

Groundwater Protection

The Brookhaven National Laboratory Groundwater Protection Management Program is made up of four elements: prevention, monitoring, restoration, and communication. BNL is implementing aggressive pollution prevention measures to protect groundwater resources. BNL's extensive groundwater monitoring well network is used to verify that prevention and restoration activities are effective. In 2002, BNL collected groundwater samples from 745 monitoring wells during 2,345 individual sampling events. During 2002, seven groundwater remediation systems removed 720 pounds of volatile organic compounds and returned approximately 1.3 billion gallons of treated water to the Upper Glacial aquifer. Since the beginning of active groundwater remediation in December 1996, BNL has removed 3,662 pounds of volatile organic compounds by treating nearly 5.5 billion gallons of groundwater.

7.1 THE BNL GROUNDWATER PROTECTION MANAGEMENT PROGRAM

U.S. Department of Energy Order 5400.1, *General Environmental Protection Program*, requires development and implementation of a groundwater protection program. The primary goal of Brookhaven National Laboratory's (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 Management Program Description* document (Paquette et al. 2002). The BNL Groundwater Protection Program consists of four interconnecting elements: 1) preventing pollution of the groundwater, 2) monitoring the effectiveness of engineered and administrative controls at operating facilities and groundwater treatment systems, 3) restoring the environment by cleaning up contaminated soil and groundwater, and 4) communicating with interested parties on groundwater protection issues. BNL is committed to protecting groundwater resources from further chemical and

radionuclide releases, and to remediating existing contaminated groundwater.

7.1.1 Prevention

BNL has conducted a three-phased project to prevent further groundwater contamination from ongoing operations. The first phase was to identify past or current activities with the potential to affect groundwater quality. This effort resulted in the implementation of operational and engineered controls at potential source areas and the installation of 85 new monitoring wells to confirm that these controls are working. The second phase resulted in 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 and waste minimization, resource conservation, and compliance into planning, decision making, and implementation. Finally, phase three was to develop and implement an Environmental Management System (EMS), which was finalized when BNL received ISO 14001 certification in 2001. The continuous improvement aspects of the EMS and ongoing reviews 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).

7.1.2 Monitoring

BNL's groundwater monitoring network is 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 duplication of effort in the installation, monitoring, and abandonment of wells. The monitoring program elements have been integrated and include data quality objectives, plans and procedures, sampling and analysis, quality assurance, data management, and the installation, maintenance, and abandonment of wells. These elements were integrated to create a cost-effective monitoring system and to ensure that water quality data are available for review and interpretation in a timely manner.

7.1.3 Restoration

BNL was added to the National Priorities List in 1989 (see Chapter 2 for a discussion of BNL's ER Program). To help manage the restoration effort, 30 separate Areas of Concern (AOC) were grouped into six Operable Units

(OU). Remedial Investigation/Feasibility Studies have been conducted for each OU, and the focus is now on designing and implementing 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 involving the U.S. Environmental Protection Agency (EPA), the New York State Department of Environmental Conservation (NYSDEC), and DOE.

7.1.4 Communication

BNL's Community Education, Government and Public Affairs Program ensures 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. Technical reports summarizing data, evaluations, and program indices are prepared annually. 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 toward eliminating new contamination of the aquifer system. The Laboratory has made significant investments in environmental and groundwater protection since 1998 and is making real progress in achieving its goal of preventing any new groundwater impacts. A "new" groundwater impact is defined as the detection of unusual or off-normal groundwater monitoring results. The *Groundwater Protection Contingency Plan* (BNL 2000) is designed to ensure that appropriate and timely actions are taken if unusual or off-normal results are

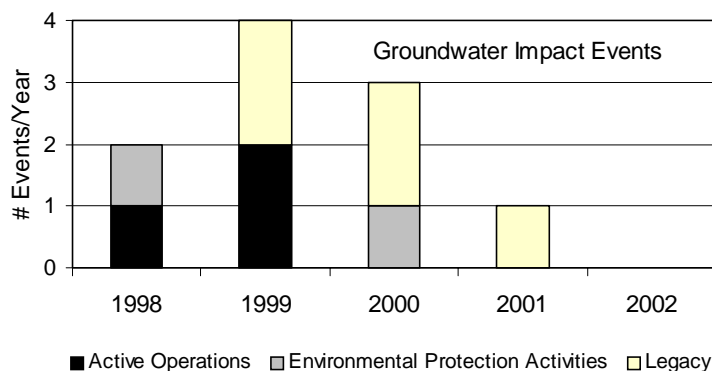


Figure 7-1. Groundwater Protection Performance 1998 through 2002.

observed. The contingency plan provides guidelines for evaluating the source of the problem, notifying stakeholders, and implementing appropriate corrective actions.

Since 1998, BNL installed several hundred permanent and temporary monitoring wells as a result of a comprehensive evaluation of known or potential contaminant source areas. Using this enhanced monitoring system, BNL identified 10 new groundwater impacts during 1998 through 2001 (Figure 7-1). No impacts were identified during 2002. It is important to note that five of the 10 identified impacts were determined to be from historical (or “legacy”) contaminant releases. These newly discovered legacy issues include low-level petroleum hydrocarbon contamination in groundwater near the BNL Service Station, tritium near the former U-Line target/beam stop area at the Alternating Gradient Synchrotron (AGS), 1,1,1-trichloroethane (TCA) near Building 830 and the BNL Motor Pool, and higher than expected strontium-90 contamination at the Brookhaven Graphite Research Reactor (BGRR) beneath the belowground ducts.

The five remaining cases were related to active science operations and environmental protection activities. Three small tritium plumes that originated from active experimental areas at the AGS (the g-2 and E-20 Catcher areas) and the Brookhaven Linac Isotope Producer (BLIP) facility were discovered in 1998 and 1999. Activities associated with the Laboratory’s environmental protection programs resulted in two 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 unexpected displacement of tritium during an innovative grout injection process designed to protect groundwater quality by stabilizing activated soils at the BLIP facility. In all ten 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 efforts to prevent new groundwater impacts, and is vigilant in measuring and communicating its performance.

7.3 GROUNDWATER MONITORING

Groundwater monitoring program elements include installing monitoring wells; planning and scheduling; developing and following quality assurance measures; collecting and analyzing samples; verifying, validating, and interpreting data; and reporting. Monitoring wells (which are not used for the drinking water supply) are used to evaluate BNL’s progress in restoring groundwater quality, to comply with regulatory permit requirements, to monitor active research and support facilities, and to assess the quality of groundwater entering and leaving the BNL site.

BNL monitors 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. The groundwater beneath the BNL site is classified by New York State as Class GA groundwater, defined as a source of potable water supply and suitable for drinking. Federal drinking water standards, New York State Drinking Water

Standards (DWS), and New York State Ambient Water Quality Standards (AWQS) for Class GA groundwater are used as goals for groundwater protection and remediation. BNL evaluates the potential impact of radiological and nonradiological 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 AWQS. Radiological data are compared to DWS (for tritium, gross beta, and strontium-90), 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 timely identification and remediation of the source.

Groundwater quality at BNL is routinely monitored through a network of approximately 780 on-site and off-site surveillance wells (see Figure 7-2). In addition to water quality assessments, water levels are routinely measured in more than 875 on-site and off-site wells to assess variations in directions and velocities of groundwater flow. Groundwater flow directions in the vicinity of BNL are shown in Figure 7-3.

Among the active and inactive facilities that have groundwater monitoring programs are the Sewage Treatment Plant (STP)/Peconic River area, Biology Agricultural Fields, Former Waste Management Facility (FWMF), new Waste Management Facility (WMF), two former landfill areas, Central Steam Facility/Major Petroleum Facility (CSF/MPF), AGS, Waste Concentration Facility (WCF), Supply and Material, and several other smaller facilities. As the result of detailed groundwater investigations conducted over the past 15 years, six significant VOC plumes and eight radionuclide plumes have been identified (Figures 7-4 and 7-5).

7.4 SUPPLEMENTAL MONITORING OF POTABLE AND PROCESS SUPPLY WELLS

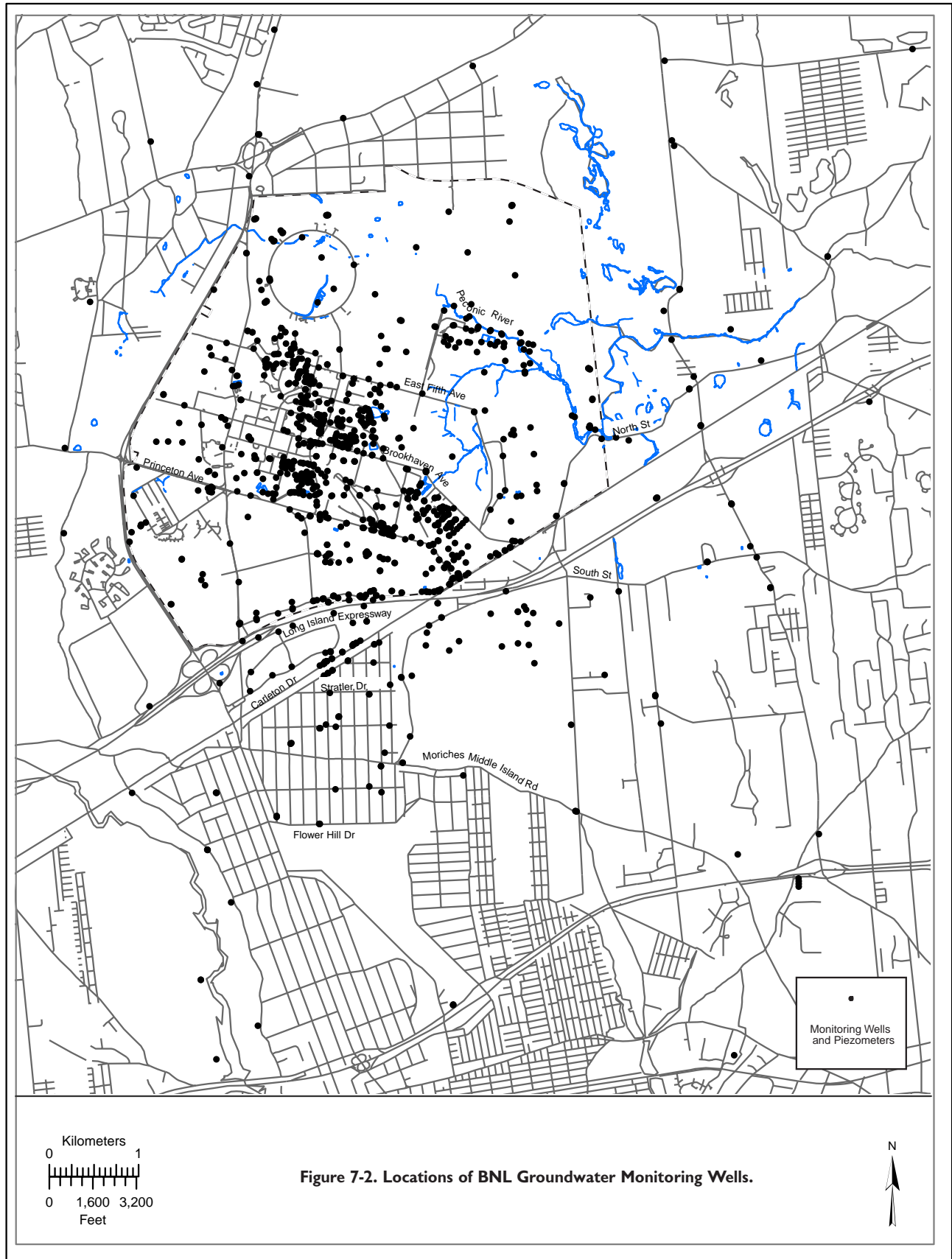
As discussed in Chapter 3, BNL is a public water purveyor and maintains water supply wells and associated treatment facilities for the distribution of potable water on the site. The BNL potable and cooling water supply well network consists of six wells (wells 4, 6, 7, 10, 11, and 12). A seventh well, number 9, is a small capacity well that supplies process water to a facility where biological research on fish is conducted. This well is not routinely monitored. The locations of the supply wells are shown in Figure 7-3.

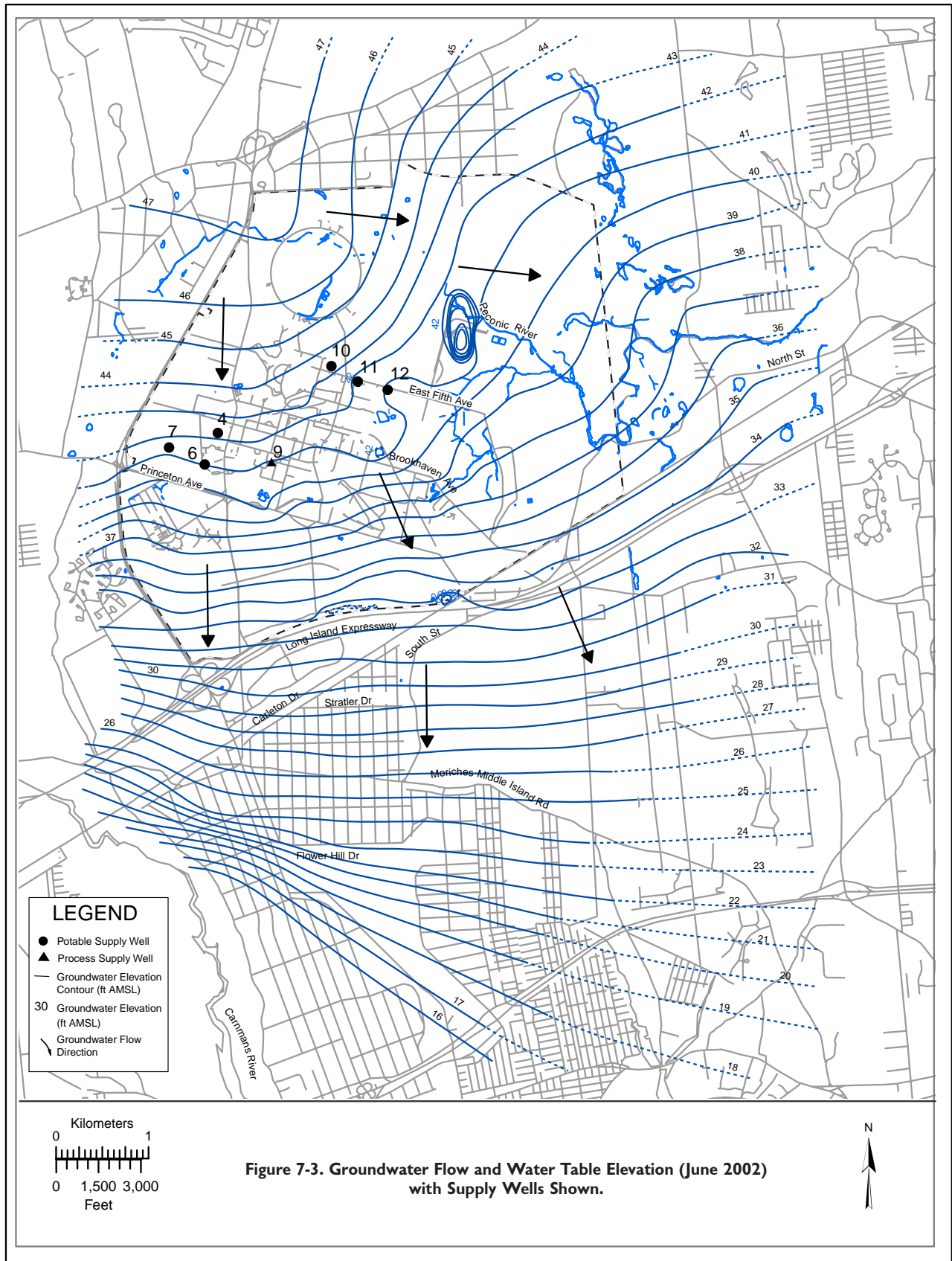
The quality of the BNL potable water supply is monitored as required by the SDWA, and the analytical results are reported to the Suffolk County Department of Health Services. As required by the SDWA, BNL also prepares an annual *Water Quality Consumer Confidence Report* (BNL 2003b) that is distributed to all employees and guests. Results of the SDWA-required monitoring are described in Chapter 3.

All of BNL's supply wells are screened within the Upper Glacial aquifer. Because of the proximity of the potable supply wells to known or suspected groundwater contamination plumes and source areas, BNL conducts a supplemental potable supply well monitoring program. Supplemental monitoring of the potable and process supply wells in 2002 included testing for VOCs, anions, metals, and radiological parameters. During 2002, the BNL potable water system fully complied with all primary drinking water requirements. To better understand the geographical source of BNL's drinking water and to identify potential sources of contamination within these geographical areas, BNL prepared the report titled *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

Samples collected from supply wells 4, 6, 7, 11, and 12 were analyzed for gross alpha and gross beta activity, tritium, and strontium-90; the results are listed in Table 7-1. (Note: Well 10 was





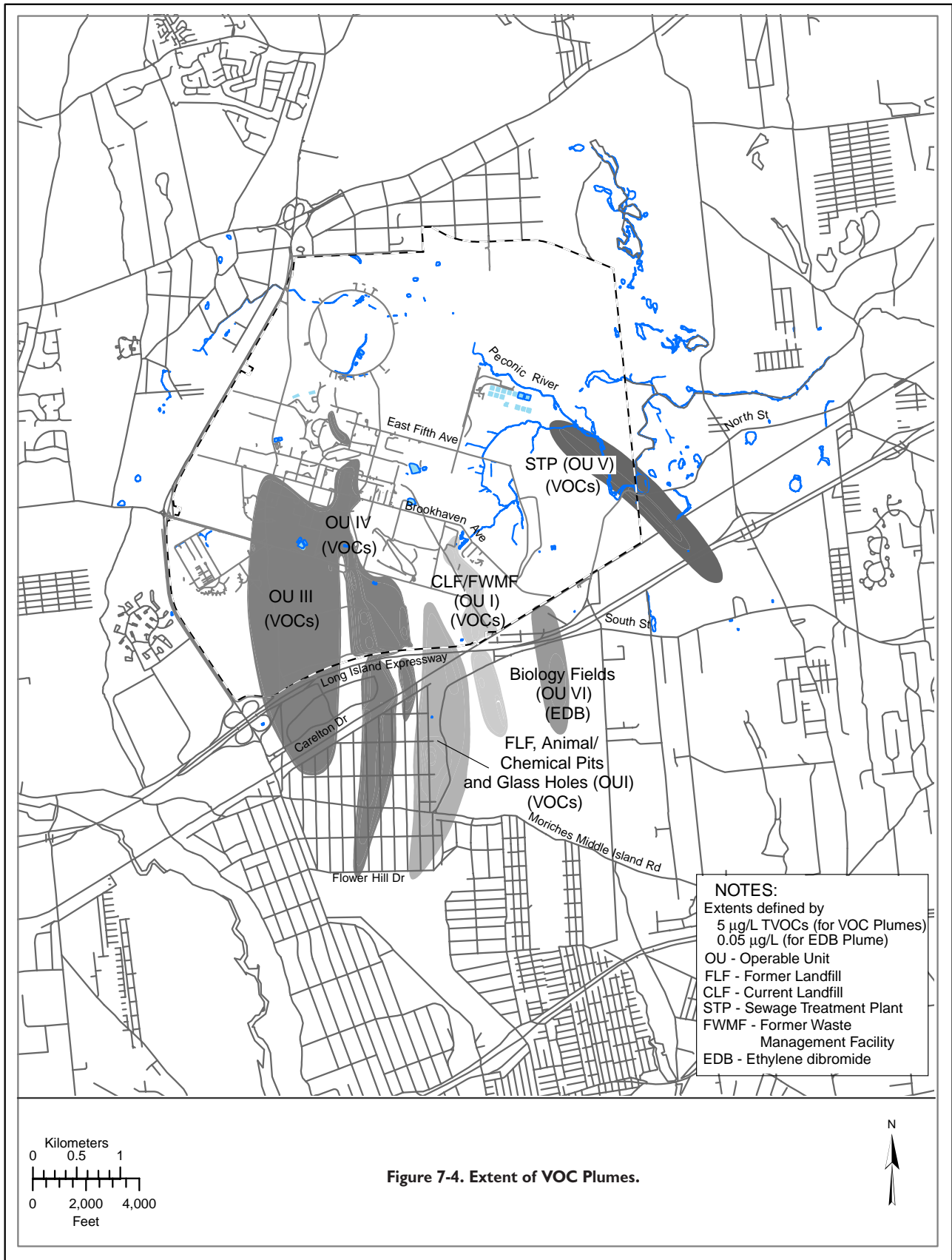


Figure 7-4. Extent of VOC Plumes.

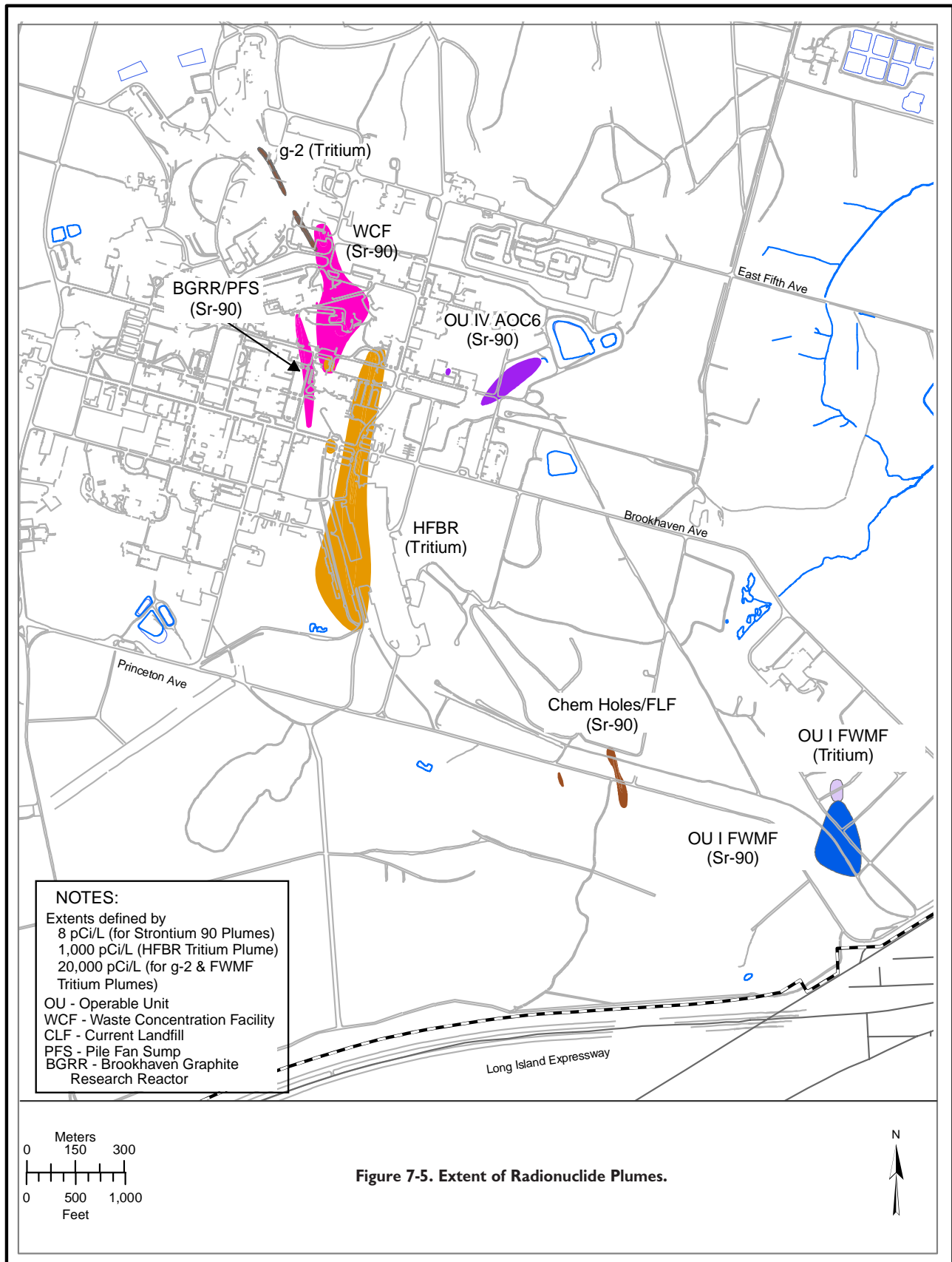


Table 7-1. Potable Well Radiological Analytical Results.

Potable Well ID ^(a)		Gross Alpha	Gross Beta	Tritium	Sr-90
4 (FD)	N	2	2	3	2
	Max.	< 0.58	< 1.69	< 286	< 1.00
	Avg.	0.24 ± 0.12	1.09 ± 0.54	-20 ± 151	0.06 ± 0.08
6 (FF)	N	4	4	8	4
	Max.	1.03±	0.49 < 1.69	< 353	< 1.00
	Avg.	0.69 ± 0.26	0.59 ± 0.48	13 ± 30	0.27 ± 0.14
7 (FG)	N	7	7	11	7
	Max.	2.86 ± 0.64	1.86 ± 0.96	< 353	< 1.00
	Avg.	0.86 ± 0.66	0.74 ± 0.55	16 ± 67	0.21 ± 0.10
11 (FP)	N	4	4	8	4
	Max.	0.87 ± 0.43	< 2.15	< 287	< 1.00
	Avg.	0.58 ± 0.25	1.27 ± 0.76	25 ± 74	0.12 ± 0.23
12 (FQ)	N	3	3	6	3
	Max.	0.94 ± 0.48	< 2.15	< 345	< 1.00
	Avg.	0.62 ± 0.27	1.39 ± 0.15	-1 ± 88	0.22 ± 0.23
Tap Water ^(b)	N	249	249	249	NS
Bldg 490	Max.	8.10 ± 3.07	11.56 ± 4.30	< 355	
FN)	Avg.	3.33 ± 0.18	4.27 ± 0.34	3 ± 15	
SDWA Limit		15 ^(c)	50 ^(d)	20,000	8

Notes:

All values shown with 95% confidence interval.

No anthropogenic gamma-emitting radionuclides were detected in samples collected from these wells in 2002.

Potable Well #10 was shut down most of the year due to its possible effect on groundwater flow directions in the vicinity of the g-2 Tritium Plume.

N = Number of samples

NS = Not sampled for this analyte

^(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.

used infrequently during 2002, and was only sampled under the compliance monitoring program described in Chapter 3.) In addition, tap water samples were collected daily from Building 490, the BNL Analytical Services Laboratory (ASL), 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. 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 other 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

Samples collected in May and August from supply wells 6, 7, 11 and, 12 were analyzed for

VOCs (following EPA Standard Method 624). Method 624 tests for 38 organic compounds, including halogenated and aromatic hydrocarbons. The only parameter detected above the MDL was chloroform, found once during the year in wells 7 and 12 at trace levels (< 2 µg/L). The chloroform concentrations were below the ambient water quality standard of 7 µg/L and well below the drinking water standard of 80 µg/L. Samples were also collected one time during the year from wells 6, 7, and 11, and analyzed for metals and anions (Tables 7-2 and 7-3). Iron was the only parameter detected at concentrations greater than the drinking water standards, which is 0.3 mg/L for iron. Iron levels in wells 6 and 7 were 3.3 and 1.2 mg/L, respectively. Because naturally high levels of iron are present in some portions of the Upper Glacial aquifer, water obtained from wells 4, 6, and 7 is treated at the BNL Water Treatment Plant to reduce the iron levels prior to distribution.

Table 7-2. Potable Water Supply Wells Water Quality Data.

Potable Well ID ^(a)		Chlorides	Sulfates	Nitrate as N
4 (FD) ^(b)	N			
	Value	NS	NS	NS
6 (FF)	N	1	1	1
	Value	23.1	10.1	1
7 (FG)	N	1	1	1
	Value	22.1	12.1	1
10 (FO) ^(b)	N	NS	NS	NS
	Value			
11 (FP)	N	1	1	1
	Value	20.9	13	1
12 (FQ) ^(b)	N	NS	NS	NS
	Value			
NYSDWS		250	250	10
Typical MDL		4	4	1

Notes:

See Figure 7-3 for location of wells.

N = Number of Samples

NYSDWS = New York State Drinking Water Standard

MDL = Minimum Detection Limit

NS = Not sampled for this analyte

^(a)Historic ID shown in parentheses.^(b)Well was shut down at time of annual sampling for anions.

7.5 ENVIRONMENTAL SURVEILLANCE PROGRAM

BNL's Environmental Surveillance Program includes groundwater monitoring at active research facilities (e.g., research reactor areas, accelerator beam stop and target areas) and support facilities (e.g., fuel storage facilities). During 2002, 130 groundwater surveillance wells were monitored during 280 individual sampling events. Results for these programs are summarized below. Detailed descriptions and maps related to groundwater monitoring in the Environmental Surveillance Monitoring Program can be found in the *2002 BNL Groundwater Status Report* (BNL 2003c).

7.5.1 Research Facilities

7.5.1.1 Alternating Gradient Synchrotron 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 soil and groundwater with VOCs. VOC contamination is monitored under the ER Program's OU III Central Areas Project (see Section 7.6.3).

During 2002, 49 groundwater wells were monitored 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). Following the installation of 39 new wells in the AGS area during 1999–2000, BNL detected three tritium plumes (i.e., groundwater with tritium concentrations greater than the drinking water standard of 20,000 pCi/L). These plumes originated from activated soil shielding at the g-2 experimental area, the former U-Line area, and the Former E-20 Catcher region of the AGS Complex. Following these discoveries, BNL installed impermeable caps over the soil activation areas to prevent rainwater from infiltrating the soil and leaching tritium into the groundwater. Monitoring conducted during 2001 and 2002 showed that these caps have effectively reduced tritium concentrations to below the drinking water standards at the former U-Line and former E-20 Catcher areas. However, tritium continues to be detected at concentrations above the drinking water standard downgradient of the g-2 facility (Figure 7-6).

g-2 Experimental Area. A groundwater investigation conducted during November and December 1999 revealed a narrow tritium plume approximately 250 to 300 feet long, with a maximum tritium concentration of 1,800,000 pCi/L and sodium-22 concentration of 60 pCi/L. (Note: The drinking water standard for sodium-22 is 400 pCi/L.) The source of the contamination was determined to be activated soil shielding adjacent to the g-2 experiment's VQ-12 Magnet. In December 1999, an impermeable coated concrete cap was installed over the soil activation area to prevent rainwater infiltration and the continued leaching of radionuclides out of the soil

and into the 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 2002, BNL conducted additional characterization work designed to obtain the necessary plume concentration and position data required to prepare the EE/CA.

Since its initial detection in 1999, the leading edge of the tritium plume has migrated to an area just south of the Waste Concentration Facility (Figure 7-6). Samples collected during 2002 from wells located approximately 150 feet downgradient of the VQ12 area indicate that tritium continues to be released to the groundwater. The highest tritium concentrations were measured in July 2002, when 3,440,000 pCi/L was detected in a sample from monitoring well 054-07 (located immediately west of Building 912A). In the area to the east of Building 912, the maximum tritium concentration observed during 2002 was 58,900 pCi/L in well 065-122. The two segments of the plume shown in Figure 7-6 are representative of two distinct periods of tritium release (also referred to as slug releases). The leading segment of tritium contamination was released in 1999 prior to the installation of the cap over the VQ12 area, and the second slug is related to tritium released in 2001–2002.

Inspections of the cap and review of its design indicate that the cap over the VQ12 area has not failed and is properly positioned. The cap appears to be effective in preventing the infiltration of rainwater into the activated soil-shielding zone. The leading hypothesis at this time is that a natural rise in the water table may have released residual tritium from the unsaturated soil into the groundwater. It is believed that this tritium had migrated close to the water table (in the “vadose zone”) before the cap was put in place in December 1999.

Water levels in the central BNL area in mid-2000 and mid-2001 were near the highest observed in 49 years of record by the US Geological Survey. Once the cap was in place,

Table 7-3. Total Metals Concentration Data for Potable Water Supply Well Samples.

Well ID ^(a)	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 mg/L	Pb µg/L	Sb µg/L	Se µg/L	Tl µg/L	V µg/L	Zn µg/L
4 (FD) ^(b)	N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Value																					
6 (FF)	N	<1.0	16.2	<3.0	27.5	<0.7	<1.1	0.8	1.4	12.3	<0.1	86.3	<5.0	3.4	11.6	<1.3	<0.9	<5.0	<0.7	<5.5	<4.0
Value																					
7 (FG)	N	<1.0	15.5	<3.0	19.3	<0.7	<1.1	0.5	<1.0	4.6	<0.1	52.3	<5.0	<1.1	12.7	<1.3	<0.9	<5.0	<0.7	<5.5	<4.0
Value																					
10 (FO) ^(b)	N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Value																					
11 (FP)	N	<1.0	5.5	<3.0	31.1	<0.7	<1.1	<0.1	<1.0	8.4	<0.1	<2.0	<5.0	<1.1	5.0	<1.3	<0.9	<5.0	<0.7	<5.5	<4.0
Value																					
12 (FQ) ^(b)	N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Value																					
NYSDWS	100	SNS	50	2000	4	5	SNS	100	1300	0.3	2	300	SNS	SNS	SNS	15	6	50	2	SNS	5000
Typical MDL	1.0	2.2	3.0	1.8	0.7	1.1	0.1	1.0	2.0	0.08	0.1	5.0	2.0	1.1	1.0	1.3	0.9	5.0	0.7	5.5	4.0

Notes:

See Figure 7-3 for well locations.

MDL = Minimum Detection Limit

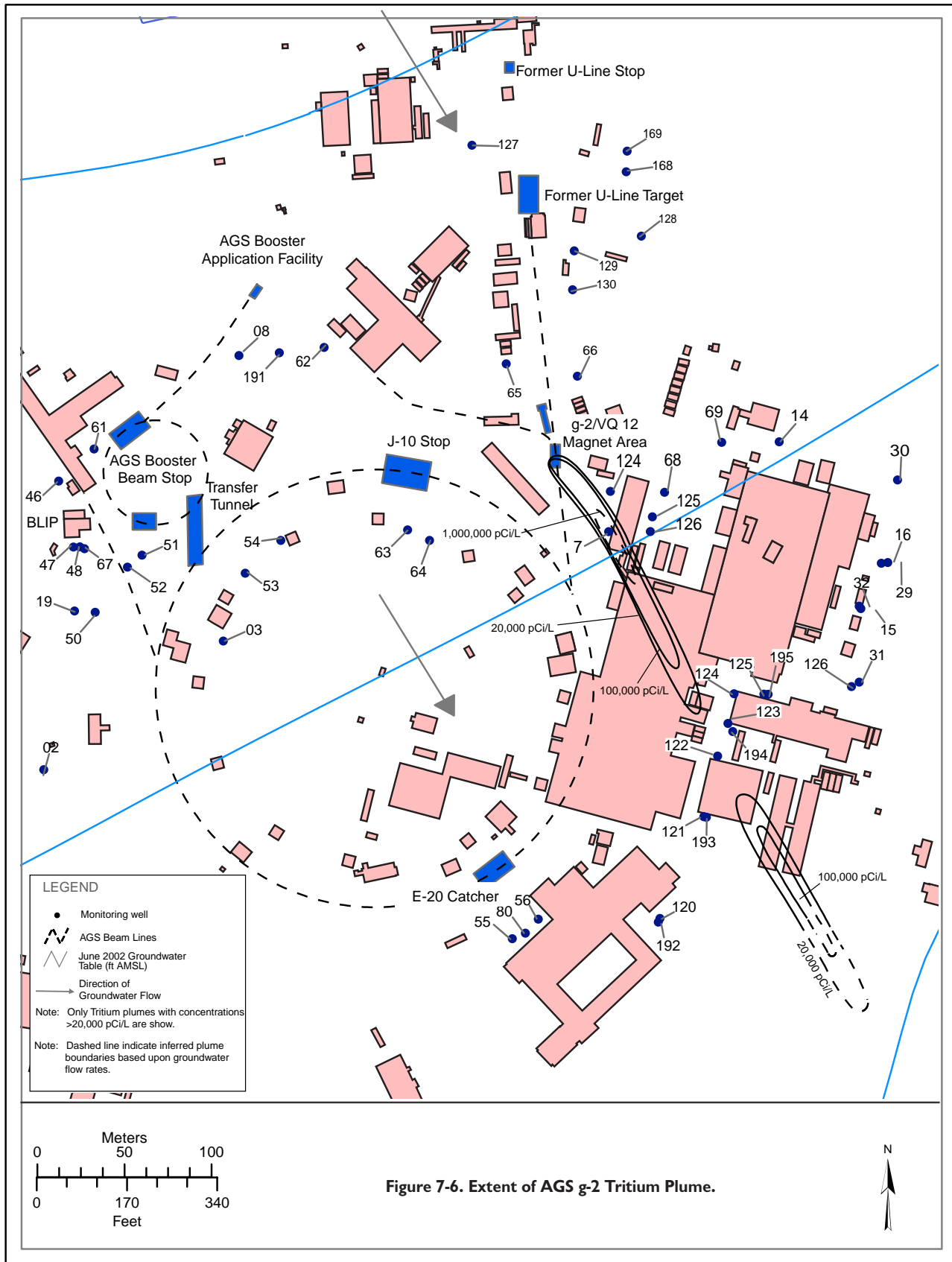
NS = Not sampled for this analyte

NYSDWS = New York State Drinking Water Standard

SNS = Drinking Water Standard not specified

^(a)Historic ID shown in parentheses.

^(b)Well was shut down at time of annual sampling for metals.



the lack of additional rainwater infiltration kept the tritium in the vadose zone from migrating into the groundwater until the significant rise in the water table mobilized it. There appears to be good correlation between high tritium concentrations detected in monitoring wells immediately downgradient of VQ12, and the groundwater table elevation about one year prior to the sampling. The groundwater travel time from beneath the source to the monitoring wells is about one year.

Former E-20 Catcher. During 1999–2000, tritium and sodium-22 were detected at concentrations above their applicable drinking water standards in wells approximately 100 feet downgradient of the former E-20 Catcher. The location of the E-20 Catcher is shown in Figure 7-6. The highest levels of tritium (40,400 pCi/L) and sodium-22 (704 pCi/L) were found in temporary well 064-65. 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 radionuclides out of the soil and into groundwater. A permanent cap was constructed by October 2000.

During 2001, all tritium and sodium-22 concentrations were found to be well below drinking water standards, with a maximum tritium concentration of 2,070 pCi/L and a maximum sodium-22 concentration of 163 pCi/L. Measurements for tritium during 2002 indicated continued reduction in tritium concentrations, with a maximum concentration of 774 pCi/L detected in well 064-80. The reduction in tritium and sodium-22 concentrations since the impermeable cap was constructed indicates that the cap has been effective in preventing additional rainwater infiltration into the activated soil that surrounds that portion of the AGS tunnel.

Former U-Line Target and Stop Areas. In 1999, BNL installed new monitoring wells downgradient of the former U-Line target area (Figure 7-6) to evaluate whether rainwater infiltration through residual activated soil shielding was affecting groundwater quality. Subsequent monitoring found low levels of tritium and sodium-22, but at concentrations well below the applicable drinking water standards. In

early 2000, BNL installed four Geoprobe™ wells downgradient of the former U-Line beam stop, which is approximately 200 feet north of the target area. Tritium was detected at concentrations up to 71,600 pCi/L. Sodium-22 was not detected in any of the samples. In May 2000, a temporary impermeable cap was installed over the U-Line stop soil activation area. By October 2000, a permanent cap was constructed and two additional permanent wells were installed to provide improved long-term monitoring of this source area.

During 2002, low levels of tritium continued to be detected in wells downgradient of the former U-Line target and stop areas, but at concentrations below drinking water standards. The highest tritium concentration during 2002 was 7,450 pCi/L, detected approximately 200 feet downgradient of the target area, in well 054-129. The highest concentration downgradient of the beam stop area was 5,650 pCi/L, detected in well 054-168. Low-level contamination from the former U-Line area reaches to well 055-14, approximately 800 feet downgradient of the target area, where a maximum tritium concentration of 772 pCi/L was observed in late 2002.

Although low levels of tritium continue to be detected in groundwater downgradient of the former U-Line target, these concentrations are well below drinking water standards. Furthermore, the significant decrease in tritium concentrations since 2000 indicates that the impermeable cap has been effective in stopping rainwater infiltration into the residual activated soils surrounding the beam stop.

7.5.1.2 Brookhaven Linac Isotope Producer

The BLIP facility is at the southern end of the Linear Accelerator (Figure 7-6). When the BLIP is operating, the Linear Accelerator (Linac) delivers a beam of protons onto a series of targets within the BLIP target vessel. During irradiation, activation of the soil immediately outside of the vessel occurs, due to the creation of secondary particles produced at the target.

In February 1998, elevated levels of tritium (52,000 pCi/L) and sodium-22 (151 pCi/L) were detected in wells downgradient of the BLIP. To prevent rainwater from infiltrating the activated

soil below the building, the BLIP building's roof drains were redirected away from the building, paved areas were resealed, and an extensive coated concrete cap was installed on three sides of the building. Groundwater monitoring data collected from January 1999 to July 2000 indicated that these corrective actions were highly effective in preventing the release of tritium and sodium-22 from the activated soil surrounding the BLIP target vessel.

In June 2000, BNL took an additional protective measure by using an innovative silica grouting technique to reduce the permeability of the activated soil. Soon after the activated soil was treated with the silica grout injection process, significant increases in tritium and sodium-22 concentrations were observed in groundwater samples. In early July 2000, samples collected from wells located approximately 40 feet downgradient of the BLIP contained tritium up to 5,700 pCi/L. By October 2000, tritium concentrations increased to 56,500 pCi/L. In accordance with the *BNL Groundwater Protection Contingency Plan* (BNL 2000), BNL and DOE notified the regulatory agencies of this situation and increased the sampling frequency for the wells. An evaluation of the grouting process suggested that it displaced residual activated pore water that was located in the soil near the target vessel. The maximum sodium-22 concentration was 299 pCi/L in well 064-67, which is below the 400 pCi/L drinking water standard. By December 21, 2000, tritium concentrations dropped to below the 20,000 pCi/L drinking water standard in the wells immediately downgradient of the BLIP. Concurrently, as the slug of tritium migrated downgradient of the BLIP, concentrations in well 064-50 increased to 20,000 pCi/L by December 2000. This well is approximately 150 feet downgradient of the BLIP.

During 2001-2002, tritium concentrations in wells located 40 feet downgradient of the BLIP did not exceed the 20,000 pCi/L drinking water standard. During 2002, the maximum tritium concentration was 15,100 pCi/L, detected in well 064-67. Tritium concentrations in well 064-50 reached a maximum of 44,100 pCi/L in April 2002, then declined to less than 5,000 pCi/L by

July 2002. 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

Within the RHIC facility, there are three areas where low levels of radionuclides could be produced in the soil outside of the collider tunnel. The first area contains two beam stops that are located at the 10 o'clock position of the ring, the second contains two collimators that are located at the 8 o'clock region, and the third is a beam stop located at the 6 o'clock position. Secondary particles created at the internal beam stop and collimator areas have the potential to activate the soil immediately surrounding those areas. Even though the predicted soil activation is expected to be very small, BNL installed impermeable caps over these areas as a precautionary measure. Thirteen monitoring wells are used to provide a means of verifying that the impermeable caps, and the operational controls designed into the RHIC beam stops and collimators, are effective in protecting groundwater quality.

Groundwater samples were collected from the 13 RHIC monitoring wells on a semi-annual schedule during 2002. Surface water samples were also collected from the Peconic River both upstream and downstream of the beam stop area to verify that potential tritium in groundwater is not discharged to the river during high water table conditions. As in previous years, no tritium was detected in any of the groundwater or surface water samples.

7.5.1.4 Brookhaven Medical Research Reactor

During a 1997 evaluation of groundwater quality near the BMRR, low levels of tritium (up to 11,800 pCi/L) were detected in the groundwater downgradient of the reactor building. No other reactor-related radionuclides were detected in the groundwater. After inspecting the facility and reviewing historical records, BNL concluded that the tritium might have originated

from past discharges of small amounts of BMRR primary cooling water to a basement floor drain and sump system that 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 soil surrounding the floor drain piping system to the groundwater. The floor drains were permanently sealed in 1998 to prevent any future accidental releases to underlying soils.

During 2002, tritium concentrations continued to be well below the drinking water standard of 20,000 pCi/L. Detectable levels of tritium were observed in all three downgradient wells, with the maximum value of 4,680 pCi/L in well 084-27. Compared to the initial monitoring results from 1997, tritium concentrations in groundwater have shown a steady decline.

7.5.1.5 Building 801

In December 2001, approximately 8,000 gallons of stormwater seeped into the basement of Building 801. Analysis of the water indicated that it contained cesium-137, strontium-90, and tritium at levels that exceeded drinking water standards. It is believed that the water became contaminated when it came into contact with the basement floor, which contains residual contamination from historical spills. On March 8, 2002, approximately 4,950 gallons of contaminated water were pumped from the basement. Taking into account possible losses due to evaporation, an estimated 1,350 to 2,750 gallons of contaminated water might have leaked into the soils below Building 801. To evaluate the potential impact this release may have on future groundwater quality, BNL initiated monthly monitoring of three existing downgradient monitoring wells and installed a new shallow well closer to the building. Two of the existing wells are screened approximately 10 feet below the water table (wells 065-169 and 065-170), and one well is screened immediately below the water table.

During May through October 2002, these three monitoring wells were monitored monthly for strontium-90, gamma emitting radionuclides (e.g., cesium-137), tritium, gross alpha and gross

beta. Strontium-90 was consistently detected in all three wells. Strontium-90 levels in wells 065-169 and 065-170 were generally less than 2.5 pCi/L. Higher levels of strontium-90 (and associated gross beta levels) were detected in shallower well 065-37. Strontium-90 concentrations in all samples from well 065-37 exceeded the 8 pCi/L drinking water standard, with a maximum concentration of 18.2 pCi/L observed in July 2002. Strontium-90 has been routinely detected in well 065-37 since 1999.

Cesium-137 was not detected in any of the groundwater samples from the Building 801 monitoring wells.

Tritium was not detected in shallow well 065-37. However, a trace level of tritium (389 pCi/L; with an analysis detection limit of 386 pCi/L) was detected in well 065-170, and low levels (<10 pCi/L) of sodium-22 were detected in wells 065-169 and 065-170. The trace levels of tritium and sodium-22 in these deeper wells are probably from source areas in the AGS facility, which is located upgradient of Building 801.

In early October 2002, BNL installed well 065-325 approximately 10 feet south of Building 801. This well is screened within the upper 10 feet of the aquifer to provide improved surveillance of potential releases from the Building 801 basement. The October, November, and December samples from this well had strontium-90 concentrations of 44 pCi/L, 37 pCi/L, and 47.9 pCi/L, respectively. No cesium-137 or tritium was detected in any of the samples from this new well.

Future Monitoring Plans. The strontium-90 concentrations in samples collected during 2002 from shallow groundwater wells downgradient of Building 801 were consistent with values before the Building 801 floodwater release, and cesium-137 has not been detected in any of the groundwater samples. It is estimated that it could take three to eight years for strontium-90, and approximately 100 years for cesium-137, from the Building 801 floodwater release to migrate to the closest downgradient well (065-325). Furthermore, any new groundwater impacts from the 2001 release will be difficult to identify, because the local groundwater was already contaminated with radioactivity from legacy

releases. The Environmental Restoration program is planning additional groundwater characterization efforts to define the extent of legacy strontium-90 contamination sources in the BGRR/Building 801/Pile Fan Sump (PFS) area in the fall of 2003 (see Section 7.6.3.2).

7.5.2 Surveillance Monitoring of Support Facilities

7.5.2.1 Sewage Treatment Plant Area

As described in Chapters 1 and 3, the Sewage Treatment Plant (STP) processes sanitary sewage from BNL facilities. Approximately 15 percent 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.

Discharges from the STP are monitored as part of the State Pollutant Discharge Elimination System (SPDES) program. The STP groundwater surveillance program provides an additional means of verifying that current treatment plant operations are not affecting groundwater quality. During 2002, 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 monitored as part of the OU V program, using wells that are at the site boundary and off-site areas (see Section 7.6.5).

Groundwater monitoring results for 2002 indicate that STP operations are not significantly affecting groundwater quality, and that BNL's administrative and engineered controls designed to prevent the discharge of chemicals and radionuclides to the sanitary system have been highly effective.

Radionuclides. Radioactivity levels in samples collected from the STP wells were consistent with ambient (background) levels from naturally occurring radionuclides, with the exception of a trace level of tritium (626 pCi/L) detected in one sample from well 039-89. During 2001, tritium was detected in this same well at a concentration of 1,420 pCi/L. This well is downgradient of the holding ponds. Because the ponds have not been used recently to hold tritiated wastewater and the wells are also

downgradient of the filter bed area, it is likely that the tritium originated from past water releases to the filter beds. (See Section 5.2.1 for information related to historical tritium concentrations in STP effluent.)

Volatile Organic Compounds, Metals, and Anions. During 2002, all water quality readings and most metal concentrations were below the applicable AWQS. Sodium was detected at concentrations slightly above the AWQS of 20 mg/L in three filter bed area wells. Wells 039-07, 039-08, and 039-86 had maximum sodium concentrations of 28 mg/L, 32.2 mg/L, and 32.8 mg/L, respectively. Although low levels of nitrates were detected in most filter bed area wells, with a maximum concentration of 8.3 mg/L detected in monitoring well 039-08, these concentrations were below the AWQS of 10 mg/L. No VOCs were detected in any of the monitoring wells.

7.5.2.2 Motor Pool Facility

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 capacity underground storage tanks (USTs), waste oil is stored in one 260-gallon capacity aboveground storage tank, and heating oil is stored in one 3,000-gallon capacity UST. Although the USTs and associated distribution lines conform with 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 affected by current Motor Pool operations.

Groundwater surveillance at the Motor Pool facility during 2002 indicated that releases from historical operations continue to have an impact on groundwater quality in the area. Several activities were conducted to determine that the groundwater contamination came from historical, not current, operations. Monitoring of the leak detection systems, groundwater wells downgradient of the gasoline USTs, and product reconciliation records indicate that the tanks and their associated distribution lines are not leaking. Furthermore, evaluation of vehicle maintenance operations indicates that all waste oils and used

solvents are being properly stored and recycled. Therefore, it is believed that the solvents detected in groundwater originate from historical vehicle maintenance activities at the Motor Pool and are not related to current operations.

Underground Storage Tank Area. During 2002, methyl tertiary butyl ether (MTBE) was the only chemical related to gasoline detected in groundwater downgradient of the UST area. MTBE was detected in the July sample from well 102-06 at a concentration of 3.5 µg/L. The AWQS guidance value for MTBE is 10 µg/L. The solvent 1,1,1-trichloroethane (TCA) was detected in both downgradient wells, but at concentrations below the AWQS of 5 µg/L. The presence of MTBE and TCA could be related to historical parts degreasing operations at the Motor Pool facility. As discussed below, these contaminants are also detected in wells located downgradient of the Motor Pool Building. Wells 102-05 and 102-06 were also tested for the presence of floating petroleum hydrocarbons. As in previous years, no floating product (oil floating on top of the groundwater) was observed.

Motor Pool Building. As in previous years, VOCs continue to be detected in all four downgradient wells at concentrations exceeding AWQS. During 2002, TCA was detected in all four wells at concentrations ranging from 4.5 µg/L to 34.5 µg/L, and 1,1-dichloroethane (DCA) was detected in well 102-12 at concentrations up to 6.2 µg/L. The AWQS for TCA and DCA is 5 µg/L. The gasoline additive MTBE was detected in all four wells, with a maximum observed concentration of 40.8 µg/L. The AWQS guidance value for MTBE is 10 µg/L. It is believed that these chemicals originate from historical vehicle maintenance/part degreasing operations.

7.5.2.3 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 capacity and one 6,000-gallon capacity USTs, and waste oil is stored in one 500-gallon capacity UST. Although the storage tanks and associated distribution lines conform with 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 affected by current operations.

Groundwater quality in the Service Station area has been impacted by carbon tetrachloride contamination associated with a nearby underground storage tank that was used as part of an experiment conducted in the 1950s. The carbon tetrachloride contamination is being remediated as part of the Laboratory's Environmental Restoration program (see Section 7.6.3.1). During 2002, the maximum carbon tetrachloride concentration observed in this area was 1,940 µg/L, in well 085-16. These concentrations are less than those observed in 2000, when carbon tetrachloride concentrations in these wells approached 4,400 µg/L. The AWQS for carbon tetrachloride is 5 µg/L.

In addition to the carbon tetrachloride contamination described above, groundwater quality has been impacted by a variety of petroleum and solvent-related VOCs that are primarily the result of historical Service Station operations. During the first half of 2000, high levels (>100 µg/L) of petroleum related compounds such as xylene and ethylbenzene were detected in wells 085-17, 085-236, and 085-237. From mid-2000 through mid-2002, individual VOC concentrations generally decreased to less than 10 µg/L. A slight increase in perchloroethylene (PCE) and xylene concentrations was observed in samples collected from well 085-236 in September and December 2002. During this time, PCE reached a maximum of 24.7 µg/L and total xylene concentrations reached a maximum of 46.1 µg/L. The gasoline additive MTBE continues to be detected in wells 085-236 and 085-237. However, MTBE levels decreased from a maximum concentration of 64 µg/L in 2001, to a maximum concentration of 32 µg/L in 2002. The AWQS guidance value for MTBE is 10 µg/L. Monitoring wells 085-17, 085-236, and 085-237 are located downgradient of the southern end of the Service Station building, and it is likely that the PCE and petroleum related chemicals detected in groundwater are due to historical discharges to the former service bay floor drains. Following the 2002 discovery of a hydraulic fluid leak in a vehicle

lift, approximately seven cubic yards of contaminated soil were removed from below the southernmost service bay. End-point samples following cleanup indicated the presence of PCE at 47 µg/Kg. No floating petroleum or semivolatile organic compounds (SVOCs) were detected in the monitoring wells during 2002.

7.5.2.4 Major Petroleum Facility

The Central Steam Facility (CSF, Building 610) supplies steam for heating to all major facilities of the Laboratory through an underground distribution system. The Major Petroleum Facility (MPF) is the storage area for most fuels used at the CSF. Eight shallow Upper Glacial aquifer wells monitor the MPF as part of the licensing requirements for this facility, and are screened across the water table so that potential free product can be detected. Additional surveillance wells are in the nearby CSF area, and are used to monitor groundwater contamination resulting from a 1977 leak of approximately 25,000 gallons of Alternative Liquid Fuel (a mixture of fuel oil and spent solvent). Contaminated soils and groundwater near the 1977 spill underwent active remediation from 1997-2001 (see Section 7.6.4.1).

In accordance with updated license conditions for the MPF, during 2002, groundwater samples were analyzed semi-annually for SVOCs and VOCs, and the wells were tested monthly for the presence of floating petroleum hydrocarbons. During 2002, none of the target compounds associated with fuel oil were detected, and no floating petroleum product was observed. In the April 2002 samples, VOCs were detected in two wells (076-19 and 076-380) at concentrations exceeding the AWQS of 5 µg/L. The compounds detected in well 076-380 were: 1,2-dichloroethene (*total*) at 300 µg/L, tetrachloroethylene (PCE) at 36 µg/L, and trichloroethylene (TCE) at 8.3 µg/L. The compound 1,2-DCE was also detected in well 076-19 at a concentration of 16 µg/L. (Note that 1,2-dichloroethene is a breakdown product of the common degreasing agent PCE.) After these results were received, BNL increased the sampling frequency for well 076-380, as well as several nearby monitoring wells. In May 2002,

1,2-DCE was detected in well 076-185 at a concentration of 26.6 µg/L. This is a shallow well located approximately 350 feet south of well 076-380. During the remainder of the year, 1,2-DCE concentrations in well 076-380 increased to a high of 566 µg/L in June, then steadily decreased to nondetectable levels by October. PCE concentrations also dropped to nondetectable levels by October; however, TCE concentrations increased slightly to 20 µg/L.

Based on an evaluation of groundwater flow directions and modeling, it is likely that the VOC contamination originates from an historical spill near the CSF area. The historical nature of this spill is supported by: 1) degreasing agents such as PCE have not been used at the CSF in many years, 2) PCE has been detected in well 076-19 since the early 1990s, and 3) the presence of 1,2-dichloroethene, which is a breakdown product of PCE. A number of historical spill sites near Building 610 were identified in the late 1990s, and the most contaminated soils were subsequently excavated in accordance with regulatory requirements. In an effort to identify the source of the contamination, BNL will install several temporary wells in early 2003 downgradient of these soil cleanup areas.

7.5.2.5 Waste Management Facility

In 1997, BNL began operating its new Waste Management Facility (WMF), 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 WMF is monitored by eight shallow Upper Glacial aquifer wells. Groundwater monitoring results for 2002 were consistent with previous monitoring, and continue to show that WMF operations were not impacting groundwater quality.

Volatile Organic Compounds, Metals, and Anions. In 2002, all water quality and most metals concentrations were below the applicable AWQS. As in past years, sodium was detected at concentrations above the AWQS of 20 mg/L in upgradient well 055-03, at a maximum concen-

tration of 29.5 mg/L. Compared to previous years when low levels of VOCs (1,1,1-trichloroethane and chloroform) were periodically detected in several of the upgradient wells, no VOCs were detected during 2002. Furthermore, the gasoline additive MTBE, which was detected in the February 2001 sample from well 056-22, was not detected in any of the WMF wells during 2002.

Radionuclides. Radioactivity levels in samples collected from the WMF wells were typical of ambient (background) levels. No Laboratory-related radionuclides were detected in the WMF wells during 2002.

7.5.2.6 *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 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 within Greenhouse 10. Analysis of groundwater samples collected to date does not indicate that greenhouse operations have affected groundwater quality.

In September 2002, the greenhouse area wells were sampled and tested for pesticides, metals, and anions. Pesticides were not detected, and all water quality concentrations were below the applicable AWQS. Sodium was the only metal detected at a concentration above the AWQS of 20 mg/L, with a maximum concentration of 26.8 mg/L in well 084-36. The detection of low levels of sodium is not uncommon in wells within the developed area of the site and could be related to road salting operations.

7.5.2.7 *Shotgun Range*

The BNL Shotgun Range was established in 1974, and is used for trap and skeet target shooting by the Brookhaven Employees Recreation Association. The range is in an isolated, wooded area north of the new Waste Management Facility and consists of an open field that is approximately 200 feet east–west by 400 feet north–south.

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 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.

Groundwater monitoring conducted to date does not indicate that Shotgun Range operations are affecting groundwater quality. The groundwater monitoring wells at the Shotgun Range were sampled one time during 2002. All metal concentrations (including lead) were below the applicable AWQS and were consistent with established background levels.

7.5.2.8 *Live Fire Range*

The BNL Live-Fire Range consists of a six-position, 100-yard, bermed, outdoor small arms range located immediately north of the BNL Sewage Treatment Plant's filter bed area. Range operations have been conducted at this site since 1963. The eastern half of the range extends to within 200 feet of the Peconic River. 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 berm is periodically screened to a depth of approximately one foot. The lead shot recovered during the screening process and the spent brass cartridges are disposed of, off site, by a commercial scrap metal waste handler.

Groundwater monitoring conducted to date does not indicate that range operations are affecting groundwater quality. During 2002, the Live Fire Range wells were sampled one time. All metal concentrations (including lead) were below the applicable AWQS and were consistent with established background levels.

7.6 ENVIRONMENTAL RESTORATION GROUND-WATER MONITORING PROGRAM

The mission of the Environmental Restoration Groundwater Monitoring Program is

to monitor the various contaminant plumes on site and off site, as well as to monitor the progress that the groundwater treatment systems are making toward plume remediation. The information below provides an overview of ER groundwater monitoring and remediation activities for 2002. In this period, a total of 615 groundwater surveillance wells were monitored during 2,065 individual sampling events.

Maps showing the main VOC and radionuclide plumes are provided as Figures 7-4 and 7-5. 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. Detailed monitoring program descriptions, maps, and cross-sections showing the extent of contamination, concentration trend data, as well as the hydrogeology for the BNL site and surrounding areas, are presented in the *2002 BNL Groundwater Status Report* (BNL 2003c).

7.6.1 Background Monitoring

Background groundwater quality for the BNL site was monitored with a network of 10 wells in the northern portion of the site and in off-site areas to the north. The background wells provide information on the 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 located upgradient of the BNL site.

Historically, low concentrations of VOCs have been detected in some background wells. During 2002, m/p xylene was detected at a trace level (1.7 µg/L) in well 034-02. Although background samples were not tested for radionuclides during 2002, historical monitoring has demonstrated that radionuclide concentrations are consistent with natural levels.

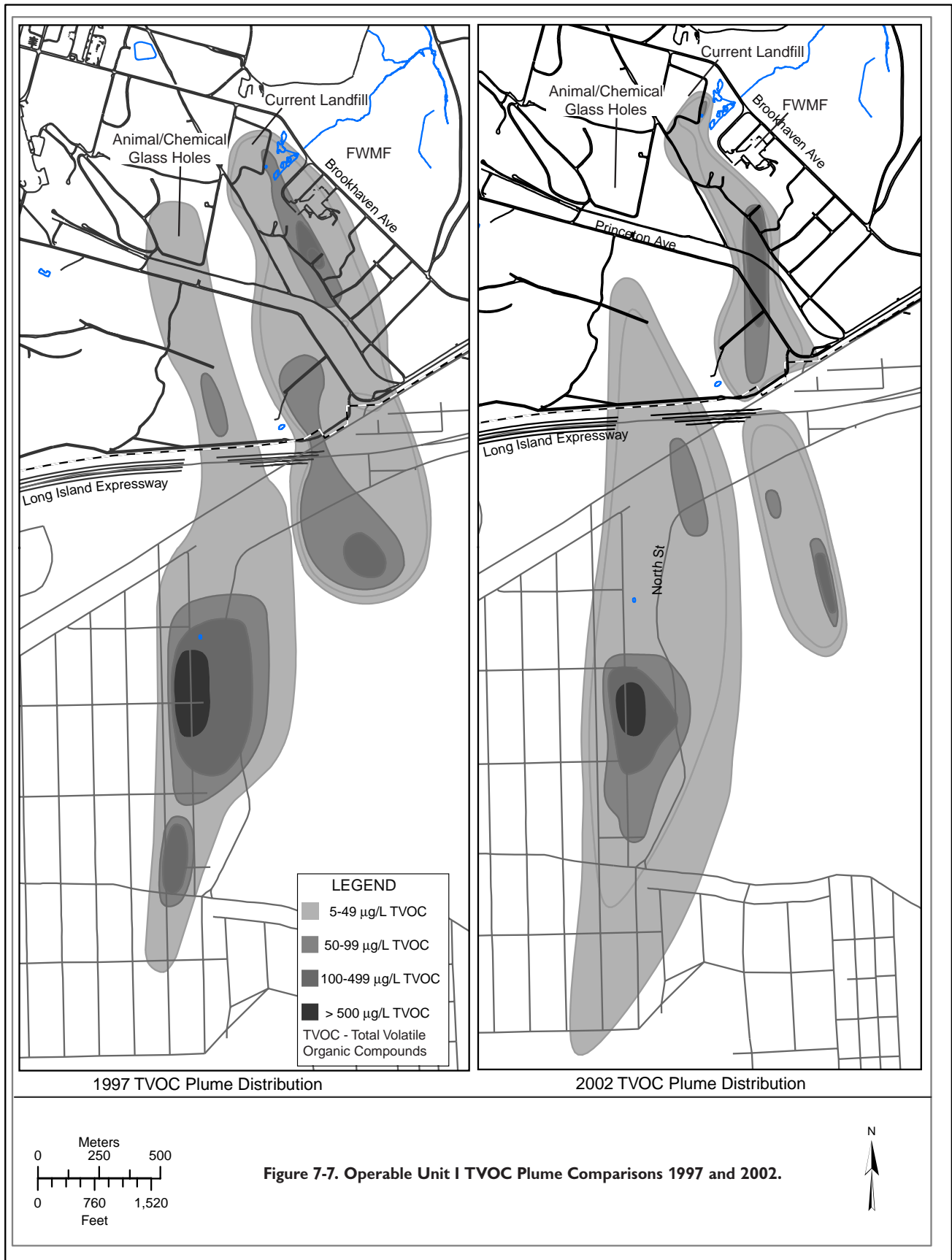
7.6.2 Operable Unit I

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. 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 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 monitors the Former Landfill area. This monitoring program is designed in accordance with post-closure operation and maintenance requirements specified in 6 NYCRR Part 360, "Solid Waste Management Facilities." The objective of this program is to verify that 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 III North Street Monitoring Program.

Former Landfill Monitoring Results. The areal extent of VOC contamination from the Former Landfill – Animal/Chemical Pits and Glass Holes area is shown in Figure 7-7. The primary VOCs that are consistently detected in the Former Landfill Monitoring Program wells are TCA, 1,1-DCA, trichloroethylene (TCE), and chloroform. The contaminants of concern for the Former Landfill wells are VOCs and strontium-90. Continued monitoring has shown declining VOC and strontium-90 concentration



trends in downgradient wells, indicating that the landfill cap is performing as planned. A detailed evaluation of VOCs, radionuclides, leachate parameters, metals, and pesticides/PCBs is provided in the *2002 Environmental Monitoring Report, Current and Former Landfill Areas* (BNL 2003a).

During 2002, VOC concentrations did not exceed the AWQS in any of the Former Landfill area monitoring wells. VOC concentrations have been low in all of the wells over the past five years, with infrequent detections that exceeded the AWQS. TCE and 1,1-DCA were consistently detected at concentrations below the 5 µg/L standard in downgradient wells 097-17, 097-64, 106-02, and 106-30. Trace levels of VOCs have also been occasionally detected in upgradient wells 087-22, 087-72, and 086-42. The trailing edge of the VOC plume emanating from the Former Landfill has migrated south of the monitoring well network (Figure 7-7).

Historically, strontium-90 has been detected in shallow well 097-64, less than 100 feet downgradient of the landfill footprint. Strontium-90 concentrations in this well have been steadily declining since 1998, when it was last detected above the 8 pCi/L drinking water standard, at a concentration of 12 pCi/L. The highest strontium-90 concentration in this well during 2002 was 2.9 pCi/L, in January. The strontium-90 plume has shifted south of wells 097-64 and 106-64, as shown in Figure 7-8.

During 2002, all conventional landfill leachate parameters (e.g., alkalinity, sulfates, chlorides, total nitrogen, nitrates, nitrites, TKN, total dissolved solids, and total suspended solids) were below applicable AWQS. Iron, manganese, aluminum, and thallium were occasionally detected at concentrations above AWQS in three downgradient wells. Sporadic, single detections of iron (0.394 mg/L), aluminum (0.338 mg/L), and thallium (0.0066 mg/L) exceeded water quality standards in several samples from well 106-30. Manganese (up to 1.79 mg/L) was detected in two samples from well 097-277, and thallium (0.005 mg/L) was detected in one sample from well 097-64. The AWQS for iron, manganese, aluminum, and thallium are 0.3 mg/L, 0.3 mg/L, 0.2 mg/L, and 0.0005 mg/L, respectively.

Animal/Chemical Pits and Glass Holes

Monitoring Results. Groundwater samples were obtained from 24 monitoring wells during 2002. Twelve of these wells were installed in 2002 as part of the Chemical/Animal Holes Strontium-90 Pilot System that is designed to determine the feasibility of treating the contaminated groundwater.

Figure 7-8 shows the strontium-90 plume distribution. The highest strontium-90 concentration observed during 2002 was 1,130 pCi/L in well 106-16, which is immediately south of the Animal Pits. This well has historically shown the highest strontium-90 concentrations in this area (see trend plot on Figure 7-8). The sharp increase in strontium-90 in this well appears to be correlated with the excavation of the Animal Pits area in 1997, which may have released additional strontium-90 to the groundwater.

The high concentration segment of the strontium-90 plume, with concentrations greater than 100 pCi/L, extends from approximately 75 feet northwest of well 106-16 to approximately 75 feet south of the Princeton Avenue firebreak road (Figure 7-8). The leading edge of the plume, as defined by the 8 pCi/L drinking water standard, is approximately 240 feet south of this firebreak road. A second, smaller plume occurs south of the Former Landfill. The trailing edge of the plume is estimated to be approximately 80 feet south of the Princeton Avenue firebreak road.

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.

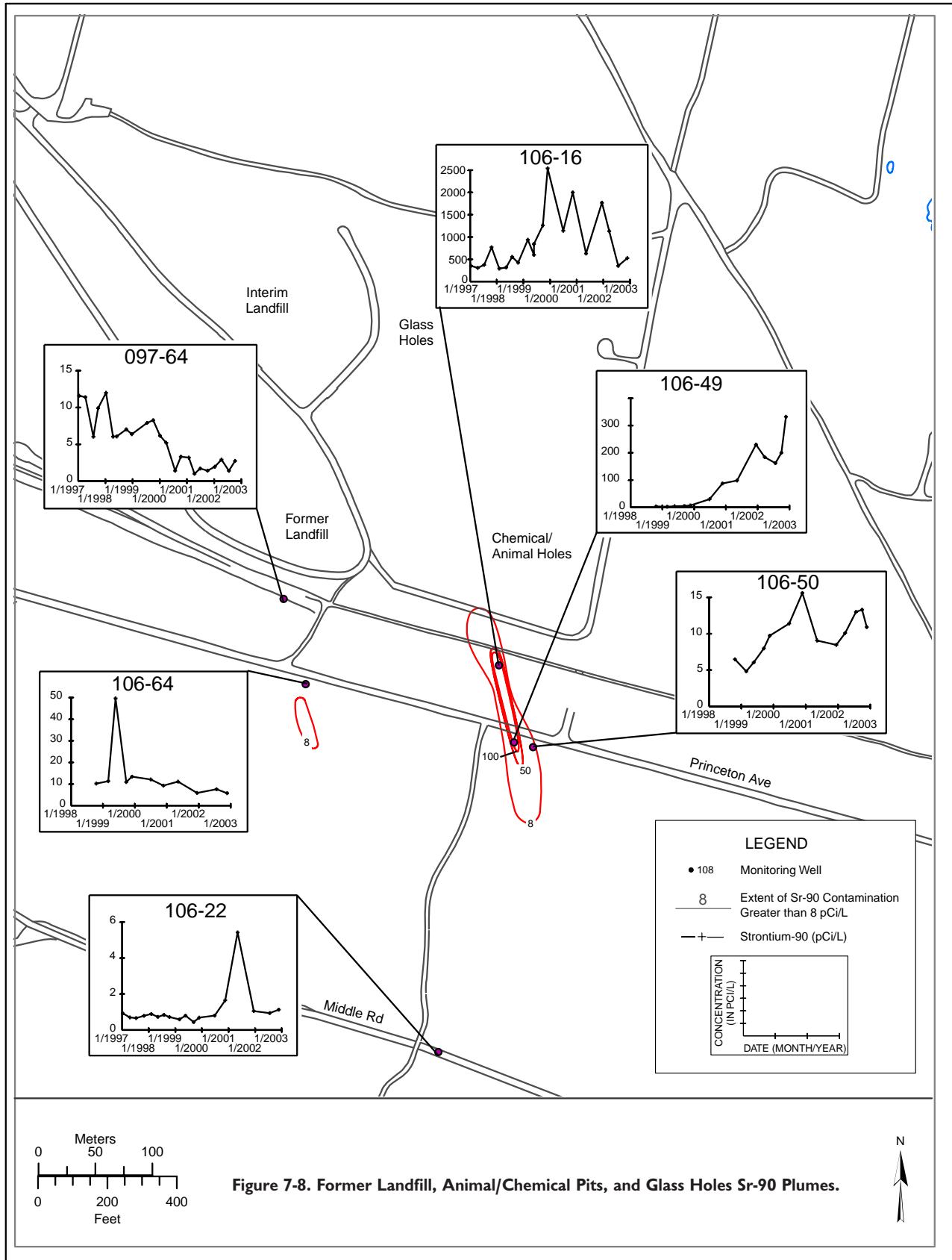


Figure 7-8. Former Landfill, Animal/Chemical Pits, and Glass Holes Sr-90 Plumes.

The Current Landfill post-closure groundwater monitoring program consists of a network of 11 monitoring wells 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. Data collected to date show that, in general, contaminant concentrations have been decreasing following the capping of the landfill in 1995. A detailed evaluation of VOCs, radionuclides, leachate parameters, metals, and pesticides/PCBs is provided in the 2002 *Environmental Monitoring Report, Current and Former Landfill Areas* (BNL 2003a).

Volatile Organic Compounds. The primary VOC that has been consistently detected in wells at the Current Landfill is chloroethane. The highest chloroethane value was 43 µg/L in well 88-109, which is adjacent to the southeast side of the landfill. The peak historical chloroethane concentration in well 088-109 was 560 µg/L in 1998. The extent of the Current Landfill VOC plume is shown in Figure 7-7.

Radionuclides. As in previous years, low levels of tritium and strontium-90 were detected in Current Landfill monitoring wells during 2002, but at concentrations well below their applicable drinking water standards of 20,000 pCi/L and 8 pCi/L, respectively.

Leachate Parameters and Metals. Most conventional landfill leachate parameters (e.g., alkalinity, sulfates, chlorides, total nitrogen, nitrates, nitrites, TKN, total dissolved solids, and total suspended solids) were below applicable AWQS, except for ammonia. Ammonia concentrations exceeded the AWQS of 2 mg/L, with the highest concentrations detected in well 088-109, at 8 mg/L. Ammonia is a common landfill contaminant and is generated by the degradation of organic material. As in past years, the metals iron and magnesium were also detected above AWQS in many of the Current Landfill wells in 2002. Their concentrations are expected to fall

relatively slowly due to their sorption to aquifer materials, thereby reducing mobility.

7.6.2.3 Current Landfill and FWMF Plumes

Groundwater contamination originating from the downgradient section of the Current Landfill plume and the Former Waste Management Facility (FWMF) is being monitored under the OU I South Boundary program. This monitoring program uses a network of 57 wells located downgradient of the Current Landfill and FWMF. Until 1997, the FWMF was BNL's central facility for processing, neutralizing, and storing hazardous and radioactive wastes before off-site disposal. As the result of past waste handling and storage practices, groundwater at the FWMF is contaminated with both chemicals and radionuclides at concentrations that exceed AWQS or DWS.

The Current Landfill and FWMF plumes become commingled south of the FWMF (Figure 7-7). The Current Landfill/FWMF plume is 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. This system provides hydraulic containment of those on-site portions of the plume that have total volatile organic compound (TVOC) concentrations greater than 50 µg/L. (Note: TVOC is a summation of all individual VOC concentrations for a particular well sample.)

Volatile Organic Compounds. Total volatile organic compound concentration distributions for the Current Landfill/FWMF plume are shown in Figure 7-7. The primary VOCs found on site include chloroethane and DCA (the signature contaminants for the Current Landfill), whereas TCA, 1,1-dichloroethene (DCE), trichloroethylene (TCE), and chloroethane are prevalent in the off-site (North Street East) segment of the plume. DCA and chloroethane are primarily detected in the Shallow Glacial aquifer near the source areas, and in the deep Upper Glacial aquifer at the site's boundary and off site. TCA, DCE, TCE, chloroethane, and chloroform are found in the mid to deep Upper Glacial aquifer off-site south of North Street.

The Current Landfill/FWMF plume (defined by TVOC concentrations greater than 5 µg/L) extends south from the Current Landfill to an area approximately 2,250 feet south of North Street (approximately 7,300 feet long as measured from the Current Landfill). Its maximum width is about 1,300 feet at the southern site boundary. The areas of the plume displaying the highest VOC concentrations (greater than 100 µg/L) are approximately 500 feet downgradient of the FWMF (at well 098-59), and off site, south of well 000-124. TVOC concentrations in wells positioned in the core of the plume are decreasing. For example, TVOC concentrations in plume core well 098-59 declined after peaking at 239 µg/L in 2001, to 125 µg/L in the fourth quarter of 2002.

The distribution of the plume has changed since the south boundary pump-and-treat system began operation in 1997 (Figure 7-7). The system appears to have created a break in the plume, characterized by a region of low-level TVOC concentrations from south of the extraction wells to just south of the Long Island Expressway (LIE). 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 off site (see Figure 7-16).

Radionuclides. Tritium levels in wells located inside the FWMF have been declining since 1997 when concentrations approached 44,000 pCi/L in well 088-26. Concentrations were less than 858 pCi/L in this same well during 2002. As previously released tritium continues to migrate away from the FWMF, tritium concentrations have been steadily increasing in downgradient well 098-30 located approximately 900 feet to the south, to a maximum of 24,600 pCi/L in 2002. Low levels of tritium continued to be detected off site during 2002, with a maximum concentration of 2,960 pCi/L, in well 000-138.

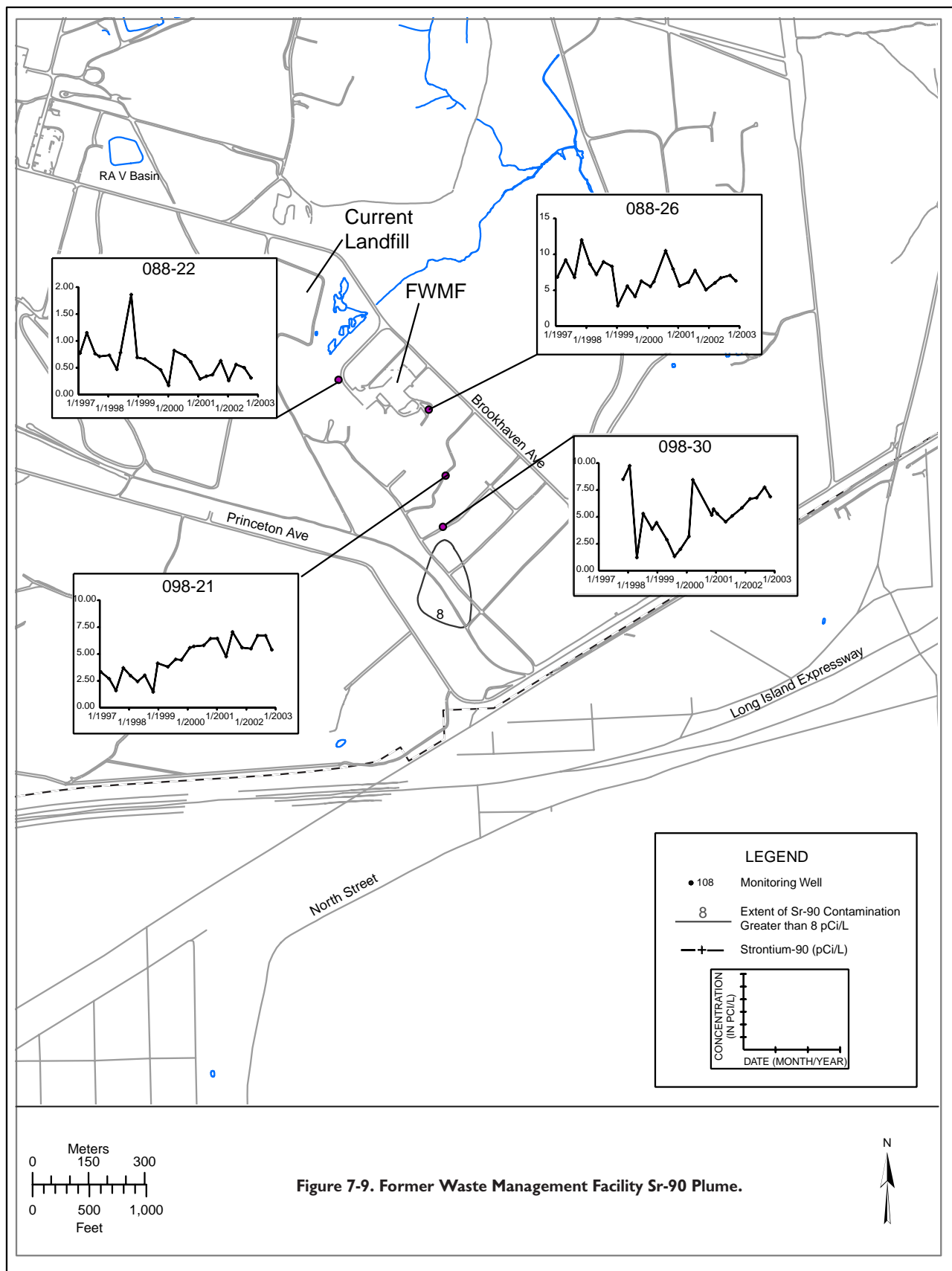
Strontium-90 has historically been detected on site at concentrations above the drinking water standard of 8 pCi/L in some wells within and downgradient of the FWMF. In 2001, additional groundwater characterization work

was performed using thirteen temporary wells downgradient of the FWMF. During this investigation, the highest strontium-90 detection was observed in temporary well 108-30, at 65.4 pCi/L. For improved monitoring, sentinel wells were installed in 2002 downgradient of the leading edge of the plume. Strontium-90 was not detected in these new wells during 2002. The peak strontium-90 concentration during 2002 was 7.8 pCi/L, in well 098-30. The extent of strontium-90 concentrations that are greater than the 8 pCi/L drinking water standard is shown in Figure 7-9.

7.6.3 Operable Unit III

The monitoring well network established to monitor the OU III VOC and radionuclide source areas and associated contaminant plumes is comprised of approximately 180 monitoring wells positioned from the north-central portion of the site to the southern site boundary and off site. 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 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.
- Evaluate the effectiveness of the OU III South Boundary, Western South Boundary, Middle Road, Carbon Tetrachloride, Industrial Park, and Building 96 groundwater treatment systems. These monitoring programs characterize the effects of the pumping on the contaminant plumes and provide the data necessary for making decisions on the future operations of the remediation systems.
- Monitor the off-site segment of the OU III plume and sentinel wells south (downgradient)



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

7.6.3.1 OU III Volatile Organic Compound Plumes

Figure 7-10 shows the areal extent of the OU III VOC plume, which 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 18,000 feet.

The OU III VOC plume consists of multiple commingled plumes originating from a number of source areas in the central areas of the BNL site. The primary VOCs detected in on-site monitoring wells include TCA, PCE, and carbon tetrachloride. Carbon tetrachloride and PCE are the primary VOCs detected in off-site groundwater monitoring wells.

In general, PCE, TCA, and carbon tetrachloride occur in the shallow Upper Glacial aquifer in the central portion of OU III, and in the deep Upper Glacial aquifer at the southern site boundary and off site. On-site portions of the plume displaying the highest VOC concentrations during 2002 were the former carbon tetrachloride UST area (with carbon tetrachloride values up to 1,940 µg/L) and the former Building 96 area (primarily PCE and lower concentrations of TCA, with TVOC values of up to 3,718 µg/L). TVOC concentrations up to 2,948 µg/L were observed at the Middle Road, and TVOC concentrations up to 1,471 µg/L were detected at the southern boundary. High levels of VOCs were also observed in wells in the Industrial Park, where TVOC levels ranged up to 1,613 µg/L (composed primarily of carbon tetrachloride and PCE).

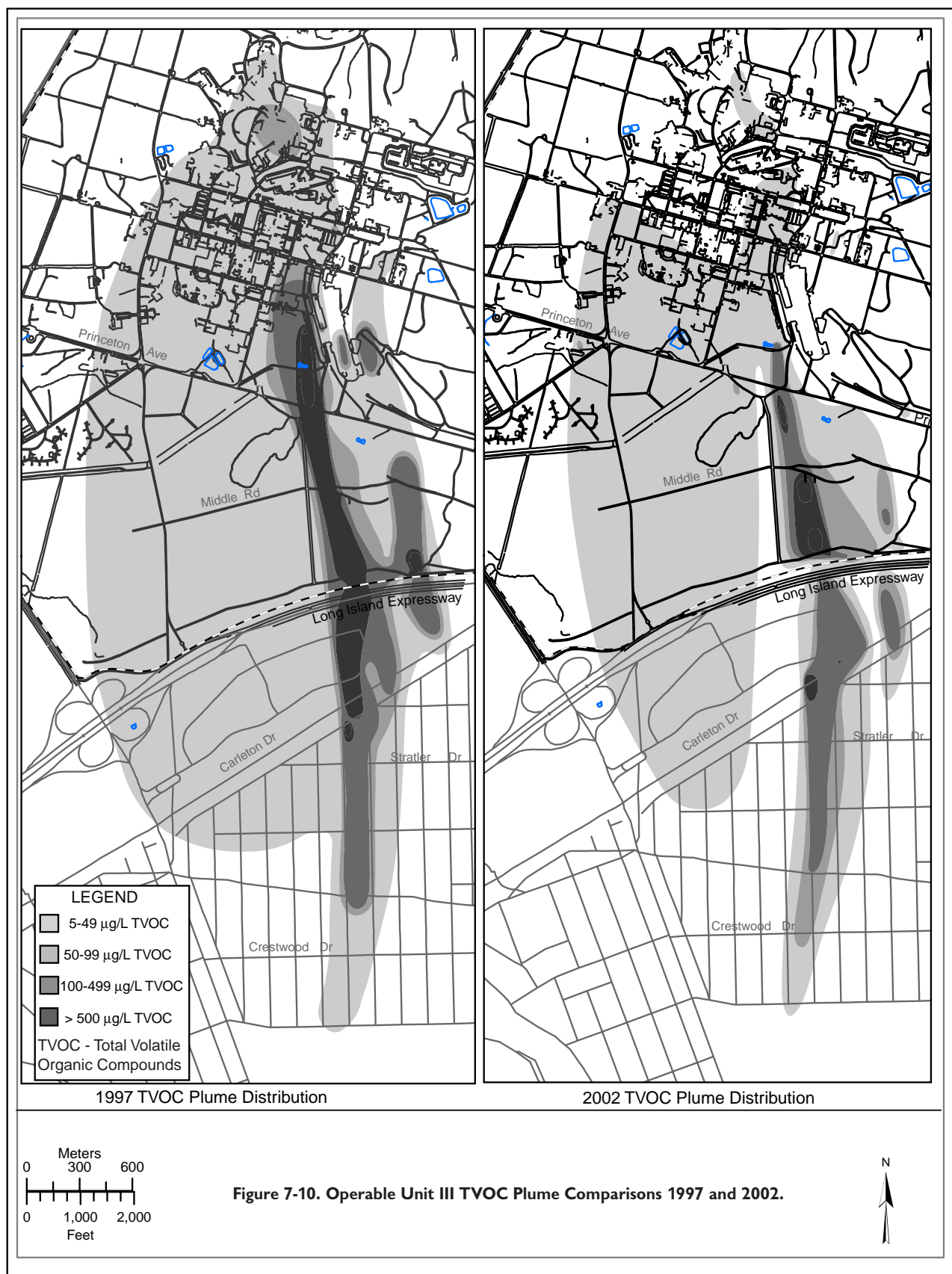
Monitoring results also indicate that there is significant carbon tetrachloride and PCE contamination off site in the Upper Magothy aquifer in the vicinity of the Industrial Park and Carleton Drive in North Shirley. Characterization of the

Magothy aquifer in this area began in 2000 and was completed in 2002 (see Arcadis-Geraghty and Miller 2003). The characterization study included the installation of 22 temporary vertical profile wells and 13 permanent monitoring wells. The highest carbon tetrachloride and PCE concentrations occurred in well 000-130, with a maximum TVOC concentration of 295.8 µg/L. A comparison of the OU III plumes between 1997 and 2002 is provided in Figure 7-10. A summary of significant source areas and groundwater treatment areas is provided below.

OU III Central Area. A number of low-level (less than 100 µg/L) source areas and nonpoint source contamination have been identified within the developed central areas of the BNL site. These areas are monitored under the OU III Central project.

The monitoring well network established for the central area of the site consists of 21 wells. This network also is supplemented with Environmental Surveillance program wells that are used to monitor active research and support facilities. During 2002, VOC concentrations in most of the OU III Central wells were near or below the AWQS. Significant observations for 2002 are described below.

- Well 065-05 is screened in the shallow Upper Glacial aquifer and is located in the AGS area. TVOC concentrations in this well peaked at 123 µg/L in September 2000, and then decreased to 17 µg/L during the fourth quarter of 2001. TVOC concentrations continued to decrease in 2002, dropping to 5 µg/L by the fourth quarter. The VOCs are likely to have originated from historical discharges to cesspools near Building 914.
- Well 066-09 is located southeast of Building 830 and is screened in the shallow Upper Glacial aquifer. VOC concentrations, primarily TCA, significantly increased during late 2000 and early 2001, peaking at 112 µg/L TVOC in February 2001. VOC concentrations during the final three quarters of 2001 dropped to below the 5-µg/L AWQS. A preliminary investigation identified several potential sources in Building 830; however, a subsequent Geoprobe™ investigation during the summer of 2001 revealed little or no



VOC contamination near the building. During 2002, VOC concentrations remained below AWQS, with the exception of a single detection of trichlorofluoromethane at a concentration of 9 µg/L in the fourth quarter of the year.

- Well 083-02 is located near the intersection of Brookhaven Avenue and Upton Road and is screened in the mid to deep Upper Glacial aquifer. Since 1997, this well consistently has contained 10 to 25 µg/L of chloroform. Potential sources of this contamination may be in the AGS area of the site.
- Wells 109-03 and 109-04 serve as sentinel wells for Suffolk County's William Floyd Well Field and are near the eastern BNL site boundary. Toluene was detected in well 109-03 (screened in the deep Upper Glacial aquifer) at 5.3 µg/L in a sample collected in September 2002. Prior to this period, VOCs had not been detected at concentrations exceeding AWQS. When the well was re-sampled in October 2002, MTBE was detected at concentrations up to 7 µg/L. The AWQS for toluene is 5 µg/L, and is 10 µg/L for MTBE. The well was re-sampled in December by BNL and January 2003 by SCDHS. In both instances, no VOCs were detected. More frequent sampling of this well will be conducted by BNL and SCDHS during 2003. As in previous years, there were no detections of Laboratory-related radionuclides in these wells during 2002.

Building 96 Area. The OU III Remedial Investigation/Feasibility Study identified the Building 96 area as a significant source of the PCE detected in the OU III plume. This area encompasses four distinct areas: Building 96 and associated leaching structures; Building 96 Scrapyard; Former Building T-239 and associated leaching structures; and the former truck wash area.

An in-well air sparging system to remediate the Building 96 VOC source area began operations in February 2001. The Building 96 groundwater treatment system consists of four recirculation treatment wells. The VOC plume consists primarily of PCE and lower concentrations of TCA. The AWQS for PCE and TCA is 5

µg/L. During 2002, the Building 96 area VOC plume was monitored using 17 permanent wells and 12 temporary wells. The temporary wells were installed to help determine the extent of contamination remaining in the source area, and to redefine the western extent of the plume. Although VOC concentrations throughout most of the plume have declined significantly since the treatment system was installed, high concentrations of VOCs were detected in the northern section of the source area (north of treatment well RTW-1), with a maximum TVOC concentration of 3,718 µg/L in temporary well 085-313. These persistent high levels of VOCs appear to be coming from a silty layer that is slowly releasing the contaminants. BNL is planning to install additional monitoring wells, and will conduct an engineering study on the source term and alternative treatment technologies.

Carbon Tetrachloride UST Area. In April 1998, an inactive underground storage tank used to store carbon tetrachloride was excavated and removed. This tank was approximately 200 feet northeast of the Upton Service Station (at the corner of Rowland Street and Rochester Street). Although groundwater samples collected from a nearby well had shown low-level concentrations of carbon tetrachloride since 1995, samples collected in June 1998 revealed levels approaching 100,000 µg/L. The AWQS for carbon tetrachloride is 5 µg/L. The increase in contaminant concentration was probably due to the spillage of residual carbon tetrachloride during removal of the underground storage tank. A groundwater remediation system consisting of two extraction wells (EW-13 and EW-14) screened in the shallow Upper Glacial aquifer began operation in October 1999. A third extraction well (EW-15) installed in the downgradient segment of the plume began operation in December 2001. The effects of the pump-and-treat system on the source area are apparent in the sharp decline in carbon tetrachloride concentrations in wells near the former UST area.

The carbon tetrachloride contamination extends from the former UST southeast to the vicinity of the Weaver Road recharge basin, a distance of approximately 1,300 feet. The width of the plume, as defined by concentrations

greater than 50 µg/L, is approximately 120 feet. In 1999, carbon tetrachloride concentrations in groundwater immediately downgradient of the former UST were greater than 150,000 µg/L (in well 085-98). Carbon tetrachloride concentrations in this area steadily decreased following the start of groundwater treatment system pumping, and were only 158 µg/L during the fourth quarter of 2002. Carbon tetrachloride concentrations were also observed to decrease in wells near the Service Station. For example, carbon tetrachloride concentrations in well 085-17 dropped from 3,760 µg/L in February 2001 to 154 µg/L by the fourth quarter of 2002. Carbon tetrachloride concentrations continue to decline in the downgradient segment of the plume as a result of the treatment system. Carbon tetrachloride levels in well 095-279, which is near the southernmost extraction well EW-15, declined from nearly 600 µg/L in the second quarter of 2002, to 122 µg/L in the fourth quarter of 2002. Carbon tetrachloride was not detected in any of the sentinel wells in the vicinity of Weaver Drive.

Middle Road Treatment Area. Six groundwater extraction wells are used to hydraulically control the OU III VOC plume located near the Middle Road. This system began operating in October 2001. The Middle Road Monitoring Program consists of a network of 26 monitoring wells.

TVOC concentrations in plume core well 105-23, approximately 2,000 feet upgradient of RW-1 near Princeton Avenue decreased from 1,794 µg/L during 2001, to 420 µg/L in the fourth quarter of 2002. The highest TVOC concentrations are found immediately south of extraction wells RW-2 and RW-3, based on influent data for these wells and nearby monitoring wells. The highest TVOC concentration was 2,948 µg/L detected in well 113-17. Although this area of high level contamination is outside capture zones of the Middle Road extraction wells, it is expected to be captured by the OU III South Boundary system. TVOC concentrations in monitoring wells in the vicinity of RW-4 and RW-5 are below the AWQS.

Southern Boundary Treatment Area. Hydraulic control of the OU III plume at the site

boundary has been attained using seven extraction wells that pump water from the deep portions of the Upper Glacial aquifer to an air stripper for treatment. This system began operation June 1997. The seven recovery wells are screened at the depths showing the highest VOC concentrations. The effectiveness of the Southern Boundary treatment system is monitored using a network of 38 wells. Monitoring data have demonstrated that the distribution of the plume has changed since the south boundary pump-and-treat system began operation in 1997. The extraction well system has created breaks in segments of the plume, characterized by a region of low-level TVOC concentrations from south of the extraction wells to just south of the Long Island Expressway. High levels of VOCs continue to be detected in some south boundary monitoring wells and are likely due to slugs of high-level contaminants migrating from upgradient areas. During 2002, the highest TVOC concentration detected near the extraction well system was 1,471 µg/L in well 121-14, located between EW-4 and EW-5.

Western South Boundary Treatment Area. The Western South Boundary pump-and-treat system began operation in 2002. The system has two extraction wells and is designed to capture the western portion of the OU III VOC plume, which contains VOC concentrations generally less than 50 µg/L. This area is monitored using a network of 17 wells. The primary contaminants associated with this portion of the OU III plume are TCA, TCE, chloroform, and dichlorodifluoromethane (a freon). The maximum TVOC concentration during 2002 was 53 µg/L, in well 127-06.

Industrial Park Area. The OU III Industrial Park Treatment system was designed to contain and remediate the portion of the OU III plume existing between BNL's southern boundary and the Parr Industrial Park. This segment of the OU III plume consists primarily of carbon tetrachloride that is 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 initiated in the Industrial Park in 1999 to treat VOC contamination in the deep Upper Glacial aquifer.

The monitoring well network for this area consists of 39 wells that extend from the Industrial Park to Carleton Drive. These wells are used to monitor the effectiveness of the in-well air stripping groundwater treatment system. The highest VOC concentrations in the Industrial Park area during 2002 were observed between remediation wells UVB-4 and UVB-5, with the maximum concentration of 1,613 µg/L observed in monitoring well 000-262 during the fourth quarter. Wells that monitor the Upper Glacial aquifer downgradient of the treatment system, along Carleton Drive, showed stable or decreasing VOC concentrations during 2002, with a maximum TVOC concentration of 12.5 µg/L observed in well 000-274.

Two new groundwater remediation systems are being planned to clean up the southern extent of the OU III plume not remediated by the Industrial Park treatment system. The treatment systems will be located along the northern edge of the Town of Brookhaven Airport and along the Long Island Power Authority (LIPA) right-of-way south of Carleton Drive. These systems will be constructed by 2004.

North Street Monitoring. The North Street Monitoring Program (formerly known as OU I/IV Monitoring Program) addresses both a VOC plume that is primarily south of the site boundary and potential radiological contaminants that may have been introduced to groundwater in the OU IV portion of the site (particularly the Building 650 and 650 Sump Outfall areas). A network of 25 wells monitors the downgradient portion of the OU IV, Former Landfill, Animal/Chemical Pits, and Glass Holes VOC plumes. Wells sampled under the OU III South Boundary and Industrial Park Programs are also utilized for mapping this plume.

The VOC plume extends from just south of the Chemical/Animal Hole area southward to the vicinity of Brookhaven Airport. The primary VOCs associated with this plume are carbon tetrachloride, PCE, and TCA. Historically the highest VOC concentrations (primarily carbon tetrachloride) have been detected in well 000-154 in the North Street area. TVOC concentrations greater than 1,000 µg/L were observed in 1997 and 1998 but have steadily declined since that

time as the high concentration segment has migrated southward. The leading edge of this high concentration segment is now being detected in well 000-153, as concentrations increased to nearly 150 µg/L in 2002. Detailed groundwater characterization data can be found in the *North Street Remedial Design Work Plan* (BNL 2002d) and the *OU III Airport Remedial Design Work Plan* (BNL 2002c).

The North Street VOC plume will be remediated using two groundwater treatment systems. The first system will consist of two extraction wells and four recharge wells located between Sleepy Hollow Road and North Street. This system will capture the higher concentration portion of the VOC plume within the Upper Glacial aquifer that contains TVOC concentrations greater than 50 µg/L. This system will help to minimize the potential for VOC migration to the Magothy aquifer. Details on the pre-design groundwater characterization and the planned groundwater treatment system can be found in the *North Street Groundwater Remediation System 90 Percent Design Report* (Arcadis-Geraghty and Miller 2002). This treatment system is scheduled to start operations in Spring 2004. The second groundwater remediation system is to be located at the Brookhaven Airport. This system will remediate the leading edge of the plume, as well as the leading edge of the OU III VOC plume to the west. Details on the proposed remediation system and pre-design characterization activities can be found in the *OU III Airport Groundwater Treatment System 90 Percent Design Documents* (J.R. Holzmacher 2002a). Construction of the system is scheduled to begin in April 2003.

Low levels of tritium have been detected off site in localized areas of the deep Upper Glacial aquifer since the monitoring program started in 1998, but at concentrations well below the 20,000 pCi/L drinking water standard. The maximum tritium concentration observed in 2002 was 1,070 pCi/L, in well 000-153. Tritium was also detected in seven of the 15 temporary vertical profile wells installed in 2001 and 2002. In six of the seven vertical profiles, tritium was detected at concentrations less than 1,000 pCi/L. The highest tritium concentration, 9,130 pCi/L,

was detected in temporary well 000-337 installed approximately 300 feet north of well 000-153. Potential sources for this tritium are located in the Former Landfill/Chemical/Animal Holes and OU IV Building 650 areas of the site.

7.6.3.2 OU III Radionuclide Plumes

HFBR Tritium Plume. In late 1996, tritium was detected in wells near the High Flux Beam Reactor. The source of the release was traced to the HFBR spent fuel pool. In response, the fuel rods were removed from the pool for off-site disposal, the spent fuel pool was drained, and the HFBR was removed from service in 1997. Also, numerous monitoring wells were constructed to characterize the tritium plume downgradient of the HFBR. In May 1997, operation of a three-well groundwater extraction system began. This system was constructed on Princeton Avenue approximately 3,500 feet downgradient of the HFBR to capture the leading edge of the tritium plume. Extracted water was recharged at the Remedial Action (RA) V recharge basin. Groundwater modeling predicts that the tritium plume will naturally attenuate to below drinking water standards before reaching the site boundary. Three years of monitoring data showed that the plume had reached a relative steady state due to natural attenuation and it was not growing significantly. As a result, the extraction system was turned off and placed on standby status in September 2000. The extraction system will be reactivated if tritium concentrations exceed 20,000 pCi/L at Weaver Drive.

The selected remedy for the HFBR tritium plume includes monitoring and low-flow extraction programs to prevent or minimize the plume's growth. During 2000 and 2001, low-flow extraction was applied to the highest concentration area of the plume. The low-flow extraction removed a total of 95,000 gallons of tritiated water that was sent off site for disposal. Tritium concentrations have remained below the 750,000 pCi/L trigger level for low flow pumping since April 2001.

A monitoring well network of 157 wells is used to monitor the extent of the plume. The extent of the tritium plume, determined from data

collected during the fourth quarter of 2002, is shown in Figure 7-11. Tritium concentrations in groundwater immediately south of the HFBR building continue to decrease. Concentrations in well 075-43 were only 22,600 pCi/L during the fourth quarter 2002. This is a significant reduction from the nearly 2,500,000 pCi/L observed in this well during 1999. During 2002, the highest concentration segment of the HFBR tritium plume was between Brookhaven Avenue and Rowland Street, with a maximum concentration of 254,000 pCi/L detected in temporary well 085-238 installed in the eastern end of Bell Avenue. The leading edge of the >20,000 pCi/L portion of the tritium plume is estimated to be in the vicinity of the Chilled Water Plant Road. There were no detections of tritium in excess of 1,000 pCi/L south of Weaver Drive during 2002.

WCF and BGRR-Area Sr-90 Plumes.

Historical waste handling operations at the Waste Concentration Facility and operations at the former BGRR and associated Pile Fan Sump and Stack resulted in the release of strontium-90 to the groundwater below these facilities. The strontium-90 plumes from these facilities are monitored using 61 wells. During 2002, additional groundwater characterization work was conducted in the BGRR area using 26 temporary wells (BNL 2002a).

There are two strontium-90 plumes, one emanating from the WCF and extending south approximately 1,500 feet to just south of Cornell Avenue, and the other beginning south of the BGRR and extending south approximately 600 feet toward Brookhaven Avenue (Figure 7-12). Variability in groundwater flow directions, due to changes in pumping and recharge patterns in the plume vicinity over time, has caused some lateral spreading of the contamination.

There are three areas where strontium-90 concentrations are greater than 50 pCi/L. These areas will be the focus of additional characterization efforts scheduled for late 2003. During 2002, the highest strontium-90 concentration was observed in WCF well 065-167, at 599 pCi/L. This well is located immediately downgradient of the WCF's former "D" tanks area.

The second area of high strontium-90 contamination is in the vicinity of the BGRR's

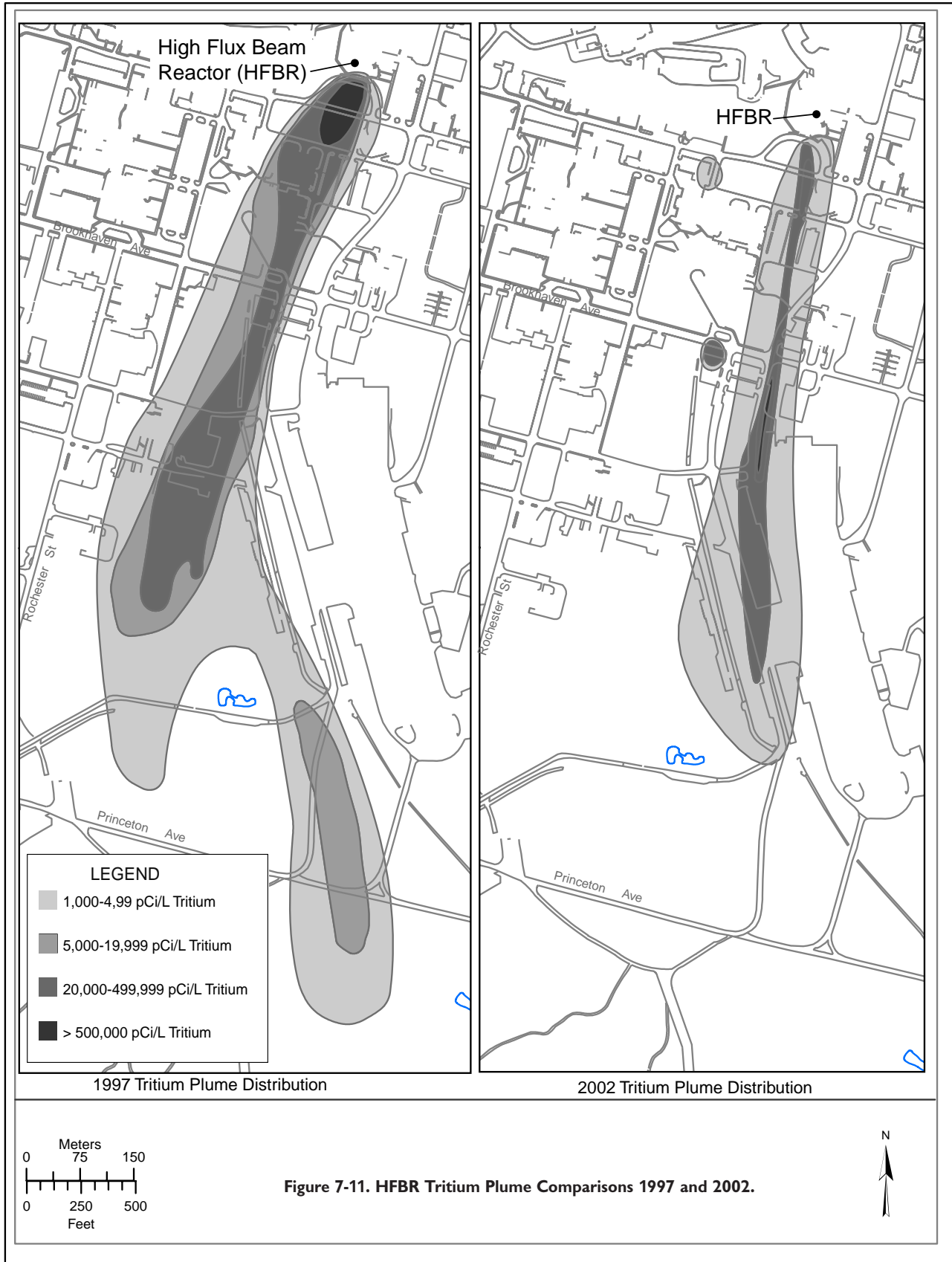




Figure 7-12. BGRR and WCF Sr-90 Plumes.

Below Ground Ducts (BGD), where a groundwater sample from a temporary well installed in August 2001 contained strontium-90 levels at 540 pCi/L. Strontium-90 concentrations greater than 50 pCi/L are estimated to extend south of the BGD area to just south of Cornell Avenue. Groundwater samples were obtained during 2002 from 26 temporary wells installed near the BGRR. Only two of 27 samples collected from the 26 temporary wells exceeded the 8 pCi/L drinking water standard, with concentrations of 12 pCi/L detected in each sample.

A third area of high strontium-90 concentrations was discovered in 2001 near the HFBR stack, in a temporary well, at a concentration of 392 pCi/L. Although there are currently no permanent monitoring wells in the HFBR stack area, strontium-90 concentrations greater than 50 pCi/L are estimated to extend from the stack area several hundred feet to the south.

7.6.4 Operable Unit 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

In 1977, between 23,000 and 25,000 gallons of a mixture of Number 6 fuel oil and mineral spirits were released when a pipe ruptured as the contents of an underground storage tank were being transferred to aboveground storage tanks at the Central Steam Facility. The primary chemical contaminants that were found in the OU IV plume near this 1977 spill site were TCA, PCE, DCE, TCE, toluene, ethylbenzene, and xylenes. In addition, several small spills of Number 6 fuel oil from the CSF fuel unloading area were documented between 1988 and 1993; it also is suspected that small volumes of solvents such as PCE were released to the ground near the CSF.

From 1997 through 2001, BNL operated an air sparging/soil vapor extraction (AS/SVE) system to remediate soil and groundwater contaminated associated with the 1977 spill. The performance goals for soil cleanup were achieved in 1998 and the goals for groundwater cleanup

were met in August 2000. Groundwater monitoring was continued as per *OU IV Remediation Area 1 Proposed Supplemental Remedial Effort – Work Plan, May 2001* (BNL 2001). A “Petition for Closure and Termination of Formal Post-Closure Monitoring of OU IV Air Sparge/Soil Vapor Extraction Remediation System” was submitted in June 2002 (BNL 2002b). BNL is currently awaiting regulatory agency approval for system closure.

Quarterly sampling of the monitoring wells continued during 2002 as BNL awaited a decision from the regulatory agencies on system closure. There were several detections of VOCs exceeding the AWQS in wells 076-04 and 076-06. In well 076-04, 1,2,4-trimethylbenzene was detected at 6 µg/L (fourth quarter) and in well 076-06 also at 6 µg/L (third quarter). In well 076-06, 1,3,5-trimethylbenzene was detected at 10 µg/L (second quarter), 9 µg/L (third quarter), and 5 µg/L (fourth quarter). In well 076-04, m/p xylene was detected in the fourth-quarter sample.

VOCs were not detected above AWQS in the remainder of the wells in the monitoring program except for wells 076-19 and 076-185. These wells are located outside the area of influence of the AS/SVE system. The source of contamination in these wells is the Central Steam Facility.

7.6.4.2 Building 650 and 650 Sump Outfall Areas (AOC 6)

Building 650 was used as a decontamination facility for radioactively contaminated clothing and equipment. Drainage from an exterior heavy equipment decontamination pad was piped to a natural depression approximately 800 feet to the northeast, near recharge basin HO. As a result of these operations, soils and groundwater were contaminated at the decontamination pad and the sump outfall. The soils associated with the Building 650 sump outfall and the pipe leading to the outfall were excavated and disposed of off site during the spring and summer of 2002.

The overall extent of the Building 650 Sump Outfall strontium-90 plume (with concentrations greater than the 8 pCi/L drinking water standard) did not change significantly from 2000 to 2002 (Figure 7-13). The leading edge of the plume projected to be just north of the Major

Petroleum Facility. The highest strontium-90 concentrations were detected in well 076-13 at 27 pCi/L in August 2002. At Building 650, strontium-90 concentrations decreased from a maximum of 14 pCi/L in 2001 (in well 076-28, near the former decontamination pad) to less than 5 pCi/L in 2002.

7.6.5 Operable Unit V

Historically, Brookhaven's Sewage Treatment Plant received discharges of contaminants from routine operations. Releases of VOCs, metals, and radionuclides to groundwater occurred via the STP sand filter beds and discharges to the Peconic River. In addition, trace levels of pesticides were detected in some wells. The OU V monitoring program uses 34 monitoring wells downgradient of the STP. These wells monitor VOC and tritium contamination resulting from historical releases at the STP. Surveillance of groundwater quality near the STP filter beds and emergency holding pond areas is performed as part of the BNL Environmental Surveillance Program for the STP (see Section 7.5.2.1).

Volatile Organic Compounds, Metals, and Pesticides. The extent of the OU V VOC plume is shown in Figure 7-14. The highest TVOC concentration observed during 2002 was 12 µg/L in well 061-05, which is near the eastern site property boundary. The only individual VOCs detected at levels exceeding AWQS were TCE and 1,2-dichloropropane. TCE was detected in well 061-05 at concentrations up to 6.5 µg/L (the standard is 5 µg/L) and 1,2-dichloropropane was detected in shallow offsite well 600-25 at concentrations up to 1.7 µg/L (the standard for this compound is 1 µg/L). Because well 600-25 is shallow, it is likely that the 1,2-dichloropropane is from an offsite source.

As in past years, trace levels of several pesticides were detected during 2002. All concentrations were less than the applicable drinking water standards. Because these pesticides were detected in shallow offsite wells, their origin is likely from agricultural spraying at farms in the vicinity.

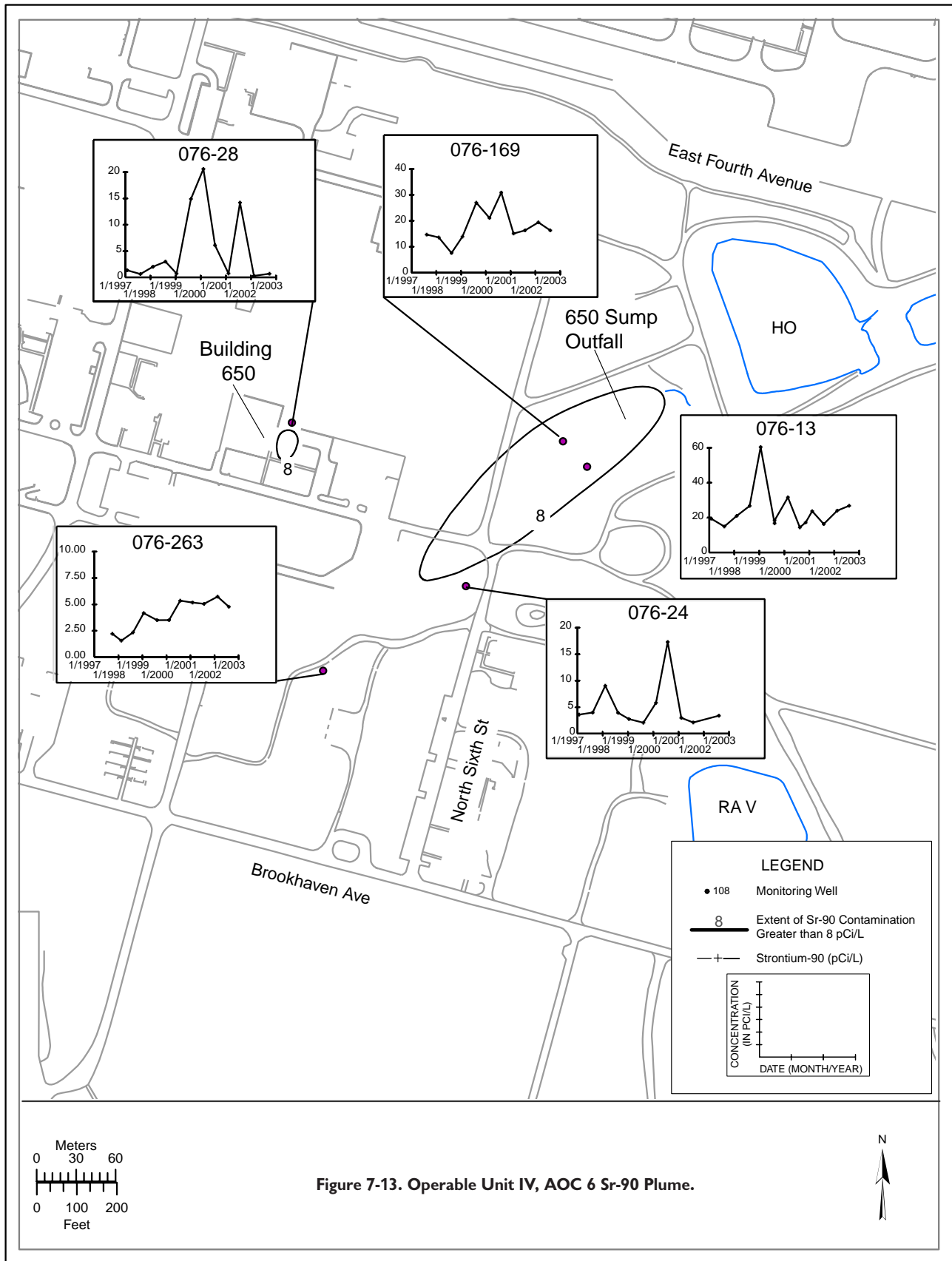
Aluminum, iron, manganese, sodium, and thallium were detected at concentrations above

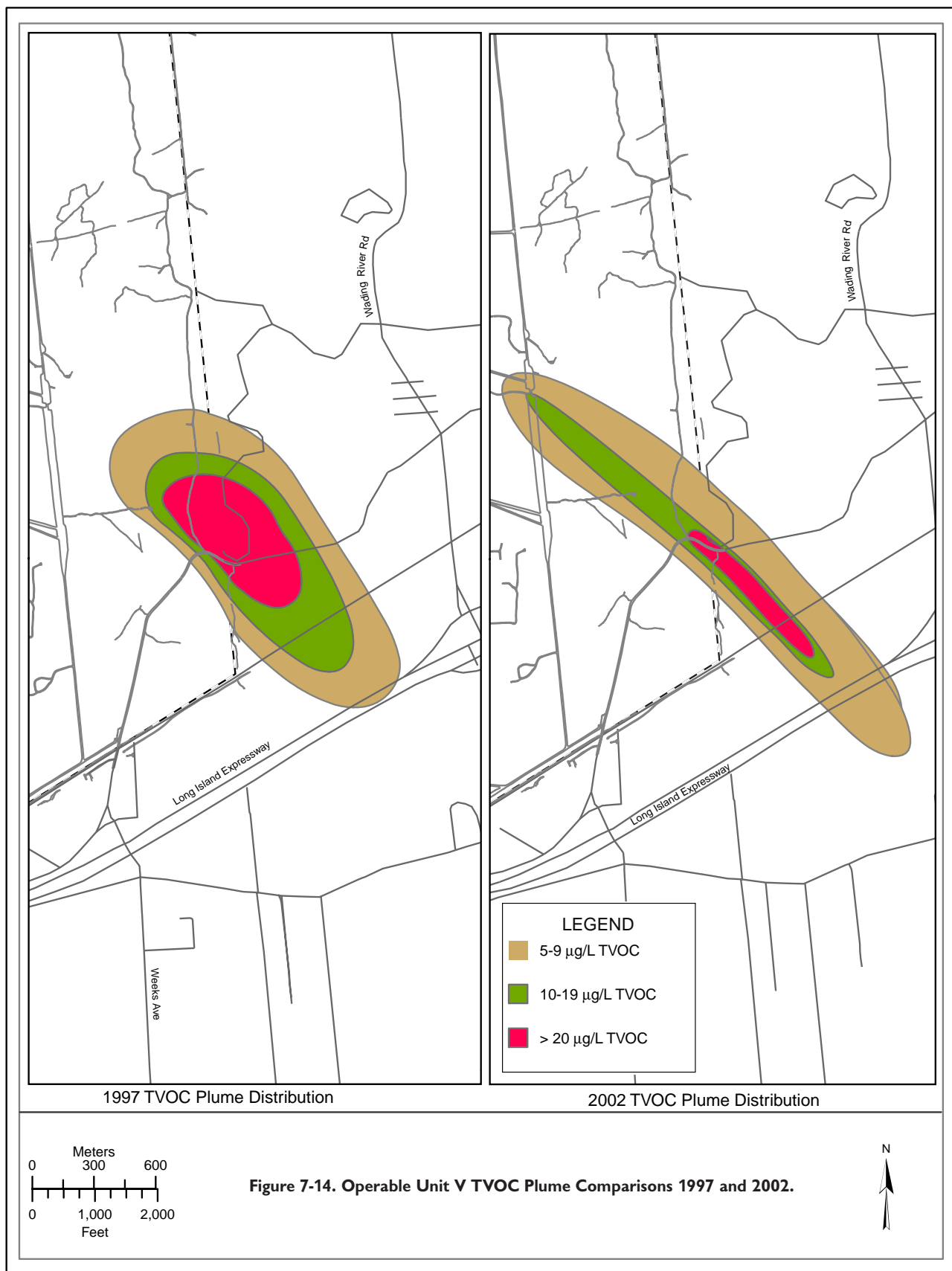
applicable AWQS levels. Aluminum was detected in 11 wells above the AWQS of 0.2 mg/L, with the highest concentration (1.16 mg/L) detected in well 061-03. Iron was detected in 17 wells above the AWQS of 0.3 mg/L, with the highest concentration of 31.5 mg/L detected in well 050-02. Manganese was detected in seven wells above the AWQS of 0.3 mg/L, with the highest concentration (1.1 mg/L) detected in well 050-02. Sodium above the AWQS of 20 mg/L was detected in two wells, with the highest concentration in well 050-02 (25.7 mg/L). Thallium was detected in two wells at a maximum concentration of 0.0047 mg/L, which exceeds the AWQS of 0.0005 µg/L.

Radionuclides. Detectable levels of tritium were found in two wells near BNL's southeastern site boundary, but the concentrations were well below the drinking water standard of 20,000 pCi/L. A maximum tritium concentration of 2,300 pCi/L was detected in well 050-02. Tritium was not detected in any of the off-site monitoring wells. A detailed discussion on the distribution of tritium within the OU V area is provided in the 2002 BNL Groundwater Status Report (BNL 2003c). Gross alpha and gross beta levels were consistent with established background levels for the site.

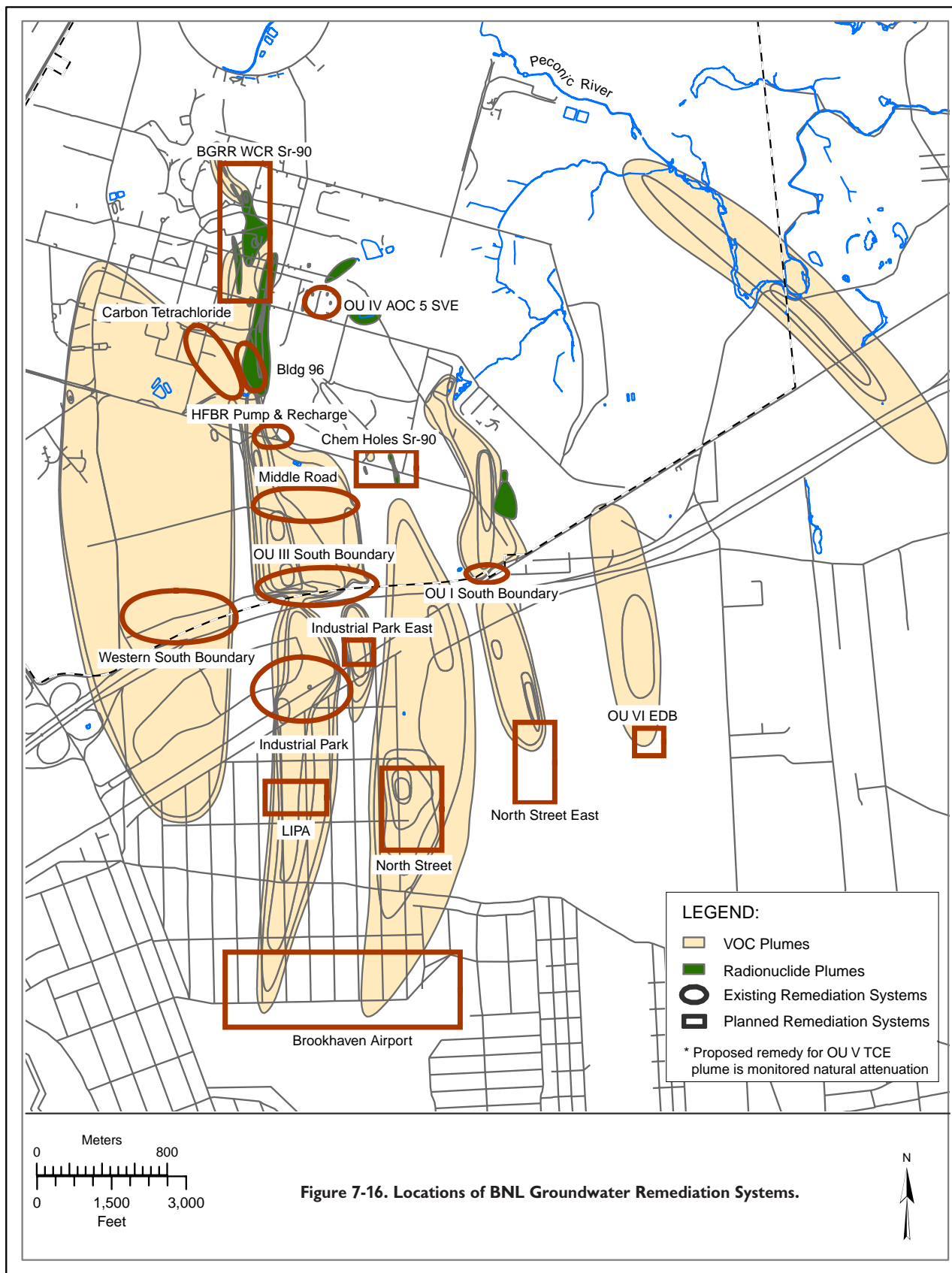
7.6.6 Operable Unit VI, Biology Fields

Ethylene dibromide (EDB) was used as a fumigant in the BNL Biology Department's agricultural fields 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 EDB) extends approximately 3,000 feet, from near BNL's southeastern site boundary to an area south of the Long Island Expressway (Figure 7-15). The leading edge of the plume is downgradient of wells 000-283 and 000-284. Additional sentinel wells to monitor the leading edge of the plume will be installed in 2003. The plume is located entirely in the deep Upper Glacial aquifer. The highest EDB concentration observed during 2002 was 4.6 µg/L, in well 000-284. The wells were also sampled for









radionuclides and, as in past years, no radionuclides were detected.

A groundwater remediation system to address the off-site EDB plume has been designed, and construction is planned for late 2003, with operations beginning in 2004. Detailed information on this remediation system is presented in the *OU VI EDB Plume Groundwater Remediation System 90 Percent Design Documents* (J.R. Holzmacher, Inc. 2002b).

7.7 GROUNDWATER TREATMENT SYSTEMS

The primary mission of the Laboratory's Environmental Restoration Program is to remediate soil and groundwater contamination and prevent additional contamination from migrating off the BNL site. The cleanup goals are to: 1) prevent or minimize plume growth, and 2) reduce contaminant concentrations in the Upper Glacial aquifer to below regulatory standards within 30 years. In 2002, BNL continued to make significant progress in restoring groundwater quality at the site. Seven groundwater remediation systems were in operation by the end of 2002, with the addition of the OU III Western South Boundary system. Ten of the 17 planned groundwater treatment plants have been constructed. Two systems

remained in standby mode in 2002 as they substantially met their cleanup goals: the OU IV Air Sparging/Soil Vapor Extraction system, and the HFBR Pump and Recharge System. Compared to 2001, the total groundwater cleanup treatment capacity was increased from 2,575 gallons per minute (gpm) to 2,875 gpm. Ultimately, the total groundwater cleanup capacity will be approximately 4,500 gpm. Figure 7-16 shows the locations of the current and planned groundwater treatment systems. Table 7-4 provides a summary of pounds of VOCs removed and gallons of water treated during 1997–2002. During 2002, 720 pounds of VOCs were removed from the groundwater and more than one billion gallons of treated groundwater were returned to the aquifer. Detailed information on these treatment systems can be found in the *2002 BNL Groundwater Status Report* (BNL 2003c).

It is expected to take up to 10 years of aquifer treatment before widespread improvements in groundwater quality at BNL are achieved. Even so, some noticeable improvements in groundwater quality are evident in OU I South Boundary, OU III South Boundary, OU IV, Building 96, and the Carbon Tetrachloride area. Groundwater remediation

Table 7-4. BNL Groundwater Remediation Systems Treatment Summary for 1997 through 2002.

Remediation System	Start Date	1997– 2001		2002	
		Water Treated (Gallons)	VOCs Removed (Pounds)	Water Treated (Gallons)	VOCs Removed (Pounds) ^(d)
OU III South Boundary	June 1997	1,558,436,850	1,709	343,000,000	219
OU III Industrial Park	Sept. 1999	416,915,000	449	186,000,330	184
OU III Western South Boundary	Sept. 2002	Not in Service	0	74,287,000	10
Carbon Tetrachloride	Oct. 1999	88,337,300	241	34,461,000	86
OU I South Boundary	Dec. 1996	1,740,939,000	254	377,451,000	26
HFBR Tritium Plume ^(a)	May 1997	241,528,000	180	0	0
OU IV AS/SVE ^(b)	Nov. 1997	(c)	35	Not in Service	0
Building 96	Feb. 2001	24,238,416	35	45,000,000	11
Middle Road	Oct. 2001	55,353,550	39	281,000,000	184
Total		4,125,748,116	2,942	1,341,199,330	720

Notes:

^(a) System was shut down and placed in standby mode on September 29, 2000.

^(b) System was shut down on January 10, 2001.

^(c) Air Sparging/Soil Vapor Extraction system performance measured by pounds of VOC removed per cubic feet of air treated.

^(d) Values rounded to the nearest whole number.

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activities are expected to continue until approximately 2030 to meet the ultimate cleanup objective.

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