# 7 Groundwater Protection

*The Brookhaven National Laboratory Groundwater Protection Management Program is made up of four elements: prevention, monitoring, restoration, and communication. BNL has implemented aggressive pollution prevention measures to protect groundwater resources. BNL's extensive groundwater monitoring well network is used to verify that prevention and restoration activities on site are effective. In 2003, BNL collected groundwater samples from 754 monitoring wells during 2,810 individual sampling events. Seven groundwater remediation systems removed 510 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 4,156 pounds of volatile organic compounds by treating nearly 6.8 billion gallons of groundwater.*

## 7.1 THE BNL GROUNDWATER PROTECTION MANAGEMENT PROGRAM

The primary goal of BNL's 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. BNL's program helps to fulfill the environmental monitoring requirements outlined in U.S. Department of Energy Order 450.1, Environmental Protection Program. 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, completed in 1998-2000, 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, completed in May 2000, 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 (USTs), 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 former and current operations and to track cleanup progress (Table 7-1). 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) monitoring, 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, USTs) are being removed or remediated to prevent further contamination of groundwater. All remediation work is carried out under the Interagency Agreement involving 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 press releases, web pages, mailings, public meetings, briefings, and roundtable discussions. Specific examples include the Community Advisory Council (CAC) and the Brookhaven Executive Roundtable. Technical reports that summarize 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 preventing new contamination of the aquifer system. The Laboratory has made significant investments in environmental and groundwater protection, 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 observed. The contingency plan provides guidelines for evaluating the source of the problem, notifying stakeholders, and implementing appropriate corrective actions.

Since 1998, BNL has 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 or 2003. It is important to note that five of the 10 identified impacts were determined to be from historical (or "legacy") contaminant releases. These legacy issues include low-level petroleum hydrocarbon contamination in groundwater near the Upton Service Station, tritium near the Former U-Line target and 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 (Sr-90) groundwater contamination at the Brookhaven Graphite Research Reactor (BGRR).

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 impact was the inadvertent release of carbon tetrachloride during the removal of a UST, 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 soil 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.

**Table 7-1. Summary of BNL Groundwater Monitoring Program, 2003.**

| | Restoration | Environmental Surveillance |
|---|---|---|
| Number of wells monitored | 629 | 125 |
| Number of sampling events | 2,510 | 300 |
| Number of analyses performed | 5,504 | 552 |
| Number of results | 106,000 | 6,400 |
| Percent of non-detectable analyses | 68 | 95 |
| Number of new wells installed[a] | 40 | 0 |
| Number of wells abandoned | 9 | 0 |

[a]Permanent wells only. Single-use temporary wells used for characterization, not included.

## 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, which is defined as a source of potable water supply. Federal drinking water standards (DWS), New York State DWS, and New York State Ambient Water Quality Standards (NYS 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 NYS AWQS. Radiological data are compared to NYS DWS (for tritium, gross beta, and Sr-90), NYS AWQS (for gross alpha and radium-226/228),

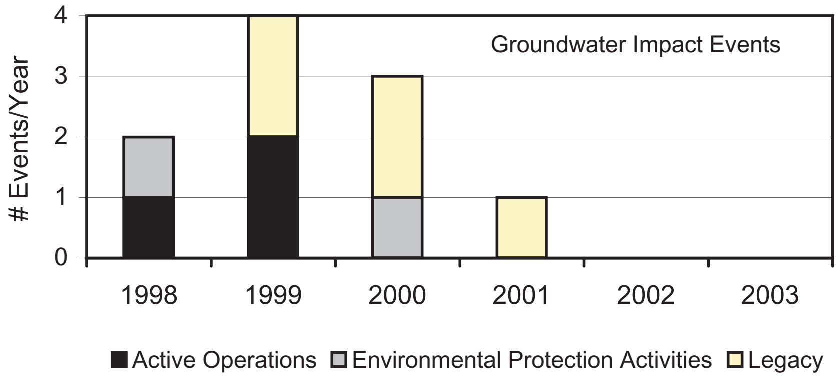



**Figure 7-1. Groundwater Protection Performance, 1998 – 2003.**

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 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- 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) and Peconic River area, Biology Agricultural Fields, Former Waste Management Facility (FWMF), new Waste Management Facility (WMF), two former landfill areas, Central Steam Facility (CSF) and Major Petroleum Facility (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 classified as a public water purveyor and maintains water supply wells and associated treatment facilities for the distribution of potable water on the site. The BNL network of potable and cooling water supply wells 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 (SCDHS). As required by the SDWA, BNL also prepares an annual Water Quality Consumer Confidence Report (BNL 2004b) 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 2003 included testing for VOCs, anions, metals, and radiological parameters. During 2003, the BNL potable water system fully complied with all

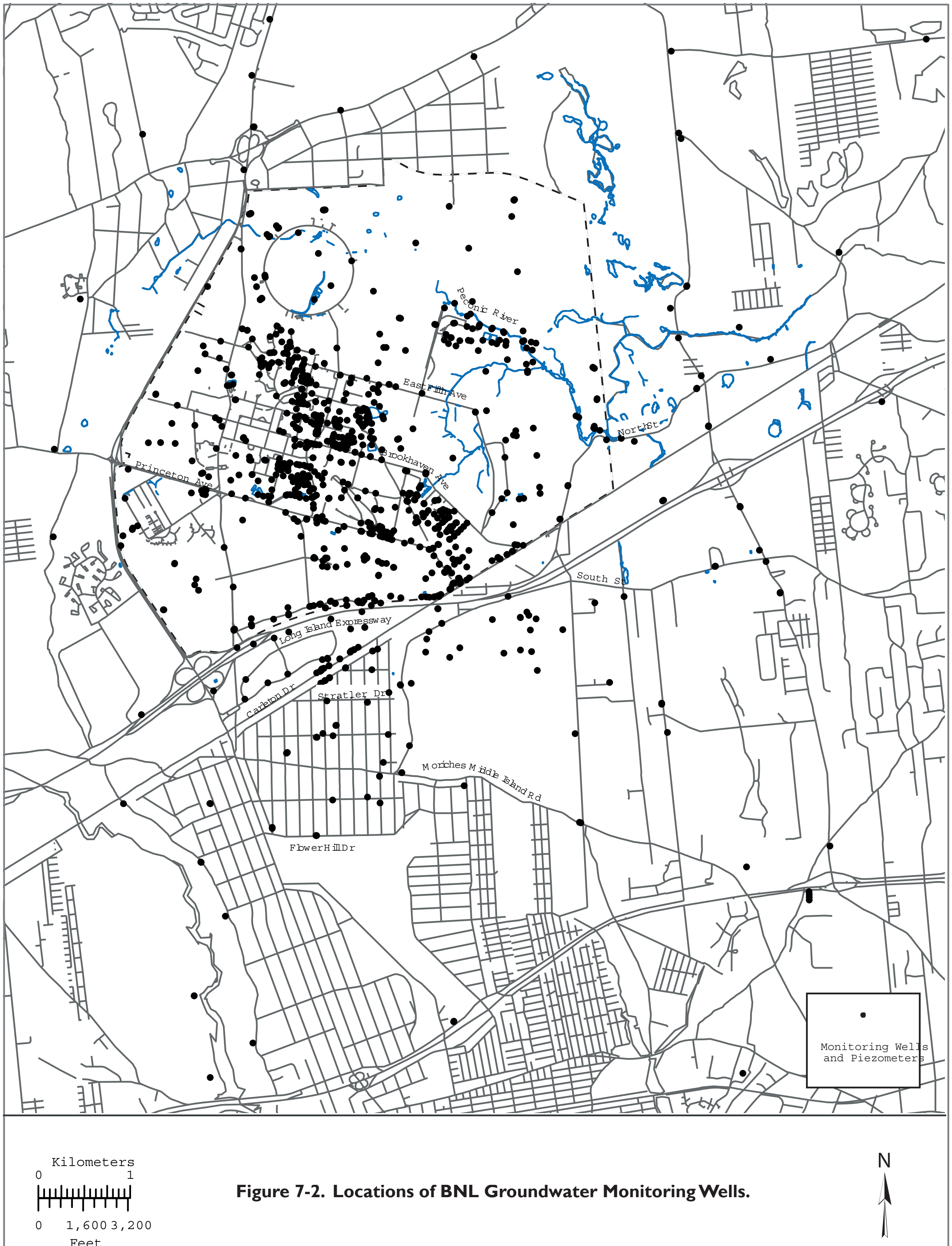



**Figure 7-2. Locations of BNL Groundwater Monitoring Wells.**

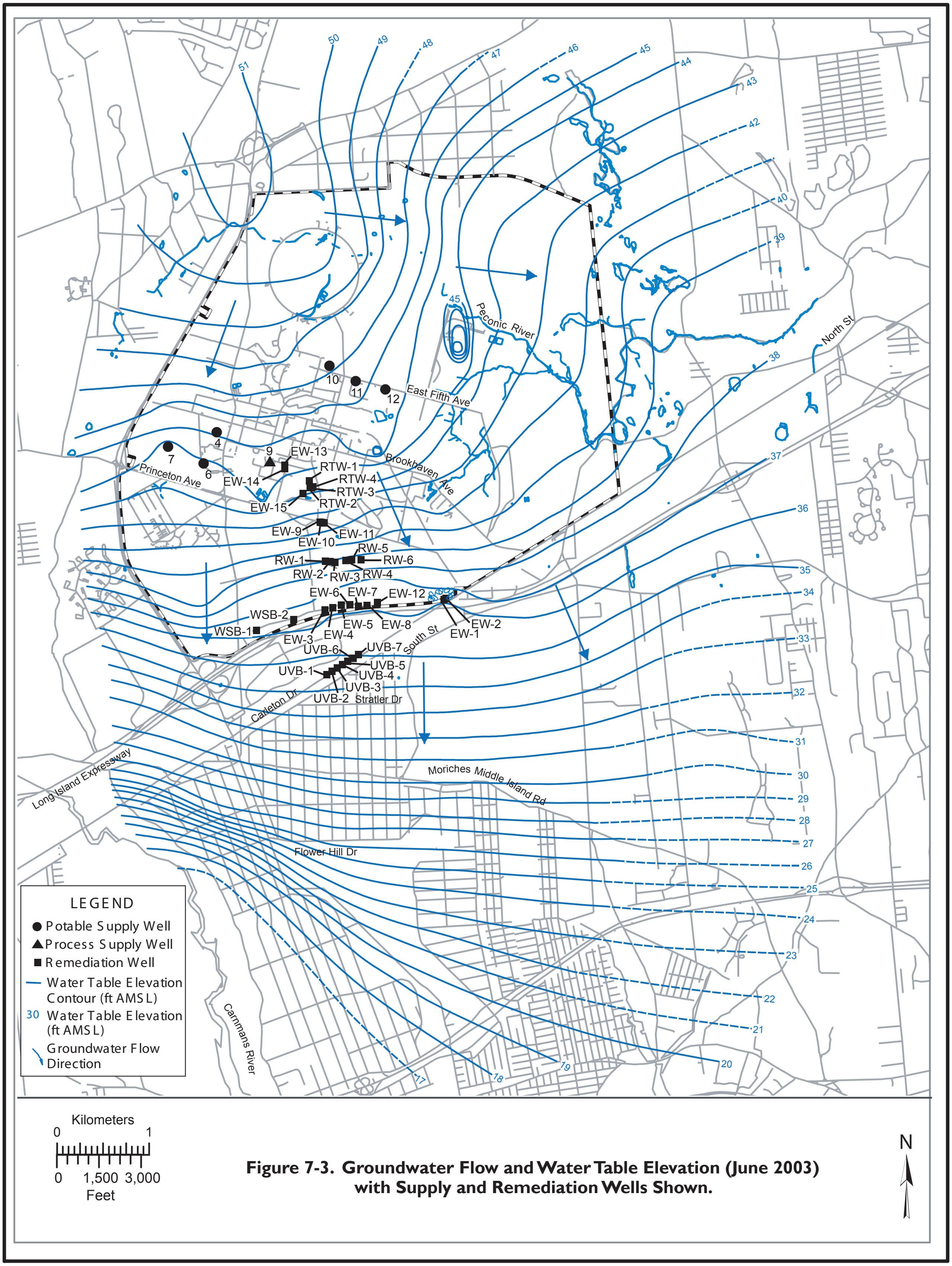



**Figure 7-3. Groundwater Flow and Water Table Elevation (June 2003) with Supply and Remediation Wells Shown.**

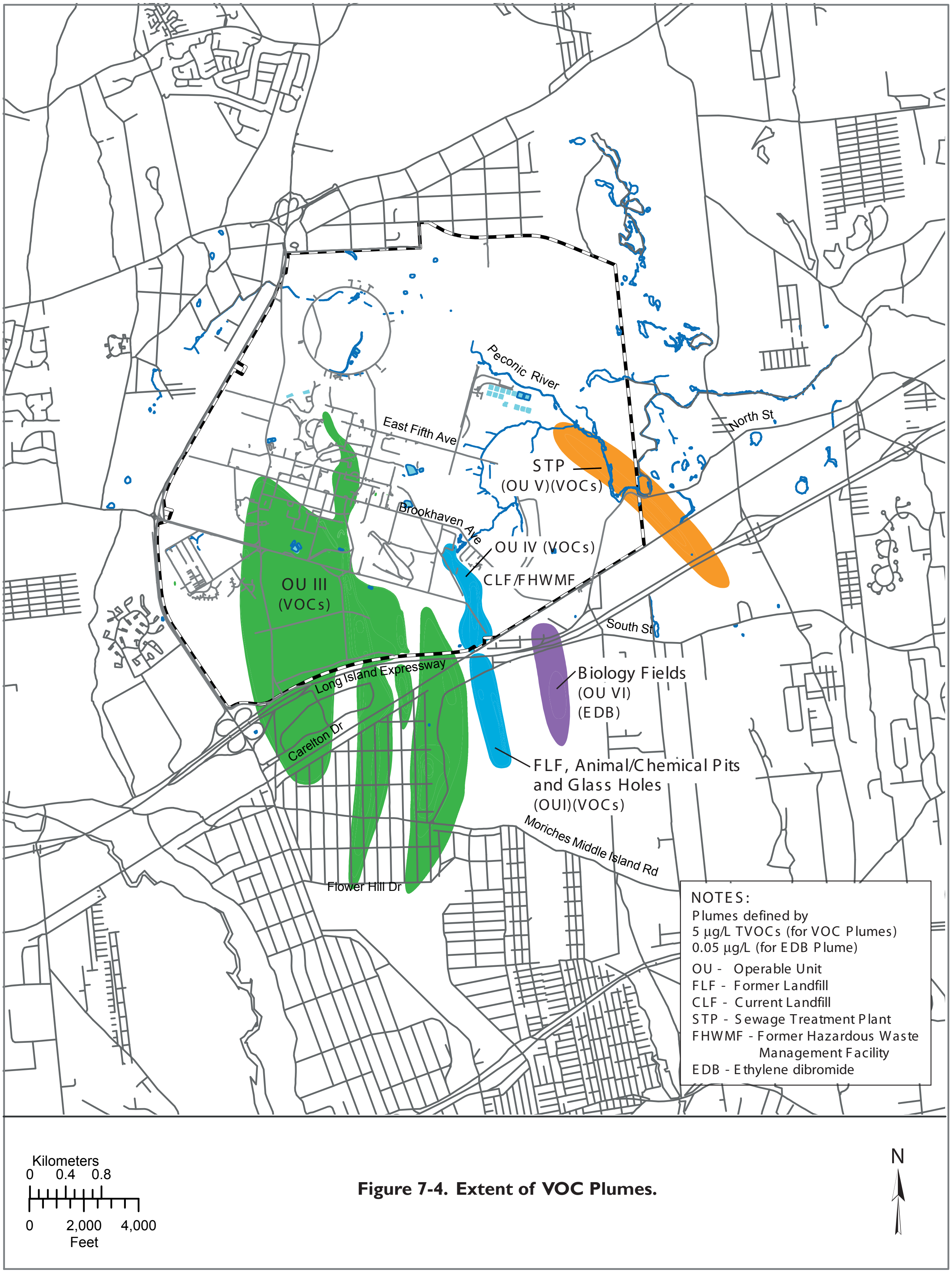



**Figure 7-4. Extent of VOC Plumes.**

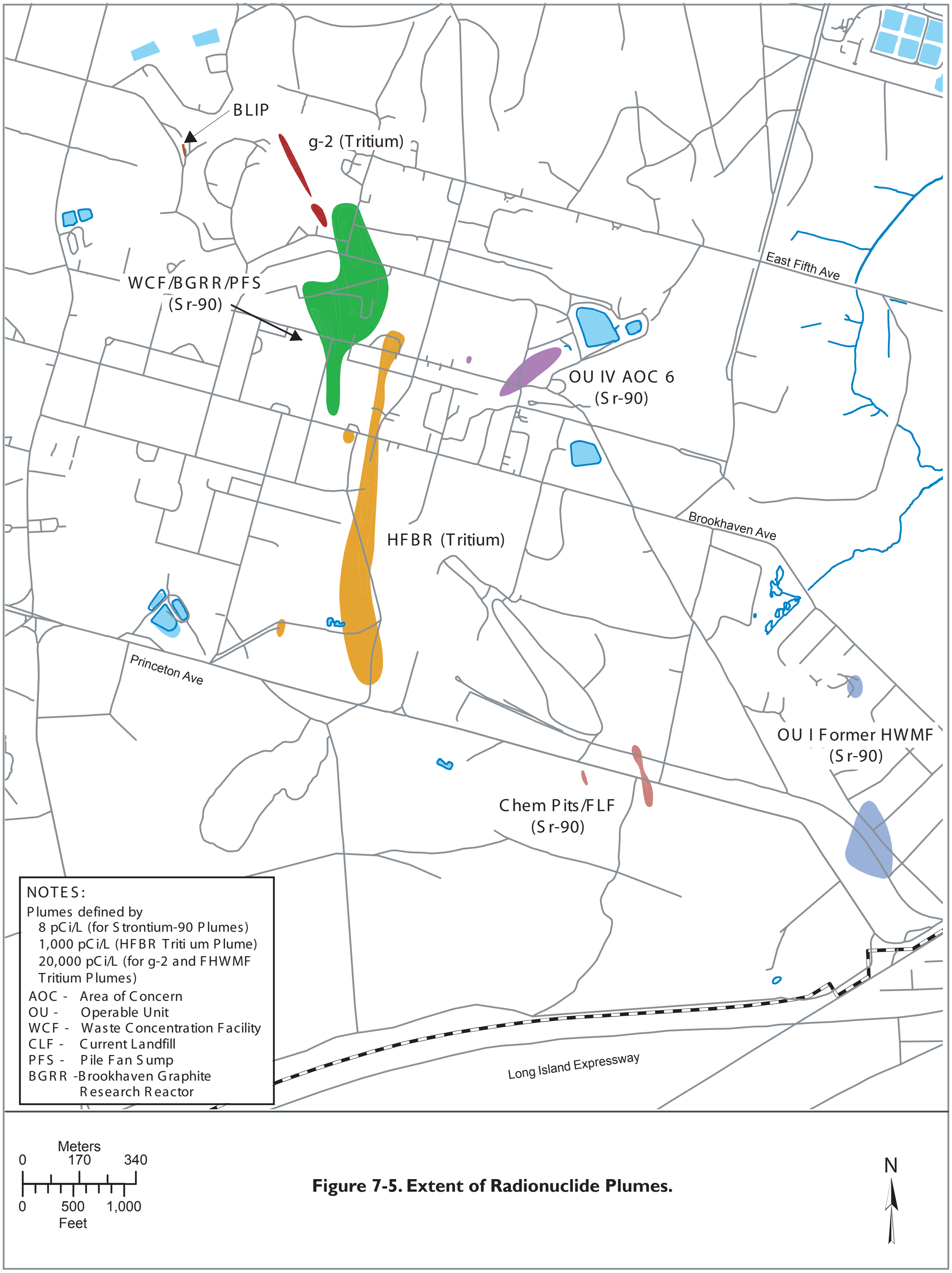



**Figure 7-5. Extent of Radionuclide Plumes.**

**Table 7-2. Potable Well Radiological Analytical Results.**

| Potable Well ID | | Gross Alpha | Gross Beta | Tritium | Sr-90 |
|---|---|---|---|---|---|
| | | (pCi/L) | | | |
| Well 4 | Samples | 4 | 4 | 4 | 4 |
| | Max. | 2.62 ± 0.64 | 3.92 ± 1.02 | < 280 | < 0.44 |
| | Avg. | 0.96 ± 1.14 | 0.76 ± 2.32 | 2 ± 172 | 0.04 ± 0.19 |
| Well 6 | Samples | 4 | 4 | 4 | 4 |
| | Max. | 2.11 ± 0.61 | 2.70 ± 1.11 | < 337 | < 0.49 |
| | Avg. | 0.97 ± 0.76 | 0.77 ± 1.56 | 9 ± 146 | 0.12 ± 0.18 |
| Well 7 | Samples | 4 | 4 | 4 | 4 |
| | Max. | 2.08 ± 0.61 | < 1.69 | < 280 | < 0.61 |
| | Avg. | 1.03 ± 1.01 | 0.73 ± 0.32 | 14 ± 134 | 0.05 ± 0.23 |
| Well 11 | Samples | 4 | 4 | 13 | 4 |
| | Max. | 1.31 ± 0.45 | < 1.62 | < 273 | < 0.48 |
| | Avg. | 0.61 ± 0.56 | 0.13 ± 0.89 | 63 ± 47 | 0.23 ± 0.11 |
| Well 12 | Samples | 5 | 5 | 14 | 4 |
| | Max. | 2.16 ± 0.58 | 2.67 ± 0.96 | < 282 | < 0.57 |
| | Avg. | 0.80 ± 0.80 | 1.14 ± 1.39 | 74 ± 62 | 0.21 ± 0.10 |
| Tap Water(a) | Samples | 246 | 246 | 246 | NS |
| Control Samples | Max. | 8.14 ± 2.96 | 14.61 ± 4.28 | 366 ± 209 | |
| Building 490 (FN) | Avg. | 3.33 ± 0.19 | 4.79 ± 0.33 | 25 ± 16 | |
| SDWA Limit (pCi/L) | | 15 (b) | 50 (c) | 20,000 | 8 |

Notes:
See Figure 7-3 for well locations.
All values shown with 95% confidence interval.
No anthropogenic gamma-emitting radionuclides were detected in samples collected from these wells in 2003.
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.
NS = Not Sampled for this analyte
(a) The gross activity values for Building 490 tap water (FN sample point) are elevated compared with the potable well samples, due to differences in the analytical procedure (i.e., smaller sample volumes and shorter counting times) used to obtain the activity values.
(b) Excluding radon and uranium.
(c) Screening level above which analysis for individual radionuclides is required.

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). In 2003, the NYS Department of Health prepared a source water assessment for all potable water supply wells on Long Island (NYSDOH, 2003). The source water assessments are designed to serve as management tools in further protecting Long Island's sole source aquifer system.

### 7.4.1 Radiological Results

During 2003, samples were typically collected quarterly from supply wells 4, 6, 7, 11, and 12, and were analyzed for gross alpha and gross beta activity, tritium, and Sr-90. Because of the detection of low levels of tritium in a WMF monitoring well, nearby supply wells 11 and 12 were tested for tritium on a more frequent basis (see Section 7.5.2.5). The analytical results are listed in Table 7-2. (Note: Well 10 was used infrequently during 2003, and was only sampled under the compliance monitoring program described in Chapter 3.) In addition, tap water

**Table 7-3. Potable Water Supply Wells Water Quality Data.**

| Potable Well ID | | Chlorides | Sulfates | Nitrate as N |
|---|---|---|---|---|
| | | | mg/L | |
| | N | 1 | 1 | 1 |
| Well 4 | Value | 25 | 11.4 | < 1.0 |
| Well 6 | N | 1 | 1 | 1 |
| | Value | 20.2 | 11.1 | < 1.0 |
| Well 7 | N | 1 | 1 | 1 |
| | Value | 21.9 | 12.6 | < 1.0 |
| Well 10 (a) | N | NS | NS | NS |
| | Value | | | |
| Well 11 | N | 1 | 1 | 1 |
| | Value | 17.2 | 13.3 | < 1.0 |
| Well 12 | N | 1 | 1 | 1 |
| | Value | 16.3 | 13.6 | < 1.0 |
| 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) Well was shut down at time of annual sampling for anions.

samples were collected daily from Building 490 and 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 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 Sr-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

In addition to the quarterly SDWA compliance samples described in Section 3.7 of Chapter 3, BNL collected additional VOC samples from active supply wells during the year. These samples were analyzed for VOCs following either EPA Standard Method 524 or 624. Trace levels (typically <2 µg/L) of chloroform were routinely detected in samples from most wells, with a maximum concentration of 8.4 µg/L. The DWS for chloroform is 80 µg/L. Low levels of several other VOCs (e.g., TCA, bromodichloromethane, and dibromochloromethane) were occasionally detected, but at concentrations well below applicable DWS. Samples were also collected and analyzed for metals and anions one time during the year from wells 4, 6, 7, 11, and 12 (Tables 7-3 and 7-4). As in previous years, iron was the only parameter detected at concentrations greater than the DWS, which is 0.3 mg/L for iron. Iron levels in wells 6 and 7 were 3.56 and 2.01 mg/L, respectively. Because naturally high levels of iron are present in some portions of the Upper Glacial Aquifer on the western side of the BNL site, water obtained from wells 4, 6, and 7 is treated at the BNL Water Treatment Plant to reduce the iron levels before distribution.

### 7.5 ENVIRONMENTAL SURVEILLANCE PROGRAM

BNL's ES Program includes groundwater monitoring at active research facilities (e.g., accelerator beam stop and target areas) and support facilities (e.g., fuel storage facilities). During 2003, 125 groundwater surveillance wells were monitored during approximately 300 individual sampling events. Results for these programs are summarized in this section. Detailed descriptions and maps related to groundwater monitoring in the ES Monitoring Program can be found in the 2003 BNL Groundwater Status Report (BNL 2004c).

#### 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 (Na-22), have been produced by the interaction of these secondary particles with the soils that surround the experimental areas. Furthermore,

Table 7-4. Total Metals Concentration Data for Potable Water Supply Well Samples.

| Well ID | | 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 | Na mg/L | Ni µg/L | Pb µg/L | Sb µg/L | Se µg/L | Tl µg/L | V µg/L | Zn µg/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Well 4** | N | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Value | < 1.0 | < 2.2 | < 3.0 | 25.9 | < 0.66 | < 1.1 | 0.5 | < 1.0 | 26.4 | 1.43 | < 0.1 | 129 | < 5.0 | 16.8 | < 1.1 | 2.0 | < 0.88 | < 5.0 | < 0.66 | < 5.5 | 10.4 |
| **Well 6** | N | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Value | < 1.0 | < 2.2 | < 3.0 | 25.4 | < 0.66 | < 1.1 | 1.0 | 1.5 | 15.3 | 3.56 | < 0.1 | 124 | < 5.0 | 14.9 | 7.0 | < 1.32 | < 0.88 | < 5.0 | < 0.66 | < 5.5 | 12.0 |
| **Well 7** | N | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Value | < 1.0 | < 2.2 | < 3.0 | 19.7 | < 0.66 | < 1.1 | 0.7 | 1.0 | 3.1 | 2.01 | < 0.1 | 61.8 | < 5.0 | 14.9 | 1.6 | < 1.3 | < 0.88 | < 5.0 | < 0.66 | < 5.5 | < 4.0 |
| **Well 10(a)** | N | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| | Value | | | | | | | | | | | | | | | | | | | | | |
| **Well 11** | N | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Value | < 1.0 | < 2.2 | < 3.0 | 27.0 | < 0.66 | < 1.1 | < 0.12 | 1.1 | 5.7 | < 0.08 | < 0.1 | < 2.0 | < 5.0 | 14.9 | < 1.1 | < 1.32 | < 0.88 | < 5.0 | < 0.66 | < 5.5 | < 4.0 |
| **Well 12** | N | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Value | < 1.0 | < 2.2 | < 3.0 | 22.9 | < 0.66 | < 1.1 | < 0.12 | < 1.0 | 6.1 | < 0.08 | < 0.1 | < 2.0 | < 5.0 | 13.1 | < 1.1 | < 1.32 | < 0.88 | < 5.0 | < 0.66 | < 5.5 | < 4.0 |
| **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 | 1.0 | 1.1 | 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)Well was shut down at time of annual sampling for metals.

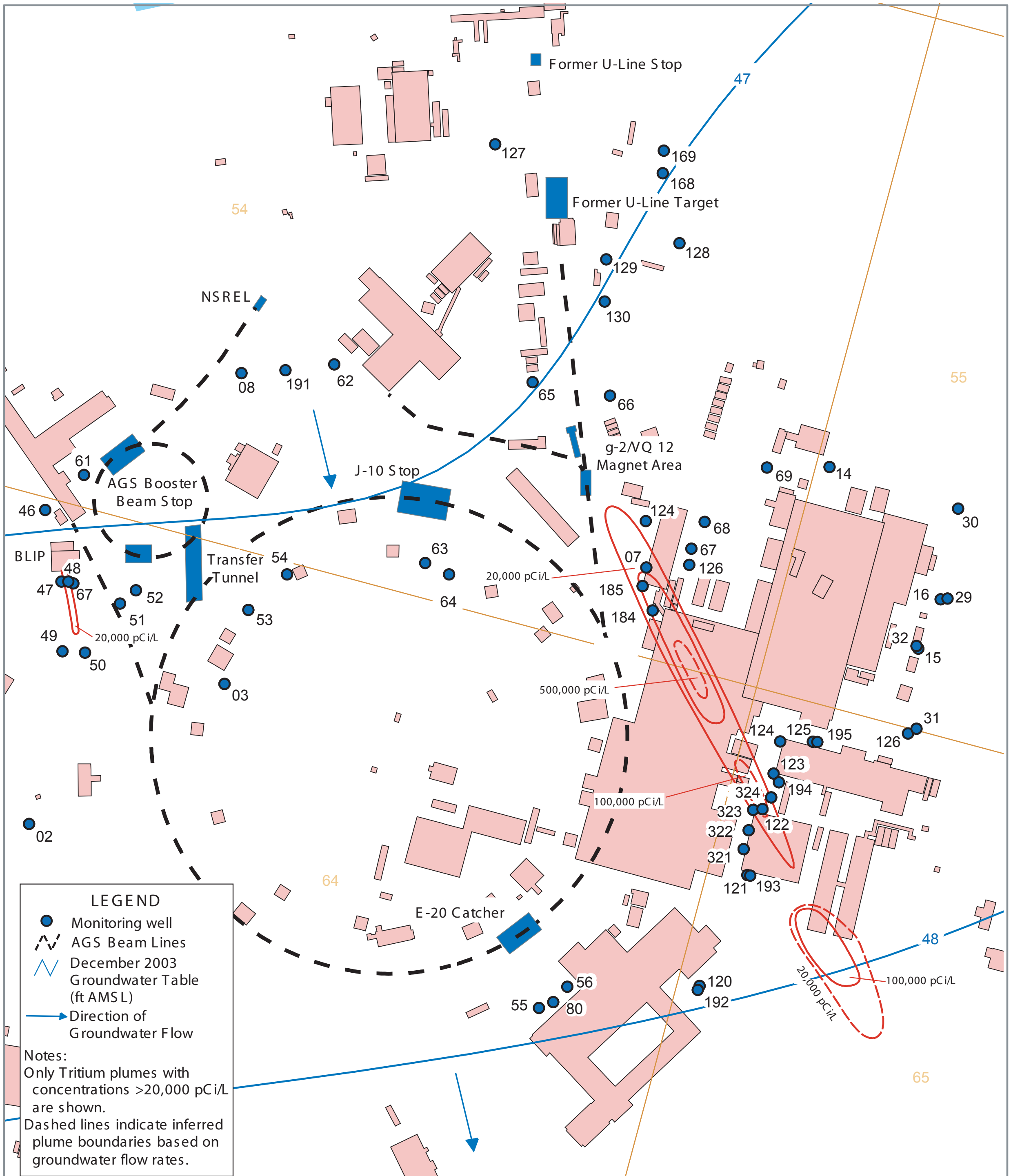
historical surface spills and discharges of solvents to cesspools and recharge basins near the AGS have contaminated soil and groundwater with VOCs. VOC contamination is monitored under the ER Program's OU III Central Areas Project (see Section 7.6.3).

During 2003, 56 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 area, 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 DWS 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 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 since 2001 has shown that these caps have effectively reduced tritium concentrations to less than the 20,000 pCi/L DWS at the Former U-Line and Former E-20 Catcher areas. However, tritium continues to be detected at concentrations above the DWS 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 Na-22 concentration of 60 pCi/L. (Note: The DWS for Na-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, a 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." During 2001 through 2003, BNL monitored the source area to evaluate the effectiveness of the cap and conducted additional characterization work to obtain the necessary plume concentration and position data required to determine whether additional corrective actions are required. Characterization efforts will continue until 2005, and a Focused Feasibility Study will be prepared in 2006.

Samples collected during 2003 from wells approximately 150 feet downgradient of the VQ-12 area indicate that tritium continues to be released to the groundwater, but at lower concentrations compared to those observed in July 2002, when a tritium concentration of 3,440,000 pCi/L was observed in well 054-07. During 2003, tritium concentrations showed a steady decline from a maximum of 1,040,000 pCi/L (well 054-07) in January to 113,000 pCi/L (well 054-185) in October. During 2003, 12 temporary Geoprobe™ wells were installed in the AGS parking lot area to characterize the leading edge of the g-2 tritium plume. The maximum observed tritium concentration was 415,000 pCi/L, which was detected in Geoprobe™ well GP-20. This well is approximately 1,000 feet from the VQ-12 source area. Figure 7-6 shows the locations of the Geoprobe™ wells and the position of the g-2 tritium plume during 2003. The two segments of the plume depicted on Figure 7-6 are representative of three distinct periods of tritium release (also referred to as slug releases). The leading segment of tritium contamination was released in 1999 before the installation of the cap over the VQ-12 area, whereas the second and third slug are related to tritium released in 2000 and 2001.

Inspections of the cap and review of its design indicate that the cap over the VQ-12 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. There appears to be good correlation between high tritium



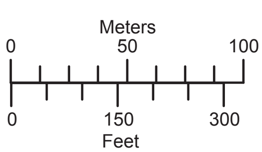




**Figure 7-6. Extent of AGS g-2 Tritium Plume.**

concentrations detected in monitoring wells immediately downgradient of VQ-12, 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.

It is expected that the amount of tritium remaining in the vadose zone close to the water table will decline over time due to this flushing mechanism and by natural radioactive decay.

***Former E-20 Catcher.*** During 1999–2000, tritium and Na-22 were detected at concentrations above their applicable DWS in wells approximately 100 feet downgradient of the Former E-20 Catcher. The location of the Former E-20 Catcher is shown in Figure 7-6. The highest levels of tritium (40,400 pCi/L) and Na-22 (704 pCi/L) were found in temporary well 064-65. In April 2000, a temporary impermeable cap was installed over the Former 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.

Following the installation of the cap in 2000, tritium and Na-22 concentrations decreased to levels well below applicable DWS. During 2003, the maximum tritium concentration was 3,430 pCi/L, detected in well 064-55. The reduction in tritium and Na-22 concentrations since the impermeable cap was constructed indicates that the cap has been effective in preventing rainwater infiltration into the activated soil.

***Former U-Line Target and Beam Stop Areas.*** The U-Line experiment area operated from 1974 through 1986. In 1999 and 2000, BNL installed permanent and temporary monitoring wells downgradient of the Former U-Line target and beam stop areas (Figure 7-6) to evaluate whether rainwater infiltration through residual activated soil shielding was affecting groundwater quality. Although only low levels of tritium were observed downgradient of the former target area, tritium was found in concentrations up to 71,600 pCi/L downgradient of the beam stop area. Na-22 was not detected in any of the samples. In May 2000, a temporary impermeable cap was installed over the Former U-Line beam stop area, and a permanent cap was constructed by October 2000.

From 2001 through 2003, low levels of tritium continued to be detected in wells downgradient of the former target and stop areas, but at concentrations below the 20,000 pCi/L DWS. The highest tritium concentration downgradient of the Former U-Line target area was 321 pCi/L, detected in well 054-130. The highest concentration downgradient of the Former U-Line beam stop area was 577 pCi/L, detected in well 054-128.

The significant decrease in tritium concentrations since 2000 indicates that the impermeable cap has been effective in stopping rainwater infiltration into the residual activated soil surrounding the Former U-Line beam stop.

*7.5.1.2 Brookhaven Linac Isotope Producer*

The BLIP facility is at the southern end of the Linear Accelerator (Linac) (Figure 7-6). When the BLIP is operating, the 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 Na-22 (151 pCi/L) were detected in wells downgradient of the BLIP. To prevent rainwater from infiltrating the activated soil beneath 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 additional release of tritium and Na-22 from the activated soil.

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 Na-22 concentrations were observed in groundwater samples. In early July 2000, tritium concentrations in wells approximately 40 feet downgradient of the BLIP increased 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 in the soil near the target vessel. The maximum Na-22 concentration was 299 pCi/L in well 064-67, which is below the 400 pCi/L DWS. By December 21, 2000, tritium concentrations dropped to below the 20,000 pCi/L DWS in the wells immediately downgradient of the BLIP. During 2001–2002, tritium concentrations in wells immediately downgradient of the BLIP did not exceed the 20,000 pCi/L DWS. During 2002, the maximum tritium concentration was 15,100 pCi/L, detected in well 064-67. In January 2003, tritium concentrations once again exceeded the 20,000 pCi/L standard in wells immediately downgradient of the BLIP, with a concentration of 27,700 pCi/L detected in well 064-67. Tritium concentrations increased throughout most of the year, reaching a maximum of 42,900 pCi/L in October. Tritium concentrations declined to less than 20,000 pCi/L by November. Na-22 concentrations reached a maximum concentration of 185 pCi/L, well below the 400 pCi/L standard. Tritium concentrations in wells 150 feet downgradient of the BLIP were less than 5,000 pCi/L during the year.

A comparison of tritium concentrations to changes in water table position suggests that the 2003 increase in tritium concentrations may be correlated to a 6.5-ft increase in water table elevation that occurred between November 2002 and July 2003. As the water table rose, older tritium that was leached from the activated soil prior to capping in 1987 and released during the grout injection project may have been flushed from the soil close to the water table. It is expected that the amount of tritium remaining in the vadose zone close to the water table will decline over time due to this flushing mechanism and by natural radioactive decay.

#### *7.5.1.3 Relativistic Heavy Ion Collider*

Within the Relativistic Heavy Ion Collider (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 at the 10 o'clock position of the ring, the second contains two collimators at the 8 o'clock region, and the third is a beam stop 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 level of 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 2003. 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 Brookhaven Medical Research Reactor (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 soil.

During 2003, tritium concentrations continued to be well below the DWS of 20,000 pCi/L. Detectable levels of tritium were observed in two downgradient wells, with a maximum value of 892 pCi/L observed in well 084-27.

*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 Cs-137, Sr-90, and tritium at levels that exceeded DWS. 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, all the remaining contaminated water (approximately 4,950 gallons) was pumped from the basement. Taking into account possible losses due to evaporation, an estimated 1,350 to 2,750 gallons of contaminated water may have leaked into the soil beneath Building 801. To evaluate the potential impact this release may have on future groundwater quality, BNL increased the monitoring frequency for three existing nearby monitoring wells, and installed a new well (065-325) closer to the building to provide improved monitoring of the release area.

Sr-90 concentrations in samples collected during 2002 were consistent with values observed before the Building 801 floodwater release. During 2002, the highest Sr-90 concentrations were detected in shallow well 065-235, at concentrations up to 47.9 pCi/L. During 2003, samples from well 065-325 had Sr-90 concentrations ranging between 33.4 to 54.2 pCi/L, and Sr-90 was detected at 83.1 pCi/L in nearby temporary well PFS-1. No Cs-137 or tritium was detected in any of the samples.

It is estimated that it could take three to eight years for Sr-90, and approximately 100 years for Cs-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.

#### 7.5.2 Surveillance Monitoring of Support Facilities

*7.5.2.1 Sewage Treatment Plant Area*

As described in Chapters 1 and 3, the 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 collected by drainage piping and 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 2003, 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 located at the site boundary and off-site areas (see Section 7.6.5).

Groundwater monitoring results for 2003 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 low level of tritium (1,690 pCi/L) detected in one sample from well 039-88. Low levels of tritium have been periodically detected in well 039-88 and nearby well 039-89 since their installation in 2000. These wells are 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 2003, 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 filter bed area well 039-86, at a maximum concentration of 33.3 mg/L. Nitrates were detected in most filter bed area wells, with a maximum concentration of 7.4 mg/L detected in monitoring well 039-08. The AWQS for nitrate is 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 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 results for 2003 indicate that releases from historical operations continue to have an impact on groundwater quality in the area. Several activities were conducted to verify 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 2003, the gasoline additive methyl tertiary butyl ether (MTBE) was the only chemical related to gasoline detected in groundwater downgradient of the UST area. Compared to previous years when MTBE concentrations were less than the NYS AWQS for MTBE (10 µg/L), MTBE concentrations in well 102-06 increased to 33.8 µg/L in March 2003, then decreased to 13 µg/L by September. In past years, low levels of the solvent TCA were also detected in both downgradient wells, but at concentrations below the NYS AWQS of 5 µg/L. The presence of MTBE and TCA could be related to historical parts degreasing operations at the Motor Pool facility, because these contaminants are also detected in wells 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 NYS AWQS. During 2003, TCA was detected in all four wells at concentrations ranging from 6 µg/L to 53.4 µg/L, and 1,1-dichloroethane (DCA) was detected in wells 102-11 and 102-12 at concentrations up to 14.8 µg/L. The NYS 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 27.3 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 USTs and one 6,000-gallon capacity UST, 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 Upton Service Station area has been impacted by historical station operations and by carbon tetrachloride contamination released from a former nearby UST that was used as part of a scientific experiment conducted in the 1950s. During 2003, carbon tetrachloride continued to be observed in the service station monitoring wells. The maximum carbon tetrachloride concentration was 278 µg/L, observed in well 085-17 in May 2003. The NYS AWQS for carbon tetrachloride is 5 µg/L. Carbon tetrachloride concentrations decreased during the year, with concentrations dropping to less than 120 µg/L by September. These concentrations were considerably less than those observed in 2000, when carbon tetrachloride concentrations in wells near the service station approached 4,500 µg/L. The decrease reflects the effectiveness of the groundwater remediation system designed to treat this plume.

In addition to the carbon tetrachloride contamination, groundwater quality has been affected by a variety of petroleum- and solvent-related VOCs that appear to be related to historical Service Station operations. During 2003, 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. Samples collected from well 085-17 in July 2003 indicated petroleum-related compounds such as m/p xylene at 129 µg/L, o-xylene at 108 µg/L, 1,2,4-trimethylbenzene at 60 µg/L, and 1,3,5-trimethylbenzene at 22 µg/L. A similar increase in these compounds was detected in samples collected from well 085-236 in March 2003. The solvent PCE was detected also, with a maximum concentration of 22 µg/L observed in the July sample from well 085-17.

The gasoline additive MTBE continued to be detected in wells 085-236 and 085-237 at concentrations exceeding the NYS AWQS of 10 µg/L. In 2003, MTBE levels increased from a maximum concentration of 32 µg/L in 2002, to a maximum concentration of 144 µg/L in the July sample from well 085-237. MTBE levels dropped to <50 µg/L by October.

Monitoring of the leak detection systems, groundwater wells downgradient of the gasoline USTs, and product reconciliation records indicated that the tanks and their associated distribution lines were not leaking. Furthermore, evaluation of vehicle maintenance operations indicated that all waste oils and used solvents were being properly stored and recycled. Therefore, it is believed that the solvents detected in groundwater originated from historical vehicle maintenance activities at the Motor Pool and were not related to current operations.

#### *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. 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 soil and groundwater near the 1977 spill underwent active remediation from 1997–2001 (see Section 7.6.4.1).

In accordance with the license conditions for the MPF, groundwater samples are analyzed twice a year for semivolatile organic compounds (SVOCs) and VOCs, and the wells are tested monthly for the presence of floating petroleum hydrocarbons. During 2003, none of the target compounds associated with fuel oil were detected, and no floating petroleum product was observed. However, as in past years, VOCs continued to be detected in several wells at concentrations exceeding the NYS AWQS of 5 µg/L. TCA was detected in upgradient well 076-25 at a concentration of 15 µg/L. Low levels of TCA have been detected in this well for many years, and it probably originates from a solvent spill area near Building 650. (Note: Solvent spill areas along the north side of Building 650 were evaluated during the OU IV Remedial Investigation.) Degreasing solvents continued to be detected in downgradient well 076-380, but at lower concentrations compared to 2002. 1,2-dichloroethene (DCE) (total) was detected at a concentration of 22 µg/L, PCE at 38 µg/L, and trichloroethene (TCE) at 7.3 µg/L. (Note that 1,2-DCE is a breakdown product of PCE.)

In an effort to identify the source of the VOC contamination detected in well 076-380, in early 2003 BNL installed four temporary Geoprobe™ wells, with three wells downgradient of the suspected source areas near Building 610. Only downgradient Geoprobe™ well MPF-GP-03 had detectable levels of VOCs, with PCE at a concentration of 6.6 µg/L and cis-1,2-DCE at a concentration of 14.5 µg/L. Although well MPF-GP-03 was downgradient of the former oil tank valve house, a source closer to Building 610 cannot be ruled out.

*7.5.2.5 Waste Management Facility*

In 1997, BNL began operating its new Waste Management Facility. The WMF is designed and operated in a manner that meets all applicable federal, state, and local environmental protection requirements. Nevertheless, BNL established a voluntary groundwater monitoring program as a secondary means of verifying the effectiveness of the facility's administrative and engineered controls. The WMF is monitored by eight shallow Upper Glacial Aquifer wells. Groundwater monitoring results for 2003 were consistent with previous monitoring, and continued to show that WMF operations were not impacting groundwater quality.

***Volatile Organic Compounds, Metals, and Anions***. All anions (chlorides, sulfates, and nitrates) and most metals concentrations were below applicable NYS AWQS. As in past years, sodium was detected at concentrations slightly above the NYS AWQS of 20 mg/L in several wells. Sodium was detected in upgradient wells 055-03 and 066-07 at concentrations of 27.9 and 22.9 mg/L, respectively, and in well 056-21 near the RCRA Building at a concentration of 21.3 mg/L. No VOCs were detected at concentrations above NYS AWQS. Trace levels (<1 µg/L) of chloroform were occasionally detected in upgradient wells 055-03, 055-10, 066-03, downgradient well 066-84, and nearby water supply wells 11 and 12. Trace levels (up to 1.3 µg/L) of TCA were also detected in upgradient well 066-06.

***Radionuclides***. Gross alpha and beta concentrations in samples from both upgradient and downgradient monitoring wells are consistent with background concentrations, and no BNL-related gamma-emitting radionuclides were identified. During the year, tritium levels in monitoring well 056-23 near the Reclamation Building increased from 407 pCi/L in February to 1,120 pCi/L in August. Although these tritium concentrations were well below the 20,000 pCi/L DWS, BNL implemented its Groundwater Protection Contingency Plan in an attempt to identify the source of the tritium and verify that the tritium was not affecting the quality of water obtained from nearby supply wells 11 and 12. As part of this response, the monitoring frequency was increased for well 056-23, nearby monitoring wells 056-22 and 066-84, and supply wells 11 and 12. BNL also formed a technical team to help identify a possible source of the tritium. Tritium concentrations in well 056-23 increased to 2,430 pCi/L in November 2003. Tritium was not detected in any of the samples collected from supply wells 11 and 12. Although a definitive source for the tritium has not been identified to date, a thorough review of waste management operations suggests that the tritium was not released from the WMF. Rather, the periodic detection of tritium in upgradient well 066-07 suggests that the tritium was released from an upgradient source.

## 7.6 ENVIRONMENTAL RESTORATION GROUNDWATER MONITORING PROGRAM

The mission of the Environmental Restoration Groundwater Monitoring Program is to monitor the various contaminant plumes on and off site, as well as to monitor the progress that the groundwater treatment systems are making toward plume remediation. The information in this section provides an overview of ER groundwater monitoring and remediation activities for 2003. In this period, a total of 629 groundwater surveillance wells were monitored during 2,510 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 here, 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. The 2003 BNL Groundwater Status Report (BNL 2004) presents detailed descriptions of the monitoring program, maps, and cross sections that show the extent of contamination, concentration trend data, and the hydrogeology for BNL and the surrounding area.

#### 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 upgradient of the BNL site. Historically, low concentrations of VOCs have been detected in some background wells and this was true for 2003, also. The highest concentration detected was chloroform at 0.7 µg/L. Although background samples are no longer tested for radionuclides, 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 the 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 buried in shallow holes in an area directly east of the Former Landfill. From 1966 through 1981, BNL disposed of used glassware in shallow pits directly north of the Animal/Chemical Pits. The Former Landfill was capped in 1996 and the Animal/Chemical Pits and Glass Holes were excavated in 1997 and the waste was disposed of according to regulations.

A network of eight 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 and Animal/Chemical Pits and Glass Holes area is shown in Figure 7-7. The contaminants of concern for the Former Landfill wells were VOCs and Sr-90. Recent monitoring has shown declining VOC and Sr-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 and PCBs is provided in the Environmental Monitoring Report, Current and Former Landfill Areas (BNL 2004a).

During 2003, VOC concentrations did not exceed NYS AWQS in any of the wells monitoring the Former Landfill. VOC concentrations have been low in all of the wells over the past five years, with infrequent detections that exceeded the NYS AWQS.

Historically, Sr-90 has been detected in shallow well 097-64, less than 100 feet downgradient of the landfill footprint. Sr-90 concentrations in this well have been steadily

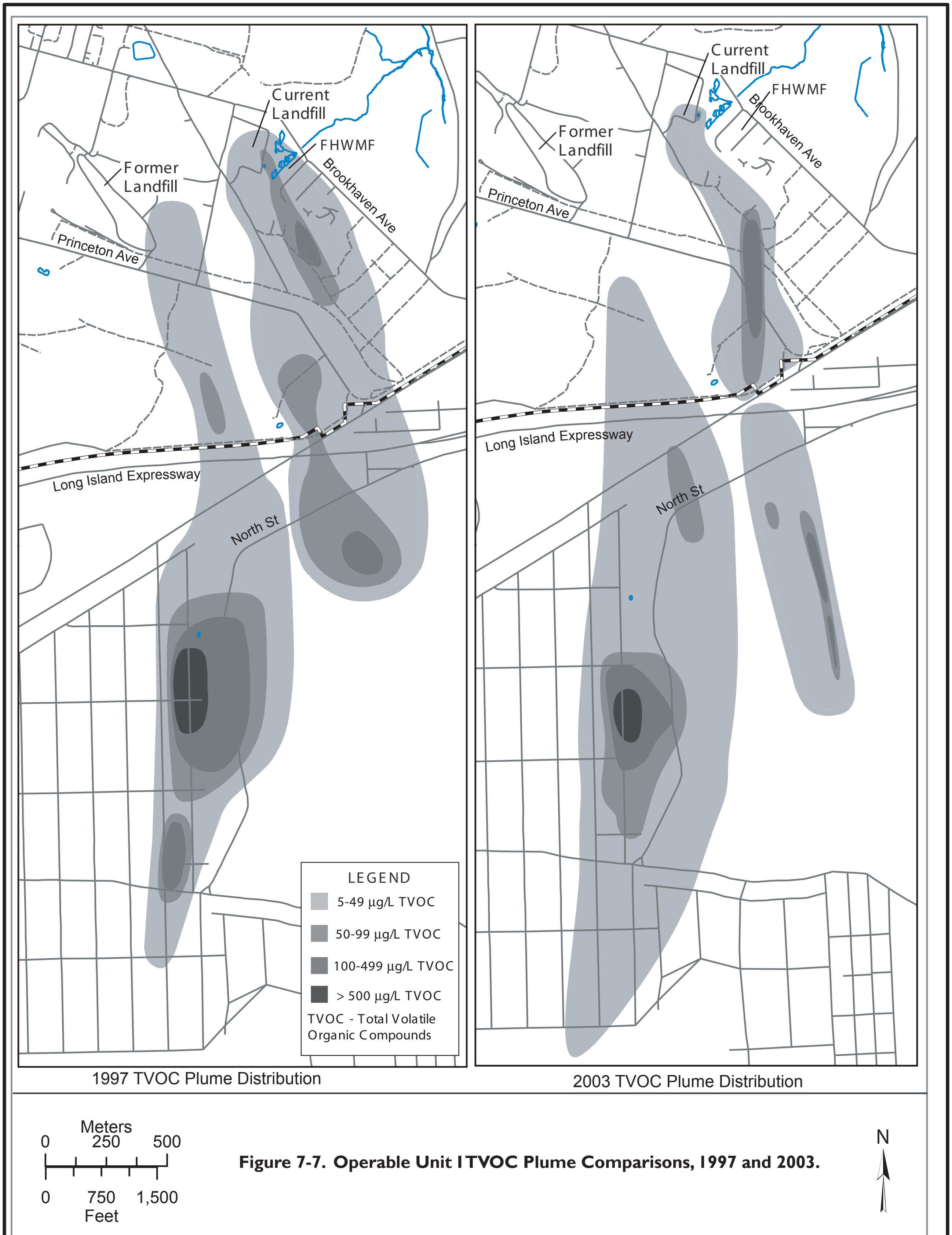



**Figure 7-7. Operable Unit I TVOC Plume Comparisons, 1997 and 2003.**

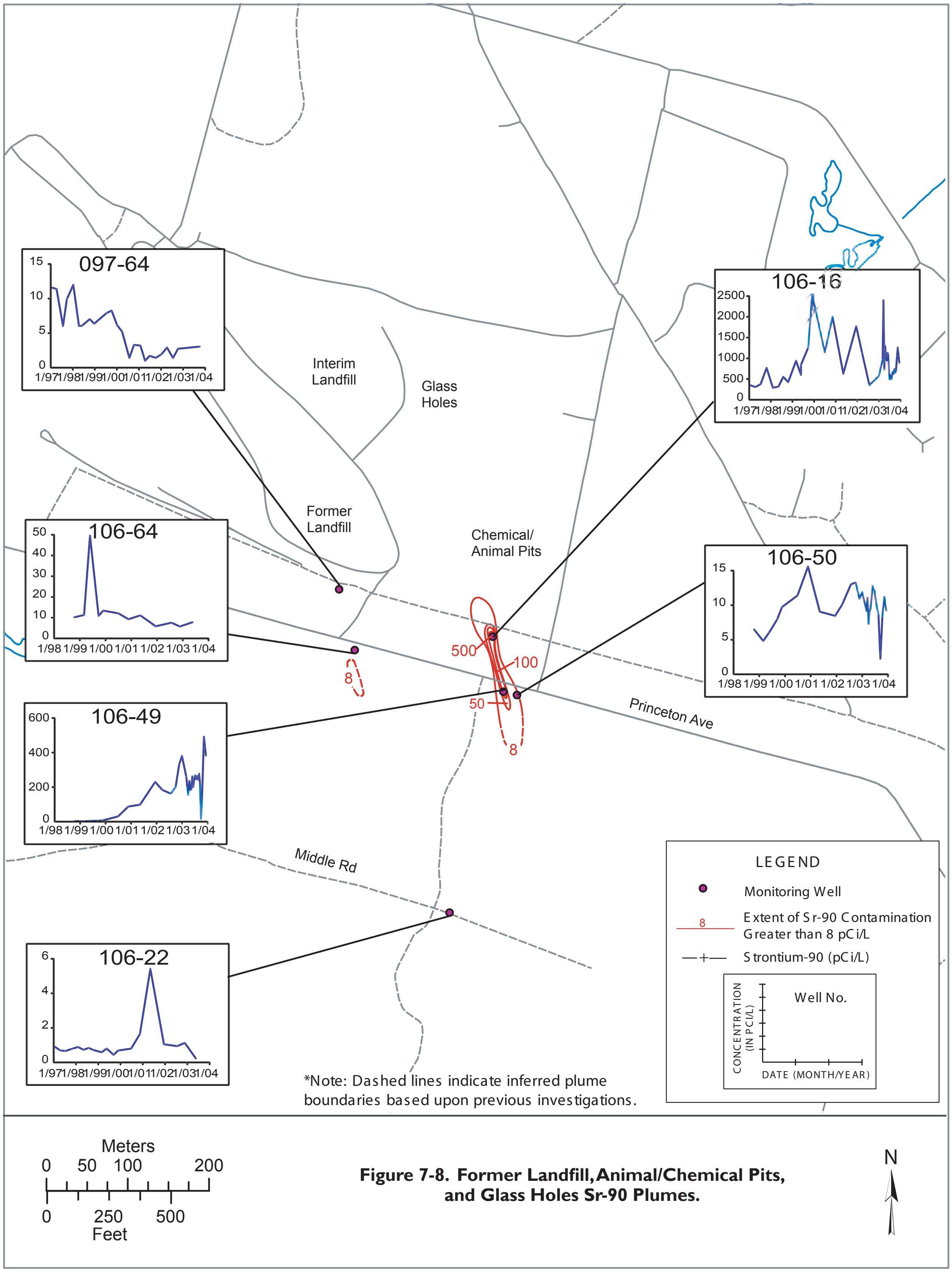



**Figure 7-8. Former Landfill, Animal/Chemical Pits, and Glass Holes Sr-90 Plumes.**

declining since 1998, when it was last detected above the 8 pCi/L DWS. The highest Sr-90 concentration in this well during 2003 was 3 pCi/L, in January. The Sr-90 plume had shifted south of wells 097-64 and 106-64, as shown in Figure 7-8.

During 2003, 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 NYS AWQS. Iron and aluminum were occasionally detected at concentrations above NYS AWQS in two downgradient wells. Iron was detected at 1.3 mg/L in well 086-72, and aluminum was detected up to 0.418 mg/L in well 106-30. The NYS AWQS for iron and aluminum are 0.3 and 0.2 mg/L, respectively.

***Animal/Chemical Pits and Glass Holes Monitoring Results.*** Groundwater samples were obtained from 36 monitoring wells during 2003. 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 Sr-90 plume distribution. The highest Sr-90 concentration observed during 2003 was 2,400 pCi/L in well 106-16, which is immediately south of the Animal Pits. This well has historically shown the highest Sr-90 concentrations in this area (see trend plot on Figure 7-8). The sharp increase in Sr-90 in this well appears to be correlated with the excavation of the Animal Pits area in 1997, which may have released additional Sr-90 to the groundwater.

The high concentration segment of the Sr-90 plume, with concentrations greater than 100 pCi/L, extends from approximately 35 feet northwest of well 106-16 to approximately 65 feet south of the Princeton Avenue firebreak road (Figure 7-8). The leading edge of the plume, as defined by the 8 pCi/L DWS, is approximately 275 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 75 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 STP sludge contained low concentrations of radionuclides, and possibly metals and organic compounds. BNL also disposed of limited quantities of laboratory wastes containing radioactive and chemical material at the landfill. As a result, the Current Landfill is a source of groundwater contamination. Permanent closure (capping) of this landfill was completed in November 1995 as part of the ER Program.

The Current Landfill post-closure groundwater monitoring program consists of a network of 11 monitoring wells 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 2003 Environmental Monitoring Report, Current and Former Landfill Areas (BNL 2004a).

***Volatile Organic Compounds***. During 2003, benzene, DCA, and chloroethane concentrations exceeded groundwater standards in four of 10 downgradient monitoring wells. Benzene was detected above the 0.7 µg/L standard in well 087-11 at a concentration of 2.6 µg/L, and DCA was detected above the 5 µg/L standard in well 088-109 at a concentration of 26 µg/L. Chloroethane was detected at concentrations above the 5 µg/L standard in wells 087-11, 087-23, 088-109, and 088-110, with a maximum concentration of 77 µg/L detected in well 088-109. The extent of the Current Landfill VOC plume is shown in Figure 7-7.

***Radionuclides.*** As in previous years, low levels of tritium and Sr-90 were detected in Current Landfill monitoring wells during 2003, but at concentrations well below their applicable DWS of 20,000 pCi/L and 8 pCi/L, respectively. The maximum Sr-90 concentration was detected in well 088-23 at 2.13 pCi/L, and the maximum tritium concentration was 1,450 pCi/L, detected in well 087-27.

***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 NYS AWQS, except for ammonia. Total dissolved solids and total suspended solids readings were similar to previous years, and indicate some continued movement of leachate from the landfill. Although there was a general decrease in ammonia concentrations from previous years, ammonia concentrations exceeded the NYS AWQS of 2 mg/L in three downgradient wells. The highest ammonia concentration was detected in well 088-110 at 3.6 mg/L. Ammonia is a common landfill contaminant and is generated by the degradation of organic material. During 2003, iron, manganese, and sodium continued to be detected above their respective groundwater standards. Iron in the downgradient wells peaked at a maximum of 68.1 mg/L in well 087-11. In contrast to background concentrations, in well 87-09 iron ranged from 0.234 to 31.7 mg/L. Manganese ranged from 0.030 to 7.2 mg/L in background well 087-09, and up to 7.4 mg/L in the downgradient wells. Background sodium levels ranged from 7.6 to 30.6 mg/L, whereas downgradient levels ranged up to 37.7 mg/L. Thallium was reported above the groundwater standard of 0.0005 mg/L in several wells, with concentrations up to 0.012 mg/L. Thallium detections have historically been observed at similar levels in Current Landfill wells.

#### *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 is being monitored under the OU I South Boundary program. This monitoring program uses a network of 57 wells 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 NYS 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.) In 2003, BNL began construction of a second treatment system, the North Street East System, to treat the off-site portion of the plume. This system will begin operations in 2004.

***Volatile Organic Compounds***. Total VOC 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-DCE, 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 2,080 feet south of North

Street (approximately 7,500 feet long as measured from the Current Landfill). Its maximum width is about 1,230 feet at the southern site boundary. The areas of the plume displaying the highest VOC concentrations (greater than 100 µg/L) are approximately 980 feet downgradient of the FWMF (at well 098-59), and off site, south of well 000-124. (Note: The depiction of the extent of the plume south of well 000-124 is based on data obtained from temporary wells installed in 2001 and from estimated plume migration rates.)

The distribution of the plume has changed since the south boundary pump-and-treat system began operations 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). The North Street East 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 inside the FWMF have been declining since 1997, when concentrations approached 44,000 pCi/L in well 088-26. During 2003, the maximum tritium concentration in this well was only 1,540 pCi/L. Tritium concentrations in downgradient well 098-30 declined from 24,600 pCi/L in 2002 to 19,400 pCi/L in 2003. Low levels of tritium continued to be detected off site during 2003, with a maximum concentration of 1,230 pCi/L, in well 000-138.

Sr-90 has historically been detected on site at concentrations above the DWS of 8 pCi/L in three wells within and downgradient of the FWMF (088-26, 098-21, and 098-30). The extent of Sr-90 concentrations that are greater than the 8 pCi/L DWS is shown in Figure 7-9. The peak Sr-90 concentration during 2003 was 21 pCi/L, in well 088-26.

### 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 UST area, former Building 96 area, and the Supply and Material area.
- Monitor the tritium plume associated with the High Flux Beam Reactor (HFBR) and Sr-90 plumes associated with the WCF and the formerly operated BGRR.
- 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 (SCWA) 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 SCWA 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 in the central part of the site south to the vicinity of Flower Hill Drive in North Shirley, a distance of approximately 17,700 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

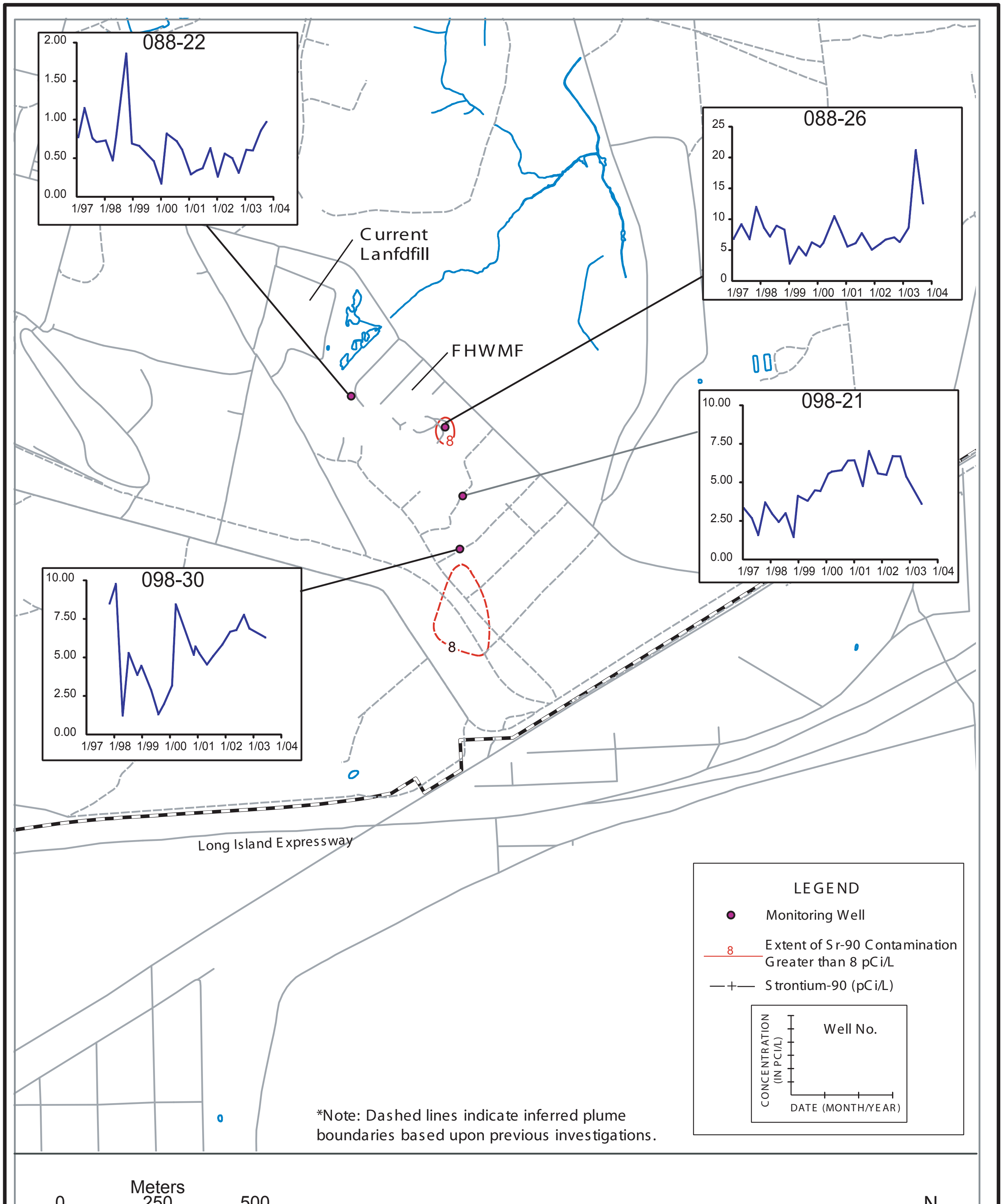



**Figure 7-9. Former Waste Management Facility Sr-90 Plume.**

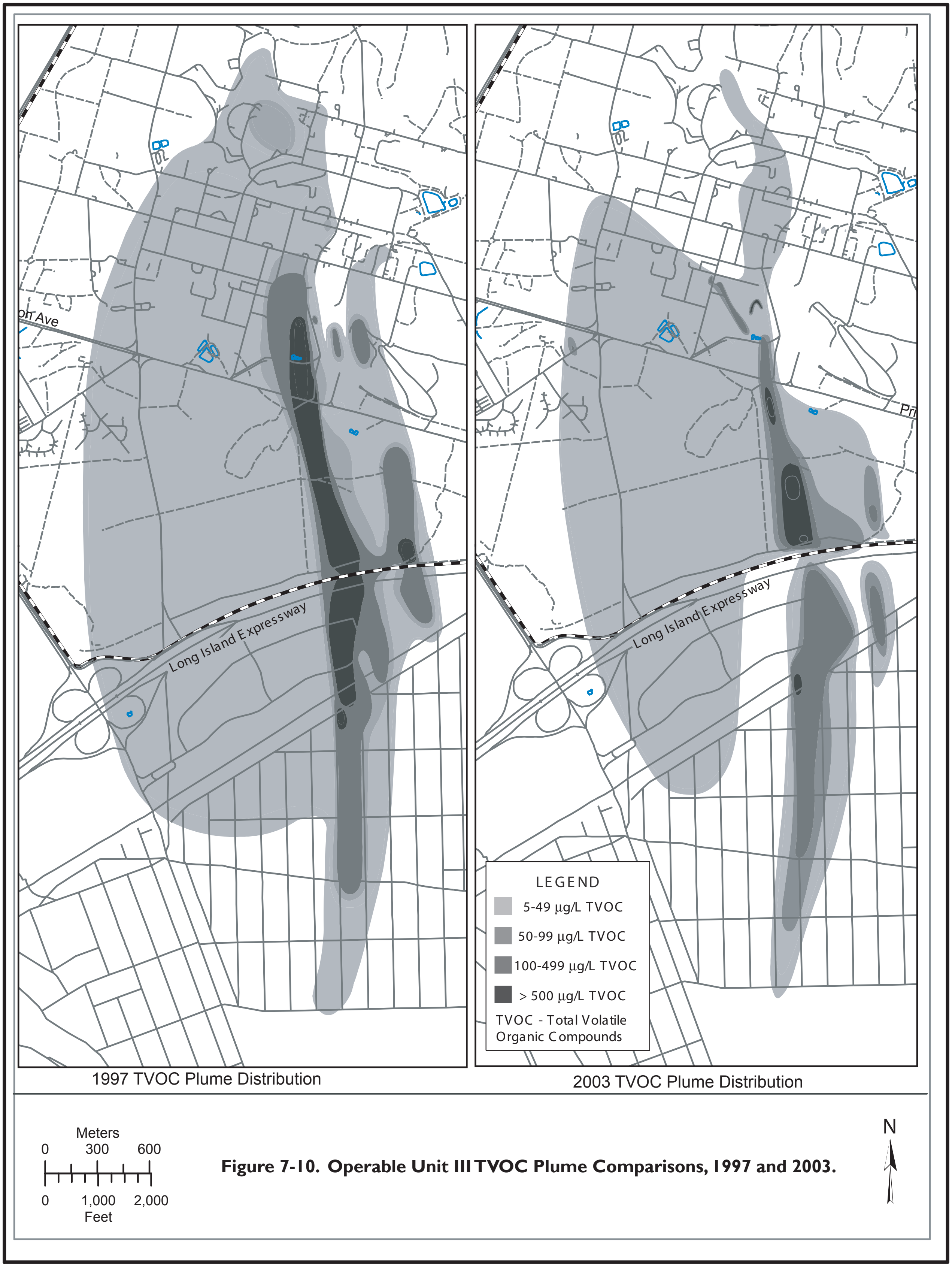



**Figure 7-10. Operable Unit III TVOC Plume Comparisons, 1997 and 2003.**

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. On-site portions of the plume displaying the highest VOC concentrations during 2003 were south of Building 96, with TVOC concentrations up to 1,312 µg/L, continuing south to the Middle Road with TVOC concentrations of 1,997 µg/L, and the south boundary with TVOC concentrations up to 857 µg/L. TVOC levels range up to 772 µg/L (primarily carbon tetrachloride and PCE) in the off-site industrial park area.

Monitoring results also indicate that there is significant carbon tetrachloride 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. During 2003, carbon tetrachloride levels exceeded NYS AWQS in five Magothy wells, with the highest levels observed in wells 000-130 and 000-249, at concentrations of 110 and 739 µg/L, respectively. Lower levels of other VOCs were also detected, such as chloroform (up to 38 µg/L in well 000-249), tetrachloroethylene (up to 13 µg/L in well 000-130), TCA (up to 16.9 µg/L in well 000-249) and TCE (up to 11.1 µg/L in well 000-425). In 2004, BNL will install two additional off-site groundwater extraction wells (one on Stratler Drive and one at the Industrial Park East area). The purpose of these extraction wells is to treat existing high TVOC concentrations in the Upper Magothy Aquifer and to prevent the continued migration of contaminants into the Magothy Aquifer.

A comparison of the OU III plumes between 1997 and 2003 is provided in Figure 7-10. A summary of significant source areas and groundwater treatment areas is provided here.

***OU III Central Area***. A number of low-level (less than 100 µg/L) source areas and nonpoint source contamination sites 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 2003, VOC concentrations in most of the OU III Central wells were near or below the NYS AWQS.

Wells 109-03 and 109-04 serve as sentinel wells for the SCWA William Floyd Well Field and are located near the eastern BNL site property boundary. Toluene was detected in well 109-03 (screened in deep Upper Glacial Aquifer) at 5.3 µg/L in a sample obtained on September 12, 2002. There were no VOC detections in this well exceeding NYS AWQS or guidance values prior to this sampling event. The well was re-sampled on October 29, 2002 and sent to two different analytical laboratories. MTBE was detected by both laboratories at concentrations ranging from 4.8 µg/L to 7 µg/L, as well as trace amounts of toluene (0.2 µg/L). The well was sampled again in December 2002. No VOCs were detected in these samples. The SCDHS sampled the well in early January 2003 and also did not detect any VOCs. Routine BNL monitoring detected MTBE at 67 µg/L in a sample collected on February 21, 2003. Benzene, m/p xylene, and toluene were also detected at concentrations of 1.4, 6.2, and 8.7 µg/L, respectively. BNL sampled the well again on April 3, 2003 and detected MTBE at 5 µg/L and toluene at 1 µg/L. The well was sampled by both BNL and SCDHS on April 23, 2003 and no VOCs were detected in these samples. There were no detections of VOCs exceeding NYS AWQS during the remainder of the year for either well. There were no detections of tritium in either well during 2003.

***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 Scrap yard, 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 NYS AWQS for PCE and TCA is 5 µg/L. During 2003, the Building 96 area VOC plume was monitored using 21 permanent wells. Although VOC concentrations throughout most of the plume have declined significantly since the treatment system was installed, high concentrations of VOCs continue to be detected in the northern section of the source area (north of treatment well RTW-1), with a maximum TVOC concentration of 1,305 µg/L in well 085-335. These persistently high levels of VOCs appear to be coming from a silty layer that is slowly releasing contaminants. BNL is planning to install additional monitoring wells and will conduct an engineering study on the source term and alternative treatment technologies in 2004.

***Carbon Tetrachloride UST Area***. In April 1998, an inactive UST 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 NYS 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 UST. A groundwater remediation system consisting of two extraction wells (EW-13 and EW-14) screened in the shallow Upper Glacial Aquifer began operating in October 1999. A third extraction well (EW-15) installed in the downgradient segment of the plume began operating 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 Drive 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. The maximum carbon tetrachloride concentration during 2003 was only 184 µg/L. Carbon tetrachloride concentrations were also observed to decrease in wells near the Upton Service Station. For example, carbon tetrachloride concentrations in well 085-17 dropped from 3,760 µg/L in February 2001 to 120 µg/L by the fourth quarter of 2003. 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 388 µg/L in the first quarter of 2003, to 60 µg/L in the fourth quarter of 2003. Carbon tetrachloride was not detected in any of the sentinel wells near Weaver Drive.

The cleanup goals for this remediation system have been satisfied, and in early 2004 BNL will submit a petition to the regulatory agencies to shut down the system. Groundwater monitoring of this plume will continue.

***Middle Road Treatment Area***. Six groundwater extraction wells are used to hydraulically control the OU III VOC plume, near the Middle Road. This system began operating in October 2001. Groundwater near the Middle Road system is monitored using a network of 23 wells.

TVOC concentrations in plume core wells 105-23 and 105-44 have decreased since 2001. TVOC concentrations in well 105-23 decreased from 1,794 µg/L in 2001, to as low as 258 µg/L in 2003, and in well 105-44 TVOC concentrations decreased from 423 to 20 µg/L. High VOC concentrations continue to be found in the vicinity of extraction wells RW-2 and RW-3, based on influent concentrations for these wells and monitoring well data. For example, well 113-11 had a TVOC concentration of 1,488 µg/L in May 2003. The highest TVOC concentration detected was in bypass detection well 113-17, located south of the extraction wells, at 1,997 µg/L. High VOC concentrations had been observed in the vicinity of this bypass well before the operation of the pump-and-treat system, and it is expected that this contamination will ultimately be captured by the OU III South Boundary System.

***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 operating in 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 extraction well system has created a break in the plume, characterized by a region of low-level VOC 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 2003, the highest TVOC concentration detected near the extraction well system was 856 µg/L in well 121-23, near well EW-5.

***Western South Boundary Treatment Area***. The Western South Boundary pump-and-treat system began operating 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 2003 was 49 µg/L, in well 126-11.

***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 40 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 TVOC concentration in the Industrial Park area during 2003 was 772 µg/L, which was observed in monitoring well 000-249. Wells that monitor the Upper Glacial Aquifer downgradient of the treatment system, along Carleton Drive, showed stable or decreasing VOC concentrations during 2003, with a maximum TVOC concentration of approximately 21 µg/L.

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).

The VOC plume extends from just south of the Animal/Chemical Pits area southward to the vicinity of Brookhaven Airport (Figure 7-7). 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 appears to be approaching well 800-63.

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 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). This system is scheduled to begin operations in the summer of 2004.

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 DWS. The maximum tritium concentration observed in 2003 was 1,570 pCi/L, in well 000-153. The highest tritium concentration detected to date was 9,130 pCi/L, detected in temporary well 000-337 installed in 2001 approximately 300 feet north of well 000-153. Potential sources for this tritium are located in the Former Landfill, Animal/Chemical Pits, 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 models predict that the tritium plume will naturally attenuate to below DWS 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 in monitoring wells at Weaver Drive, or 25,000 pCi/L at the Chilled Water Plant Road.

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. A total of 95,000 gallons of tritiated water was sent off site for disposal. Since April 2001, tritium concentrations have remained below 750,000 pCi/L; a concentration above this would trigger low-flow pumping.

A monitoring well network of 159 wells is used to monitor the extent of the plume. During 2003, four temporary wells were installed to help define certain segments the plume. The extent of the tritium plume, determined from data collected during the fourth quarter of 2003, is shown in Figure 7-11. Tritium concentrations in groundwater immediately south of the HFBR building in monitoring well 075-43 increased from 22,600 pCi/L in 2002, to 130,000 pCi/L in 2003. In 1999, tritium concentrations in this well reached 2,500,000 pCi/L. The concentration increase observed in 2003 is likely due to

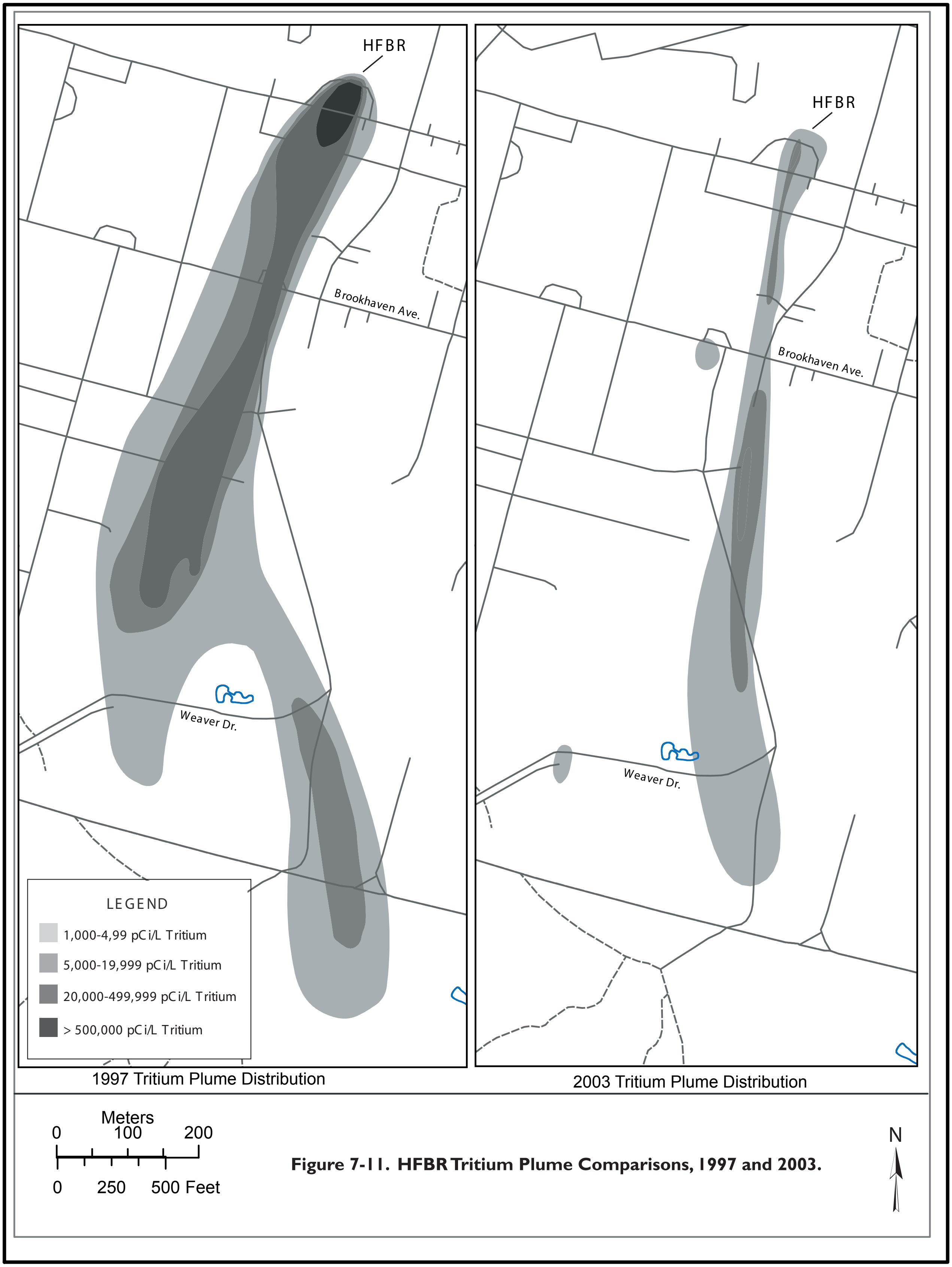



**Figure 7-11. HFBR Tritium Plume Comparisons, 1997 and 2003.**

a rise in the water table elevation and resulting flushing of residual tritium from the soil beneath the HFBR. During 2003, the highest concentration segment of the HFBR tritium plume was located in the vicinity of Bell Avenue, with a maximum concentration of 217,000 pCi/L detected in temporary well 085-341. 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.

***WCF and BGRR-Area Sr-90 Plumes.*** Historical waste handling operations at the Waste Concentration Facility and Building 801, and operations at the BGRR and associated Pile Fan Sump and Stack, resulted in the release of Sr-90 to the groundwater beneath these facilities. The Sr-90 plumes from these facilities are monitored using 61 wells. During September 2003 through January 2004, additional groundwater characterization work was conducted in the BGRR area using 60 temporary wells (BNL 2004c).

There are three source areas where Sr-90 concentrations are greater than 50 pCi/L (Figure 7-12). The first area is near the BGRR's Below Ground Ducts (BGD), where in 2003 a groundwater sample from temporary well BGRR-8 contained Sr-90 concentrations of 3,150 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. The segment of the plume with concentrations that exceed 8 pCi/L extends from the BGRR, south approximately 600 feet toward Brookhaven Avenue.

The second area of notable Sr-90 concentrations is the WCF. During 2003, the highest Sr-90 concentration was observed in temporary well WCF-13, at 1,000 pCi/L. This well is immediately downgradient of the WCF's former "D" tanks area. The segment of the plume with concentrations that exceed 8 pCi/L extends from the WCF, south approximately 1,500 feet to just south of Cornell Avenue.

The third area of notable Sr-90 concentrations is downgradient of Building 801, where Sr-90 concentrations up to 54.2 pCi/L were detected in shallow well 065-325, and up to 83.1 pCi/L in temporary well PFS-1 (see Section 7.5.1.5).

#### 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 No. 6 fuel oil and mineral spirits were released when a pipe ruptured as the contents of a UST 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 No. 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 contamination 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 until the regulatory agencies approved BNL's Petition for Closure and Termination of Formal Post-Closure Monitoring of OU IV Air Sparge/Soil Vapor Extraction Remediation System (BNL 2002), and the system was decommissioned in 2003. Post-closure groundwater monitoring of six wells was initiated in the fourth quarter of 2003. Although there were no detections of VOCs exceeding NYS AWQS in wells monitoring the 1977 spill site, VOC concentrations did exceed standards in well 076-380, west of the spill site. This contamination is associated with a source in the CSF (see Section 7.5.2.4).

##### *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

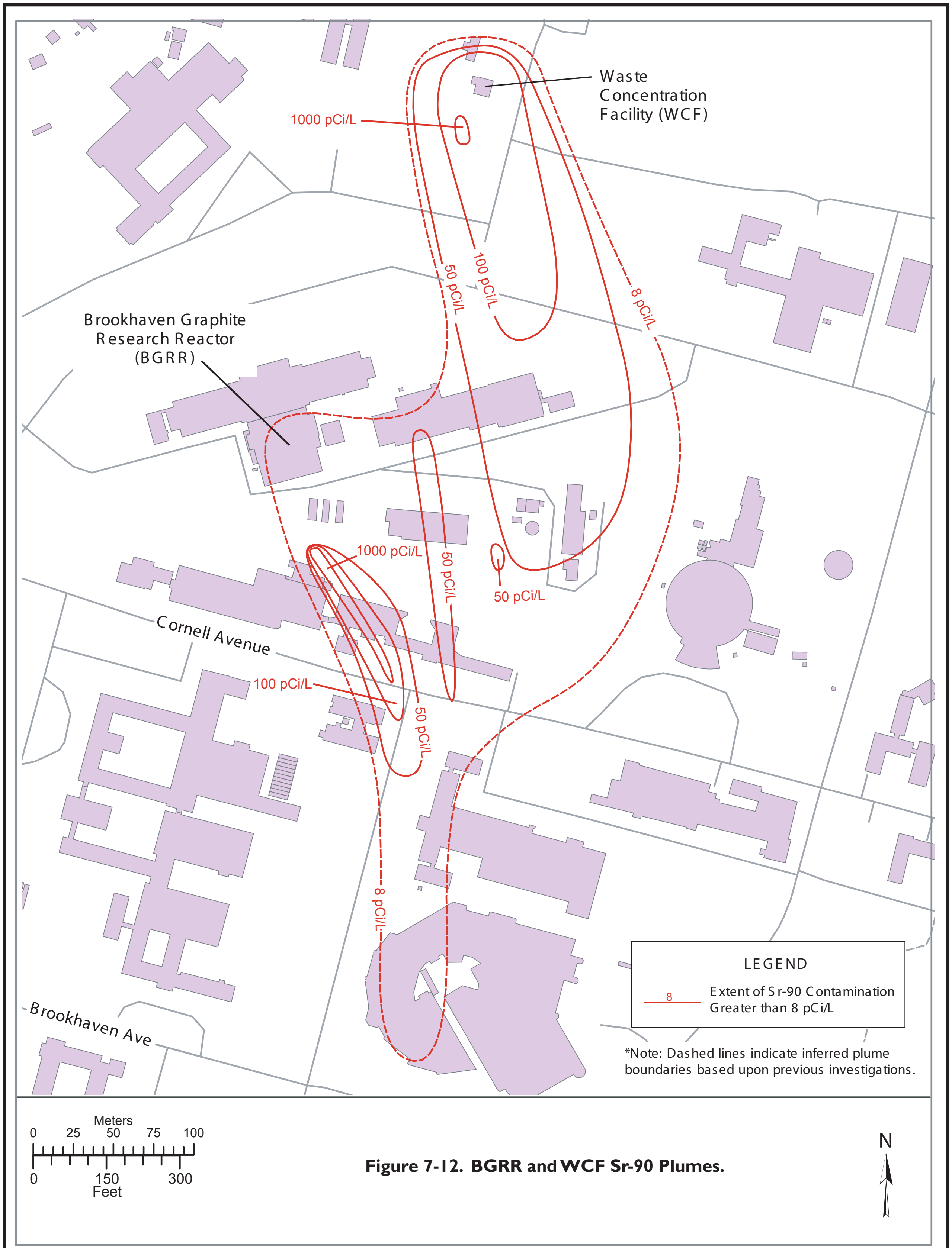



Figure 7-12. BGRR and WCF Sr-90 Plumes.

piped to a natural depression approximately 800 feet to the northeast, near recharge basin HO. As a result of these operations, soil 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 Sr-90 plume (with concentrations greater than the 8 pCi/L DWS did not change significantly from 2000 to 2003 (Figure 7-13). The leading edge of the plume is projected to be just east of the CSF. The highest Sr-90 concentrations were detected in well 076-13, at 42 pCi/L, in February 2003. Sr-90 concentrations in Building 650 monitoring well 076-28 remained below the 8 pCi/L DWS during 2003.

#### 7.6.5 Operable Unit V

Historically, BNL'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 have been detected in some off-site 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 2003 was 17 µg/L in well 061-05, near the eastern site property boundary. VOCs detected at levels exceeding NYS AWQS were TCE, TCA, 1,2-dichloropropane, and 1,2,3-trichloropropane. The maximum TCE concentration was detected in well 000-122, at 7.1 µg/L (the standard is 5 µg/L), and TCA was detected in well 061-05 at a concentration of 5.3 µg/L (the standard is 5 µg/L). Low levels of 1,2-dichloropropane and 1,2,3-trichloropropane were detected in shallow off-site well 600-25, at concentrations of 2 and 0.98 µg/L, respectively. The NYS AWQS for these compounds are 1.0 and 0.04 µg/L, respectively. Because well 600-25 is shallow, it is likely that the 1,2-dichloropropane and 1,2,3-trichlropropane originated from an offsite source.

There were no pesticide detections above reporting limits in groundwater during 2003. In past years, low levels of pesticides were detected in shallow offsite wells; their origin was likely associated with agricultural spraying at nearby farms.

Aluminum, antimony, arsenic, chromium, iron, manganese, sodium, and thallium were detected in monitoring wells for the OU V program at concentrations above the applicable NYS AWQS or federal DWS. Arsenic was detected in three wells above the federal DWS of 0.010 mg/L, with the highest concentration of 0.0178 mg/L detected in well 050-02. Aluminum was detected in 14 wells above the NYS standard of 0.2 mg/L, with the highest concentration of 24.4 mg/L detected in well 600-21. Antimony was detected in five wells above the 0.003 mg/L standard, with the highest concentration of 0.611 mg/L detected in well 600-22. Chromium was detected in well 600-21 above the 0.05 mg/L standard. Iron was detected in 19 wells at concentrations above the 0.3 mg/L standard, with the highest concentration of iron of 29.7 mg/L in well 50-02. Manganese was detected in eight wells above the 0.3 mg/L standard, with the highest concentration of 1.23 mg/L detected in well 50-02. Sodium was detected in six wells above the 20 mg/L standard, with the highest concentration of 135 mg/L detected in well 600-19. Thallium was detected in six wells above the 0.0005 mg/L standard, with the highest concentration of 0.0048 mg/L detected in well 061-05.

***Radionuclides***. Detectable levels of tritium were found in three wells near BNL's southeastern site boundary (wells 049-06, 050-02, and 061-05), but the concentrations were well below the DWS of 20,000 pCi/L. The highest level of tritium during 2003 was detected in well 050-02 at a concentration of 1,980 pCi/L. Tritium was

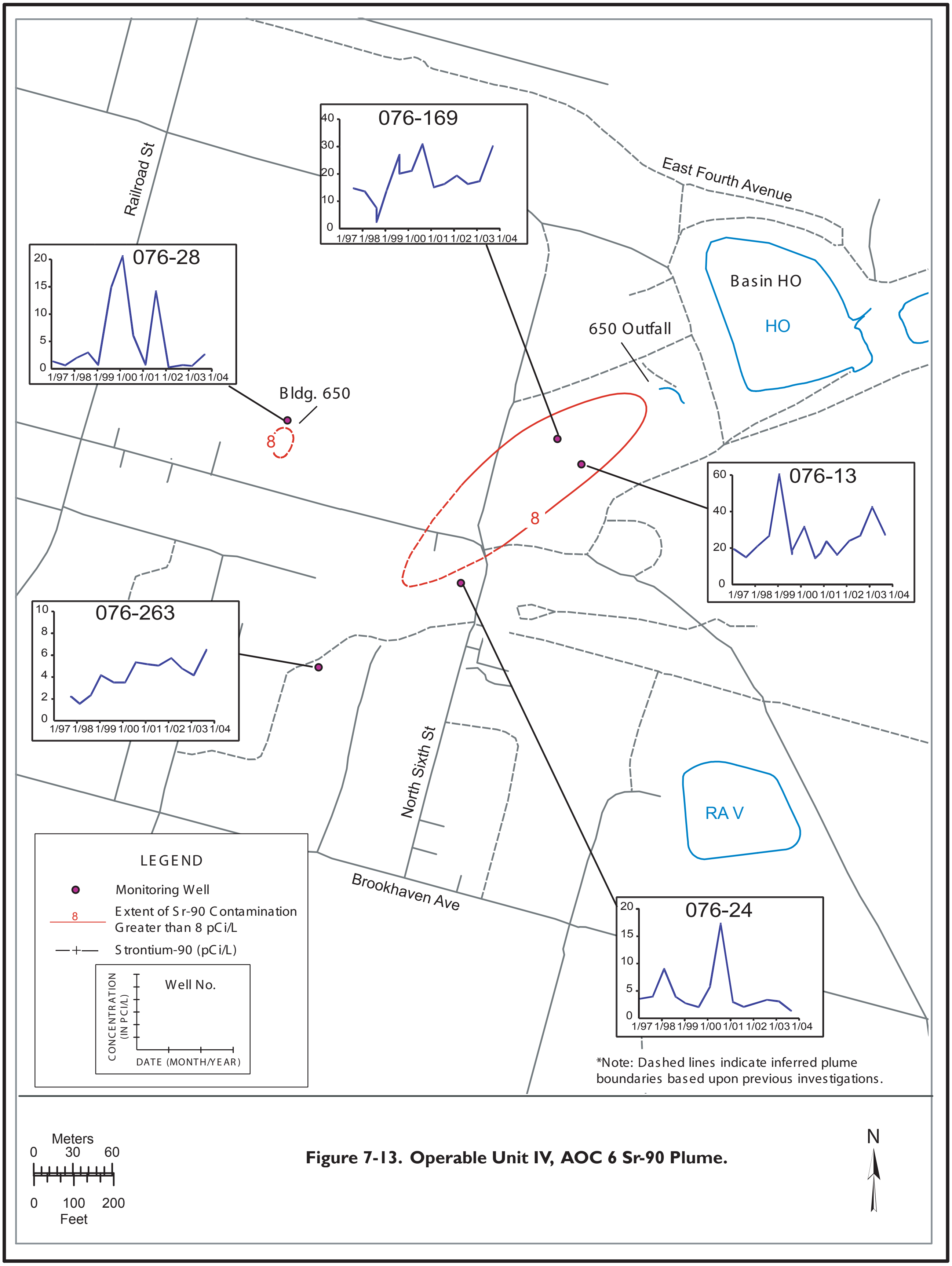



**Figure 7-13. Operable Unit IV, AOC 6 Sr-90 Plume.**

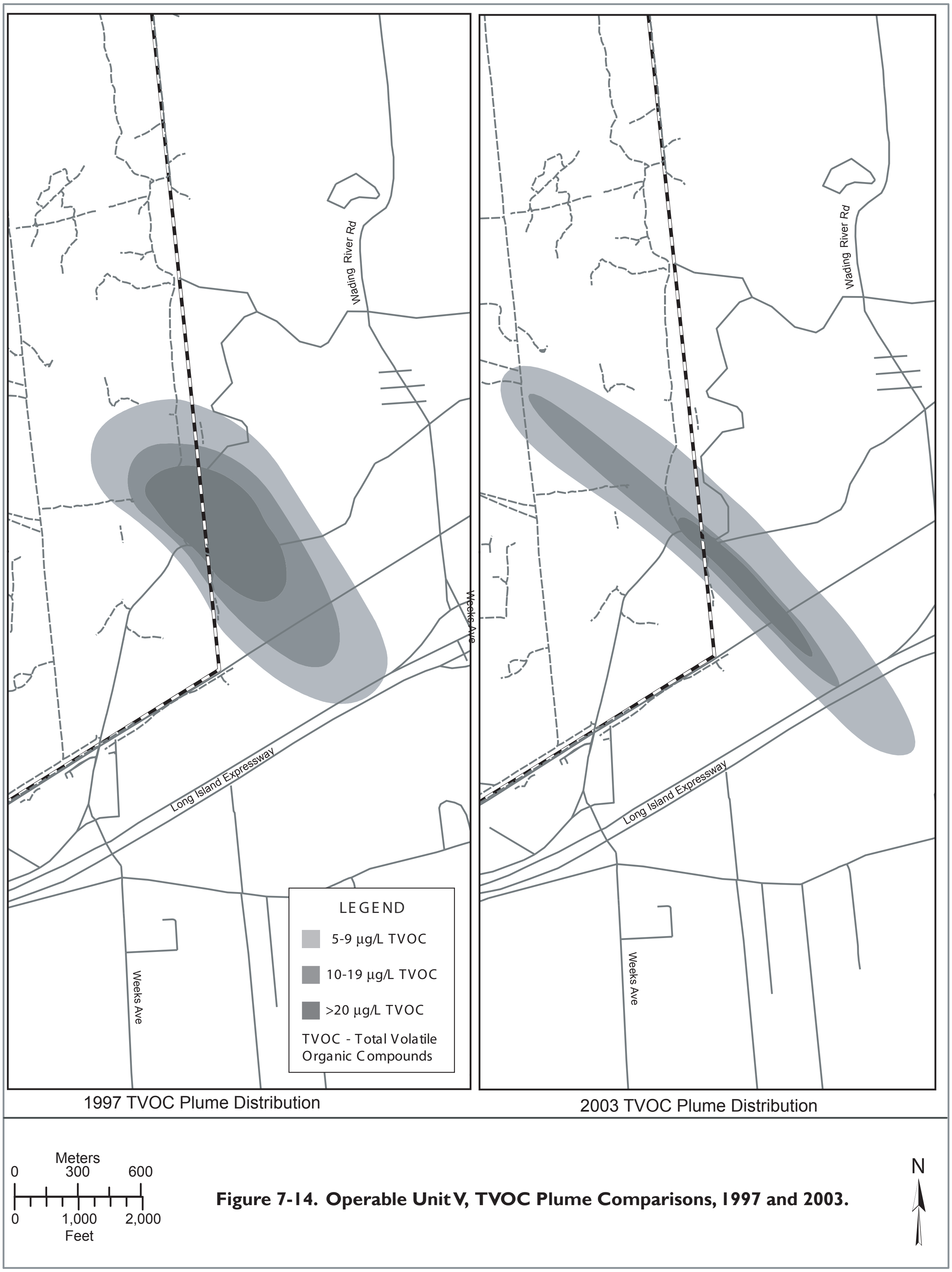



**Figure 7-14. Operable Unit V, TVOC Plume Comparisons, 1997 and 2003.**


**Figure 7-15. Operable Unit VI, EDB Plume Comparisons, 1997 and 2003.**

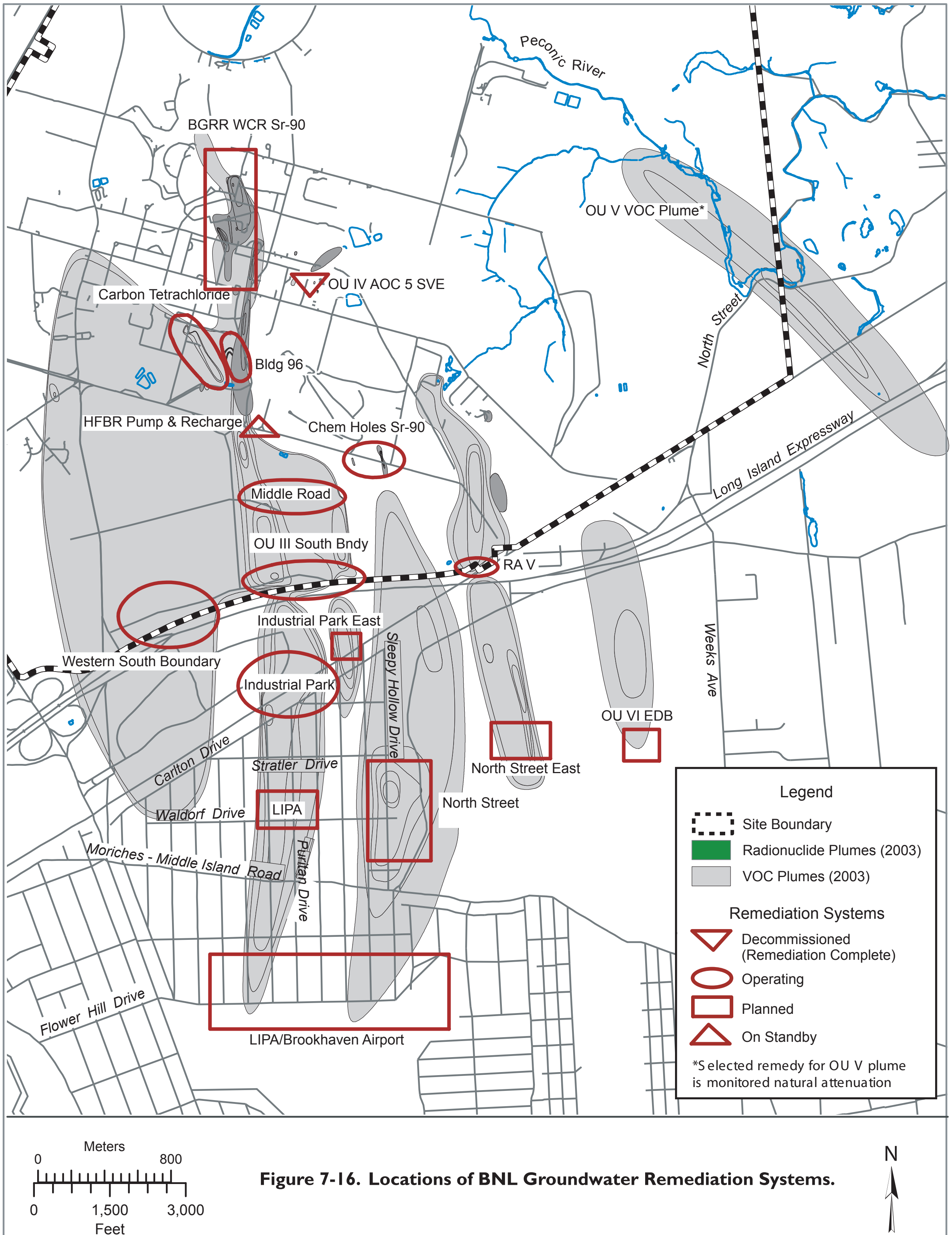



**Figure 7-16. Locations of BNL Groundwater Remediation Systems.**

**Table 7-5. BNL Groundwter Remediation Systems Treatment Summary for 1997 through 2003.**

| Remediation System | Start Date | 1997 – 2002 Water Treated (Gallons) | 1997 – 2002 VOCs Removed (Pounds) (d) | 2003 Water Treated (Gallons) | 2003 VOCs Removed (Pounds) (d) |
|---|---|---|---|---|---|
| OU III South Boundary | June 1997 | 1,901,436,850 | 1,920 | 353,423,000 | 184 |
| OU III Industrial Park | Sept. 1999 | 602,915,330 | 631 | 187,013,000 | 127 |
| OU III Western South Boundary | Sept. 2002 | 74,287,000 | 12 | 138,761,000 | 10 |
| Carbon Tetrachloride | Oct. 1999 | 122,798,300 | 327 | 27,348,000 | 14 |
| OU I South Boundary | Dec. 1996 | 2,118,390,000 | 278 | 306,390,000 | 19 |
| HFBR Tritium Plume (a) | May 1997 | 241,528,000 | 180 | Not in Service | 0 |
| OU IV AS/SVE (b) | Nov. 1997 | (c) | 35 | Decommissioned | 0 |
| Building 96 | Feb. 2001 | 69,238,416 | 46 | 29,027,000 | 9 |
| Middle Road | Oct. 2001 | 336,353,550 | 217 | 278,000,000 | 147 |
| **Total** | | 5,466,947,446 | 3,646 | 1,341,199,330 | 510 |

| Remediation System | Start Date | 1997 – 2002 Water Treated (Gallons) | 1997 – 2002 Sr-90 Removed (mCi) | 2003 Water Treated (Gallons) | 2003 Sr-90 Removed (mCi) |
|---|---|---|---|---|---|
| OU III Chemical Holes Sr-90 | Feb. 2003 | Not in Service | 0 | 3,834,826 | 0.88 |

Notes:
(a) System was shut down and placed in standby mode on September 29, 2000.
(b) System was shut down on January 10, 2001, and decommissioned in 2003.
(c) Air Sparging/Soil Vapor Extraction system performance is measured by pounds of VOC removed per cubic feet of air treated.
(d) Values are rounded to the nearest whole number.

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 2003 BNL Groundwater Status Report (BNL 2004c). 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 DWS for EDB) extends approximately 4,600 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 2004. The plume is located entirely in the deep Upper Glacial Aquifer. The highest EDB concentration observed during 2003 was 6.8 µg/L, in well 000-284. As in past years, no tritium was detected in samples from these wells.

A groundwater remediation system to address the off-site EDB plume is scheduled to begin operations 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 2003, BNL continued to make significant progress in restoring groundwater quality on site. Eight groundwater remediation systems were operating by the end of 2003. Sixteen of the 17 planned groundwater remediation systems have been constructed. The HFBR Pump and Recharge System remained in standby mode following regulatory agency approval, and the OU IV Air Sparging/Soil Vapor Extraction system was decommissioned. Compared to 2002, the total groundwater cleanup treatment capacity was increased from 2,875 gallons per minute (gpm) to 2,925 gpm. Ultimately, the total groundwater cleanup capacity will be approximately 4,800 gpm. Figure 7-16 shows the locations of the current and planned groundwater treatment systems. Table 7-5 provides a summary of pounds of VOCs and curies of radioactivity removed and gallons of water treated during 1997–2003. During 2003, 510 pounds of VOCs and 0.88 mCi of Sr-90 were removed from the groundwater and more than 1 billion gallons of treated groundwater were returned to the aquifer. Detailed information on these treatment systems can be found in the 2003 BNL Groundwater Status Report (BNL 2004c).

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

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