg) of VOCs were removed from the groundwater, and 381,700,000 gallons (1.4 billion liters) of treated groundwater were returned to the aquifer.

7.7.2 OU III OFFSITE GROUNDWATER TREATMENT SYSTEM

The OU III offsite groundwater remediation system became operational in the summer of 1999. The system was constructed south of the BNL site to remove VOC contamination that has migrated to an industrial area located between the Long Island Expressway and the residential areas of North Shirley. This remediation system consists of a series of innovative "in-well stripping" wells that use the same air stripping treatment concept as the OU III South Boundary Remediation System, but all treatment and recharge occurs within the well. Within each well, contaminated water is pumped from a deep well screen to a treatment system located near the top of the well, where VOCs are stripped from the water. The treated water is then routed to a shallower screened section of the same well where it reenters the aquifer. The VOC vapors are captured by a granular carbon filter. During 2000, approximately 177 pounds (80 kg) of VOCs were removed from 192,273,000 gallons (727 million liters) of groundwater.

7.7.3 OU I (RA V) SOUTH BOUNDARY REMEDIATION SYSTEM

This pump-and-treat system was completed in December 1996. The system uses two extraction wells to remove contaminated groundwater that originated from the Current Landfill (now closed and capped) and the former HWMF. The water is pumped approximately one mile north to an air stripper. This system processes more than 700 gallons (2,650 liters) of water per minute. Like the OU III South Boundary Remediation System, the RA V system removes close to 100% of the chemical contamination. No VOCs were detected above the minimum detection limit in treated water samples. The clean water is discharged to a nearby recharge basin, and the VOCs stripped from the water are released into the air at concentrations below state and federal emissions standards. During 2000, approximately 34 pounds (15 kg) of VOCs were removed from the groundwater, and

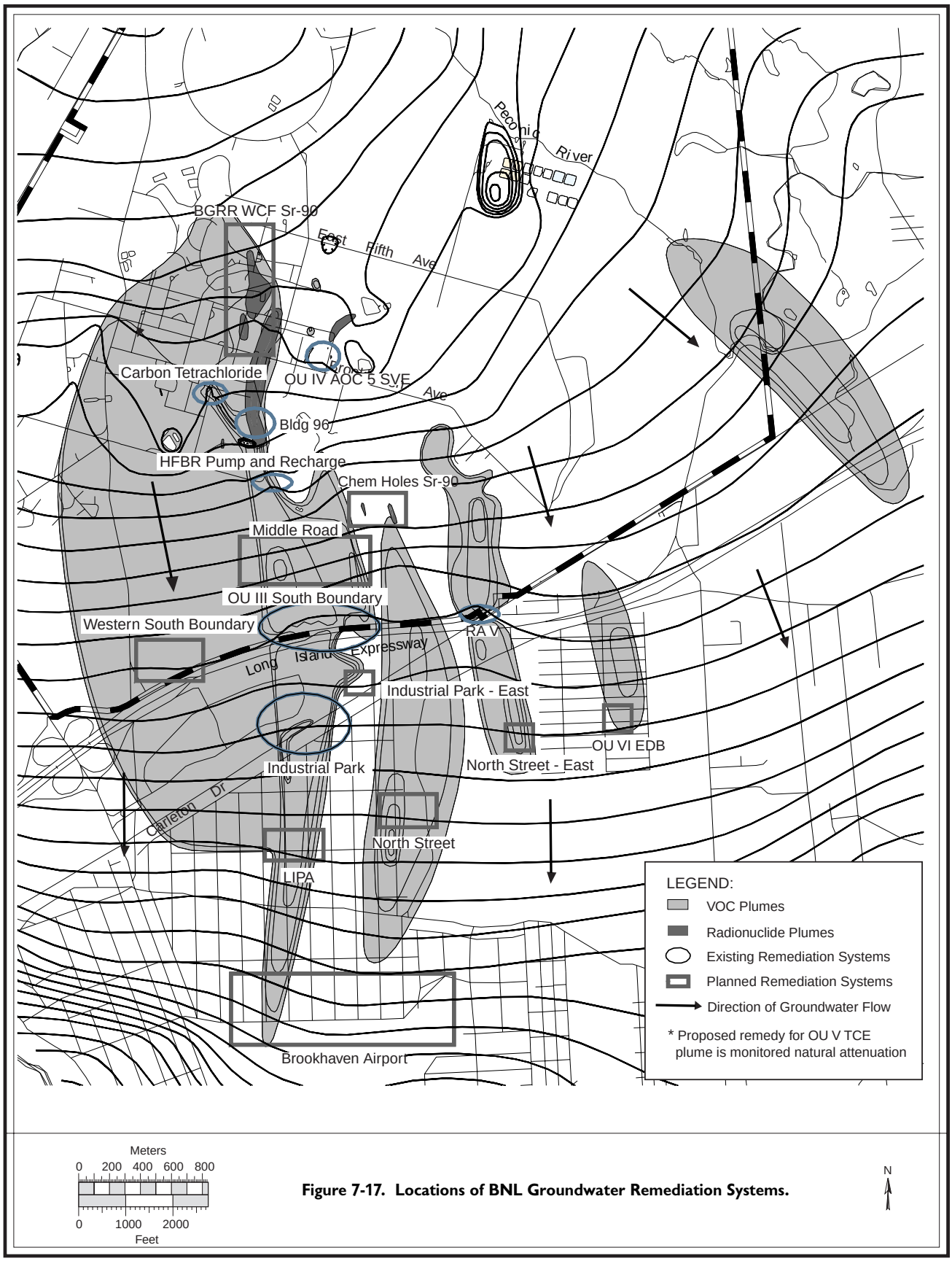


Figure 7-17. Locations of BNL Groundwater Remediation Systems.

Table 7-4. BNL Groundwater Remediation Systems Treatment Summary for 1997 through 2000.

Remediation System	1997 – 1999		2000	
	Water Treated (Gallons)	VOCs Removed (Pounds)	Water Treated (Gallons)	VOCs Removed (Pounds)
OU III South Boundary	837,300,400	1,099	381,728,000	325
OU III Offsite[a]	35,300,000	63	192,273,000	177
Carbon Tetrachloride[a]	6,900,000	112	42,273,000	80
RA V	996,000,000	195	333,540,000	34
HFBR Tritium Plume	190,000,000	104	51,528,000[b]	76
OU IV AS/SVE[c]	—	39	—	8
Total	2,065,500,400	1,612	1,001,342,000	700

Notes:
[a] Treatment system not installed/operational until 1999.
[b] System was shut down and placed in standby mode on September 29, 2000.
[c] Air Sparging/Soil Vapor Extraction system performance measured by pounds of VOC removed per cubic feet of air treated.

333,540,000 gallons (1.2 billion liters) of treated groundwater were returned to the aquifer.

7.7.4 OU III CARBON TETRACHLORIDE TREATMENT SYSTEM

A groundwater remediation system consisting of two extraction wells screened in the shallow Upper Glacial aquifer began operations on October 6, 1999 to address the carbon tetrachloride released during the removal of an underground storage tank in early 1998. Groundwater extracted from this area is treated with carbon filtration and recharged back into the aquifer through an unlined drainage swale to Recharge Basin HS located south of Princeton Avenue. During 2000, approximately 80 pounds (36 kg) of VOCs were removed, and 42,273,000 gallons (160 million liters) of treated water were recharged to the Upper Glacial aquifer.

7.7.5 OU III HFBR TRITIUM PLUME REMEDIATION SYSTEM

This groundwater pump and recharge system was constructed as an interim remedial action after the HFBR tritium plume was discovered, and has operated since May 1997. Three groundwater extraction wells were installed approximately 3,500 feet (1,070 m) south of the HFBR. Groundwater is pumped from the aquifer at a rate of about 40 gallons (151 liters) per minute and piped north to a treatment facility adjacent to the RA V treatment system. Because the water also contains VOCs that originate from another sources (possibly the former Building 96 area), the water is treated by passing it through a granular carbon filter to remove the VOCs before discharging the water to the RA V recharge basin. No VOCs were detected above the MDL in treated water samples; and tritium was not detected in samples collected at the influent to the treatment system (i.e., concentrations <500 pCi/L). This interim remediation system is designed to prevent the further southward migration of the HFBR tritium plume while long-term remediation options are evaluated and implemented. During 2000, the granular activated carbon filters removed approximately 76 pounds (35 kg) of VOCs, and 51,528,000 gallons (195 million liters) of treated water were recharged to the aquifer system. In September 2000, this treatment system was shut down because it was no longer needed to control the leading edge of the HFBR tritium plume. Remaining VOC contamination in the former Building 96 area will be remediated using a new system that is expected to begin operating in May 2001, and downgradient portions of the plume will be remediated using the planned OU III Middle Road Treatment System, which is expected to begin operations in July 2001.

7.7.6 OU IV AIR SPARGING/SOIL VAPOR EXTRACTION SYSTEM

This remediation system, which has operated since November 1997, combines two technologies to remove VOC and semi-VOC contaminants from soil and groundwater located near the BNL Central Steam Facility. The system uses air sparging and soil vapor extraction that forces pressurized air into the groundwater to "bubble" or strip the volatile

compounds out of the water and soil and into a vapor phase. Powerful vacuum pumps then recover the resulting vapors and pipe them to a nearby treatment facility where the VOC vapors are removed by a granular carbon filter system before the air is released into the atmosphere. During 2000, approximately eight pounds (3.6 kg) of contaminants were removed from the soil and groundwater. Except for a slight rebound in VOC concentrations in one well, monitoring of wells within the treatment area indicated that VOC concentrations dropped to below cleanup standards. This is an indication that soil and groundwater remediation is nearly complete.

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