7 Groundwater Protection

The Brookhaven National Laboratory Groundwater Protection Program is made up of four elements: prevention, monitoring, restoration, and communication. The Laboratory has implemented aggressive pollution prevention measures to protect groundwater resources. An extensive groundwater monitoring well network is used to verify that prevention and restoration activities are effective. In 2009, BNL collected groundwater samples from 806 monitoring wells during 1,800 individual sampling events. Twelve groundwater remediation systems removed 229 pounds of volatile organic compounds and returned approximately 1.6 billion gallons of treated water to the Upper Glacial aquifer. Since the beginning of active groundwater remediation in December 1996, the Laboratory has removed 6,363 pounds of volatile organic compounds by treating 16 billion gallons of groundwater. During 2009, two groundwater treatment systems removed approximately 1.9 millicuries of strontium-90 while remediating nearly 15 million gallons of groundwater. Since 2003, BNL has removed approximately 21.3 millicuries of strontium-90 from the groundwater while remediating 64 million gallons of groundwater.

7.1 THE BNL GROUNDWATER PROTECTION MANAGEMENT PROGRAM

The primary goal of BNL's Groundwater Protection Program is to ensure that plans for groundwater protection, management, monitoring, and restoration are fully defined, integrated, and managed in a manner that is consistent with federal, state, and local regulations. The program helps to fulfill the environmental monitoring requirements outlined in DOE Order 450.1, Environmental Protection Program. The 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 stakeholders on groundwater protection issues. The Laboratory is committed to protecting groundwater resources from further chemical and radionuclide releases, and to remediate existing contaminated groundwater.

7.1.1 Prevention

As part of BNL's Environmental Management System, the Laboratory has implemented a number of pollution prevention activities that are designed to protect groundwater resources (see Chapter 2). BNL has established a work control program that requires the assessment of all experiments and industrial operations to determine their potential impact on the environment. The program enables the Laboratory to integrate pollution prevention and waste minimization, resource conservation, and compliance into planning and decision making. Efforts have been implemented to achieve or maintain compliance with regulatory requirements and to implement best management practices designed to protect groundwater (see Chapter 3). Examples include upgrading underground storage tanks, closing cesspools, adding engineered controls (e.g., barriers to prevent rainwater infiltration that could move contaminants out of the soil and into groundwater), and administrative controls (e.g., reducing the toxicity and volume of chemicals in use

or storage). BNL's comprehensive groundwater monitoring program is used to confirm that these controls are working.

7.1.2 Monitoring

The Laboratory's groundwater monitoring network is designed to evaluate the impacts of groundwater contamination from former and current operations and to track cleanup progress. Each year, BNL collects groundwater samples from an extensive network of on- and off-site monitoring wells (see Table 7-1). Results from groundwater monitoring are used to verify that protection and restoration efforts are working. Groundwater monitoring is focused on two general areas: 1) Facility Monitoring (FM), designed to satisfy DOE and New York State monitoring requirements for active research and support facilities, and 2) Comprehensive Environmental Response, Compensation and Liability (CERCLA) monitoring related to the Laboratory's obligations under the Federal Facilities Agreement (FFA). These monitoring programs are coordinated to ensure completeness and to prevent duplication of effort in the installation, monitoring, and decommissioning of wells. The monitoring program elements include data quality objectives; plans and procedures; sampling and analysis; quality assurance; data management; and the installation, maintenance, and decommissioning of wells.

Table 7-1. Summary of BNL Groundwater Monitoring Program, 2009.

	CERCLA Program	Facility Monitoring Program
Number of wells monitored	688	108
Number of sampling events	1,617	183
Number of analyses performed	2,827	331
Number of results	67,472	3,819
Percent of nondetectable analyses	89	88
Number of permanent wells installed	4	0
Number of temporary wells installed	70	26
Number of wells abandoned	64	0

These elements are 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. To help manage the restoration effort, 31 separate Areas of Concern were grouped into six Operable Units (OUs). Remedial Investigation/Feasibility Studies have been conducted for each OU, and the focus is currently on operating and maintaining cleanup systems. Contaminant sources (e.g., contaminated soil and underground storage tanks) are being removed or remediated to prevent further contamination of groundwater. All remediation work is carried out under the FFA 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 Office ensures that the Laboratory communicates with its stakeholders 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 routine meetings with the Community Advisory Council and the Brookhaven Executive Roundtable (see Chapter 2, Section 2.4.2). Quarterly and annual technical reports that summarize data, evaluations, and program indices are prepared. In addition, BNL has developed a Groundwater Protection Contingency Plan (BNL 2008) that provides formal processes to promptly communicate off-normal or unusual monitoring results to Laboratory management, DOE, regulatory agencies, and other stakeholders, including the public and employees.

7.2 GROUNDWATER PROTECTION PERFORMANCE

BNL has made significant investments in environmental protection programs, and is making progress in achieving its goal of preventing new groundwater impacts and to remediate previously contaminated groundwater.

No new impacts to groundwater quality have been identified since 2001. A new impact is defined as the detection and confirmation of previously unidentified groundwater contamination. The Groundwater Protection Contingency Plan, mentioned earlier as a communications tool, also 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 verifying the data, evaluating the source of the problem, notifying stakeholders, and implementing appropriate corrective actions. The Laboratory will continue efforts to prevent new groundwater impacts, and is vigilant in measuring and communicating its performance.

Since the start of active groundwater remediation in December 1996, BNL has made significant progress in restoring groundwater quality by removing 6,363 pounds of volatile organic compounds (VOCs) and 21.3 millicuries (mCi) of strontium-90 (Sr-90) from the aquifer. Noticeable improvements in groundwater quality are evident in a number of on-site and off-site areas.

7.3 GROUNDWATER MONITORING

Elements of the groundwater monitoring program include installing monitoring wells; planning and scheduling; developing and following quality assurance procedures; collecting and analyzing samples; verifying, validating, and interpreting data; and reporting. Monitoring wells 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 that enters and exits the site.

The Laboratory monitors research and support facilities where there is a potential for environmental impact, as well as areas where past waste handling practices or accidental spills have already degraded groundwater quality. The groundwater beneath the site is classified by New York State as Class GA groundwater, which is defined as a source of potable water. 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 the standards. Contaminant concentrations that are below the standards are also compared to background values to evaluate the potential effects of facility operations. The detection of low concentrations of facility-specific 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 800 on- and off-site wells (see SER Volume II, Groundwater Status Report, for details). In addition to water quality assessments, water levels are routinely measured in more than 875 on- and off-site wells to assess variations in the direction and velocity of groundwater flow. Groundwater flow directions in the vicinity of the Laboratory are shown in Figure 7-1.

The following active facilities have groundwater monitoring programs: the Sewage Treatment Plant (STP) area, Waste Management Facility (WMF), Major Petroleum Facility (MPF), Alternating Gradient Synchrotron (AGS), Relativistic Heavy Ion Collider (RHIC), and several vehicle maintenance and petroleum storage facilities. Inactive facilities include the former Hazardous Waste Management Facility (HWMF), two former landfill areas, Waste Concentration Facility (WCF), Brookhaven Graphite Research Reactor (BGRR), High Flux Beam Reactor (HFBR), and Brookhaven Medical Research Reactor (BMRR). As a result of detailed groundwater investigations, six significant VOC plumes and eight radionuclide plumes have been identified (see Figures 7-2 and 7-3).

7.4 FACILITY MONITORING PROGRAM

BNL's Facility Monitoring program includes groundwater monitoring at 10 active research facilities (e.g., accelerator beam stop and target areas) and support facilities (e.g., fuel storage and waste management facilities). During 2009, groundwater samples were collected from 108 wells during 183 individual sampling events. Nine temporary wells were also installed as part of this program. Detailed descriptions and maps

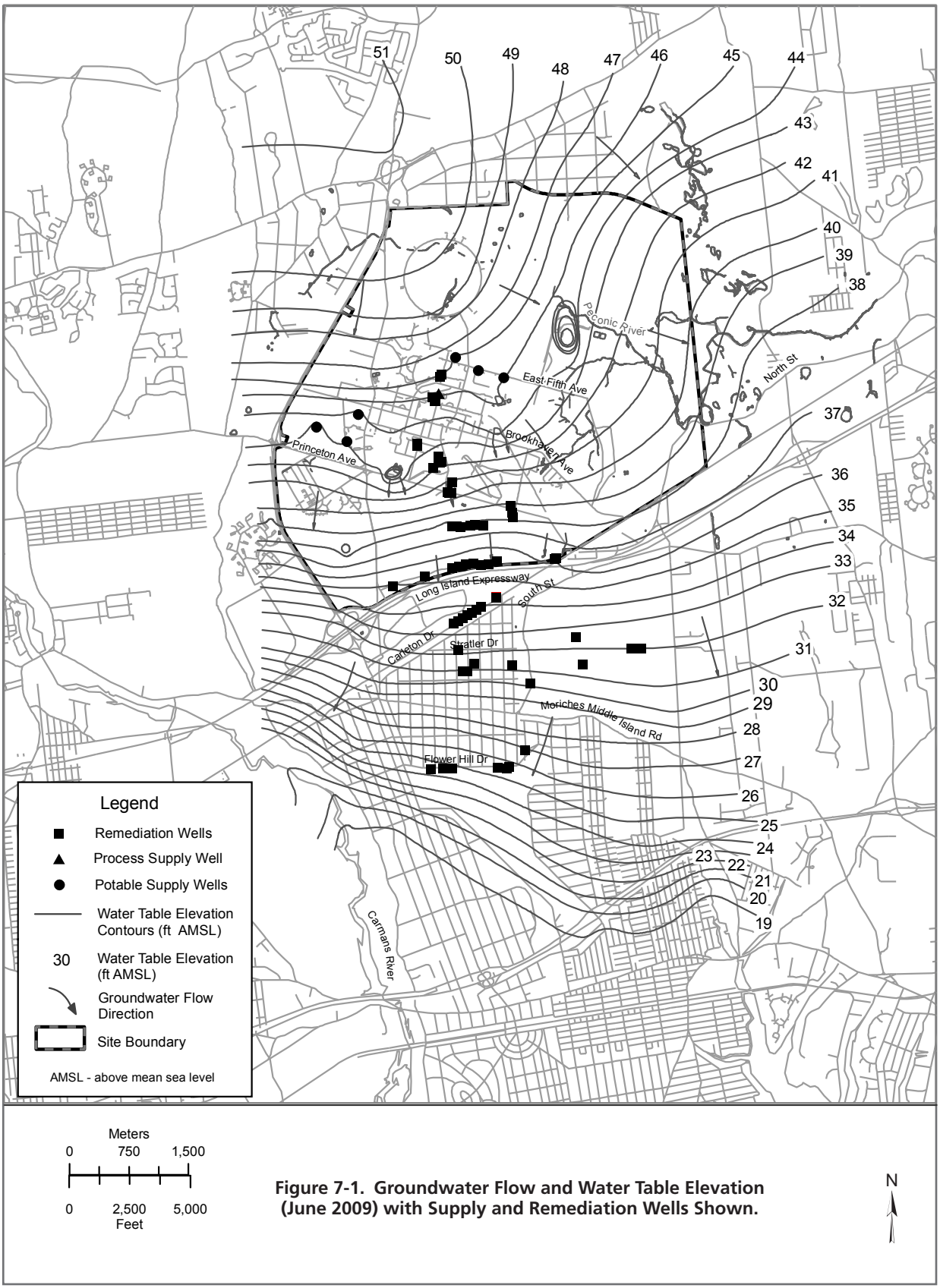

Figure 7-1. Groundwater Flow and Water Table Elevation (June 2009) with Supply and Remediation Wells Shown.

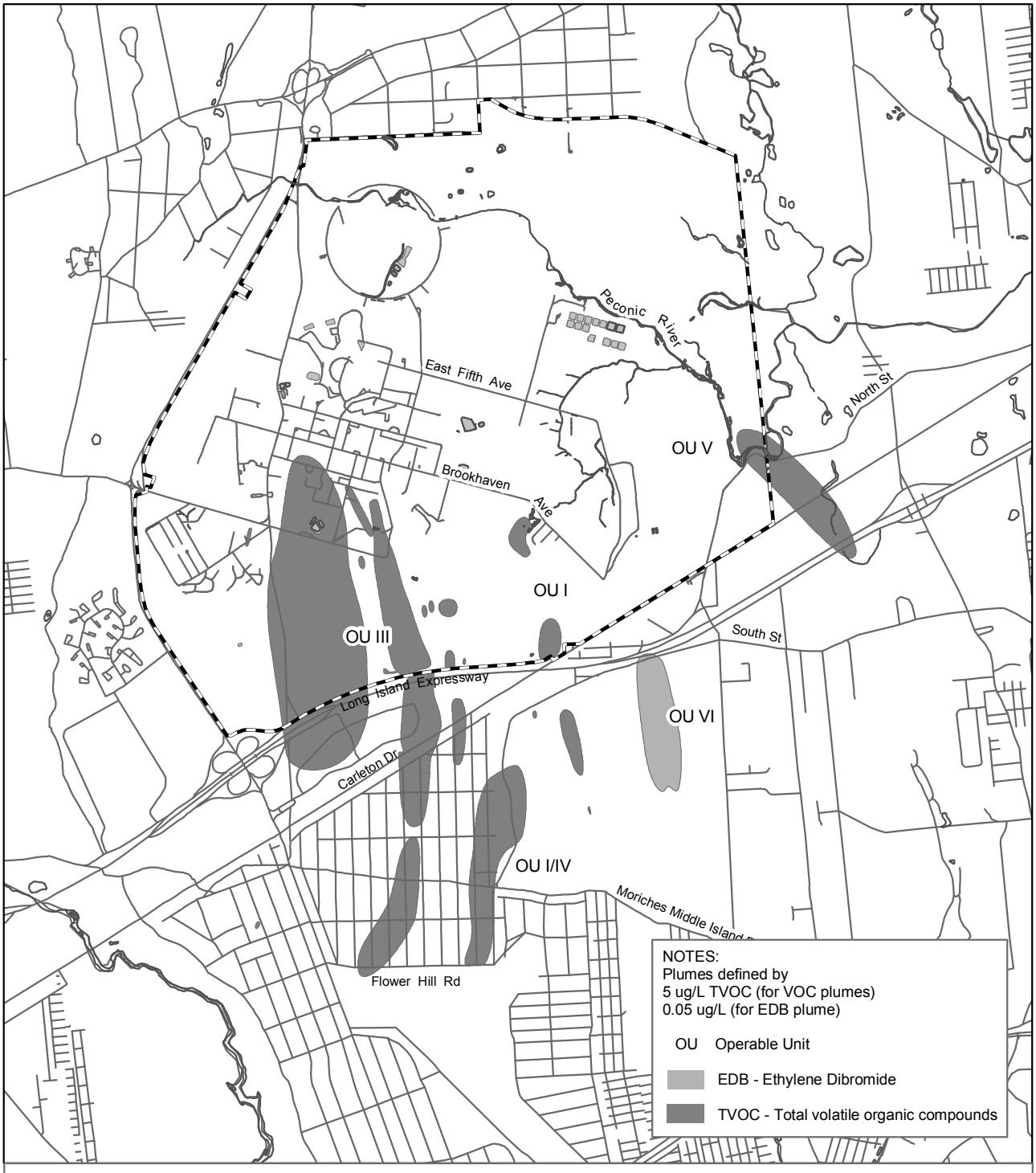

Figure 7-2. Extent of VOC Plumes.

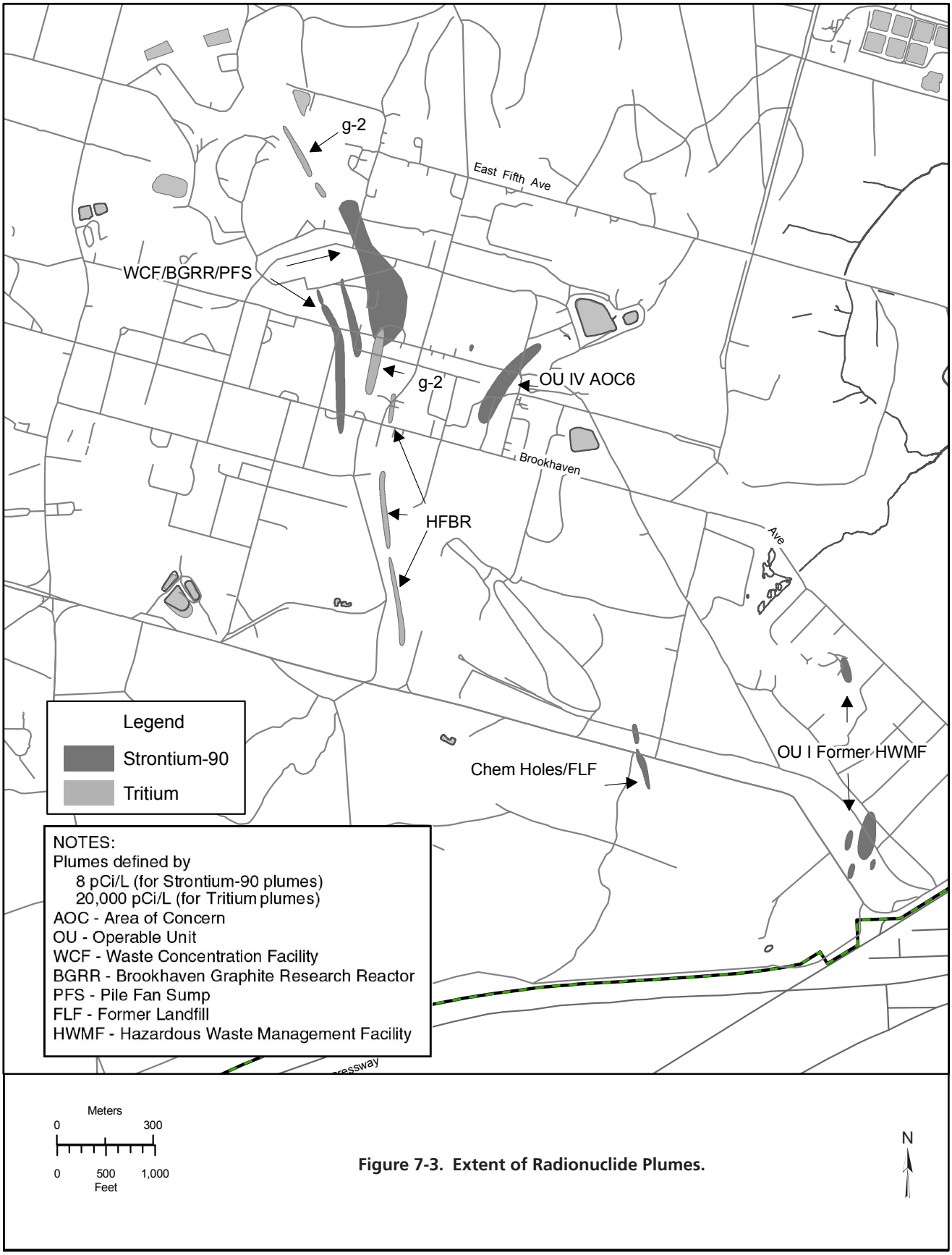

Figure 7-3. Extent of Radionuclide Plumes.

related to the FM groundwater monitoring program can be found in SER Volume II, Groundwater Status Report.

Although no new impacts to groundwater quality have been discovered since 2001, groundwater quality continues to be impacted at two BNL facilities: continued periodic high levels of tritium at the g-2 tritium source area and continued high levels of VOCs at the Upton service station. Highlights of the surveillance program are as follows:

- Tritium continues to be detected in the g-2 source area monitoring wells, at concentrations above the 20,000 pCi/L DWS. A short-term spike in tritium levels was observed in October 2009, with a tritium concentration of 138,000 pCi/L. Although the engineered stormwater controls are effectively protecting the activated soil shielding at the source area, monitoring data indicate that the continued release of tritium appears to be related to the flushing of residual tritium from the deep vadose zone following significant natural periodic fluctuations in the local water table.
- Monitoring of the downgradient areas of the g-2 tritium plume was accomplished using a combination of permanent and temporary wells. The highest tritium concentration in the downgradient segment of the plume was 92,200 pCi/L, observed approximately 400 feet south of the HFBR, along Temple Place road. The southern extent of the plume was tracked to the north side of the National Synchrotron Light Source (NSLS), where a maximum tritium concentration of 78,600 pCi/L was detected. As a result of natural radioactive decay and dispersion in the aquifer, the tritium plume is breaking up into discrete segments.
- Since April 2006, all tritium concentrations in the Brookhaven Linear Isotope Producer (BLIP) facility surveillance wells have been less than the 20,000 pCi/L DWS. The maximum tritium concentration during 2009 was 4,240 pCi/L. These results indicate that the engineered stormwater controls are effectively protecting the activated soil shielding, and that the amount of residual tritium in the deep vadose zone is diminishing.
- At the Upton Service Station, VOCs associated with petroleum products and the solvent PCE continue to be detected in the groundwater directly downgradient of the facility. Total VOC concentrations in one well reached a maximum of 617 µg/L; with the contamination consisting mostly of xylenes, ethylbenzene, and trimethylbenzenes. Groundwater monitoring results indicate that the petroleum-related compounds break down within a short distance from the facility. Monitoring of the leak detection systems at the Upton Service Station indicates that the gasoline storage tanks and associated distribution lines are not leaking, and all waste oils and used solvents are being properly stored and recycled. Therefore, it is believed that the contaminants detected in groundwater originate from historical vehicle maintenance activities and are not related to current operations.

7.5 CERCLA MONITORING PROGRAM

The CERCLA groundwater monitoring program is used to track the progress that groundwater treatment systems are making toward plume remediation (see Section 7.6, below). During 2009, the CERCLA program monitored 698 monitoring wells during 1,617 individual groundwater sampling events. Seventy temporary wells were also installed as part of this program. Detailed descriptions and maps related to the CERCLA groundwater monitoring program can be found in SER Volume II, Groundwater Status Report.

Maps showing the main VOC and radionuclide plumes are provided as Figures 7-2 and 7-3, respectively. Highlights of the program include:

- The HFBR Pump and Recharge system was operational during all of 2009. Monitoring data indicate that the elevated zone of tritium is approaching extraction well EW-16. The system is expected to remain operational for several more years until this elevated concentration zone has been completely captured and tritium concentrations

in the area decrease below the 20,000 pCi/L DWS. Tritium concentrations immediately downgradient of the HFBR remained below the DWS during all of 2009. This indicates that the inventory of tritium remaining in the deep vadose zone beneath the HFBR is diminishing.

- Plans were developed to excavate a small area of VOC contaminated soils south of the former Building 96 and to dispose of the soils off site. The removal of this source area is expected to significantly reduce PCE levels in the groundwater within three to five years, and allow for the groundwater treatment system to be turned off. A temporary plastic cover was placed over the contaminated soils source area until excavation is undertaken. An Explanation of Significant Differences (ESD) documenting the source area excavation was signed by the regulatory agencies in September 2009.
- The BGRR/Waste Concentration Facility Sr-90 Treatment System will be modified in 2010 to incorporate four additional extraction wells to remediate an area of Sr-90 contaminated groundwater near the HFBR. Furthermore, groundwater monitoring and characterization over the five years that this system has been in operation indicates that source area Sr-90 concentrations in the vicinity of both the WCF and the Building 701 areas have not shown marked decreases. This may be due to a continuing source of Sr-90 in these areas. Sr-90 from both of these source areas is presently being captured and treated by source area extraction wells, thereby preventing any plume growth.
- There have been significant improvements to the OU I South Boundary VOC plume over the past 14 years. However, based on the slower than expected migration rate of a small area of elevated VOCs located in a low permeability unit approximately 500 feet north of the south boundary, it does not appear that the Record of Decision (ROD) cleanup goals will be met if the extraction wells are shutdown in 2011, as originally planned. BNL will evaluate extending the operational duration of the existing extraction wells to ensure that the cleanup goal is attained. Furthermore, groundwater modeling using data from temporary wells installed during 2009 indicates that the Sr-90 concentrations within the OU I Sr-90 plume will drop below DWS before the plume reaches the site boundary, which is estimated to be in approximately 12 years.
- Temporary well characterization of the Building 650 and Sump Outfall Sr-90 plume in 2009 showed the area of highest concentrations approximately 500 feet north of Brookhaven Avenue. The new data will be used to update the groundwater model and determine when the plume is expected to attenuate to below DWS.
- As in 2008, elevated concentrations of dichlorodifluoromethane (Freon-12) continued to be detected in several OU III Western South Boundary area wells. Additional characterization will be conducted during 2010 to determine the extent of this contamination.

7.6 GROUNDWATER TREATMENT SYSTEMS

The primary mission of the CERCLA program is to operate and maintain groundwater treatment systems and prevent additional groundwater contamination from migrating off site. The cleanup objectives will be met by a combination of active treatment and natural attenuation. The specific cleanup goals are as follows:

- Achieve maximum contaminant levels (MCLs) for VOCs in the Upper Glacial aquifer by 2030
- Achieve MCLs for VOCs in the Magothy aquifer by 2065
- Achieve MCLs for Sr-90 at the BGRR in the Upper Glacial aquifer by 2070
- Achieve MCLs for Sr-90 at the Chemical Holes in the Upper Glacial aquifer by 2040

During 2009, BNL continued to make significant progress in restoring groundwater quality. Figure 7-4 shows the locations of 14 groundwater treatment systems currently in operation. Table 7-2 provides a summary of the amount of VOCs and Sr-90 removed from the

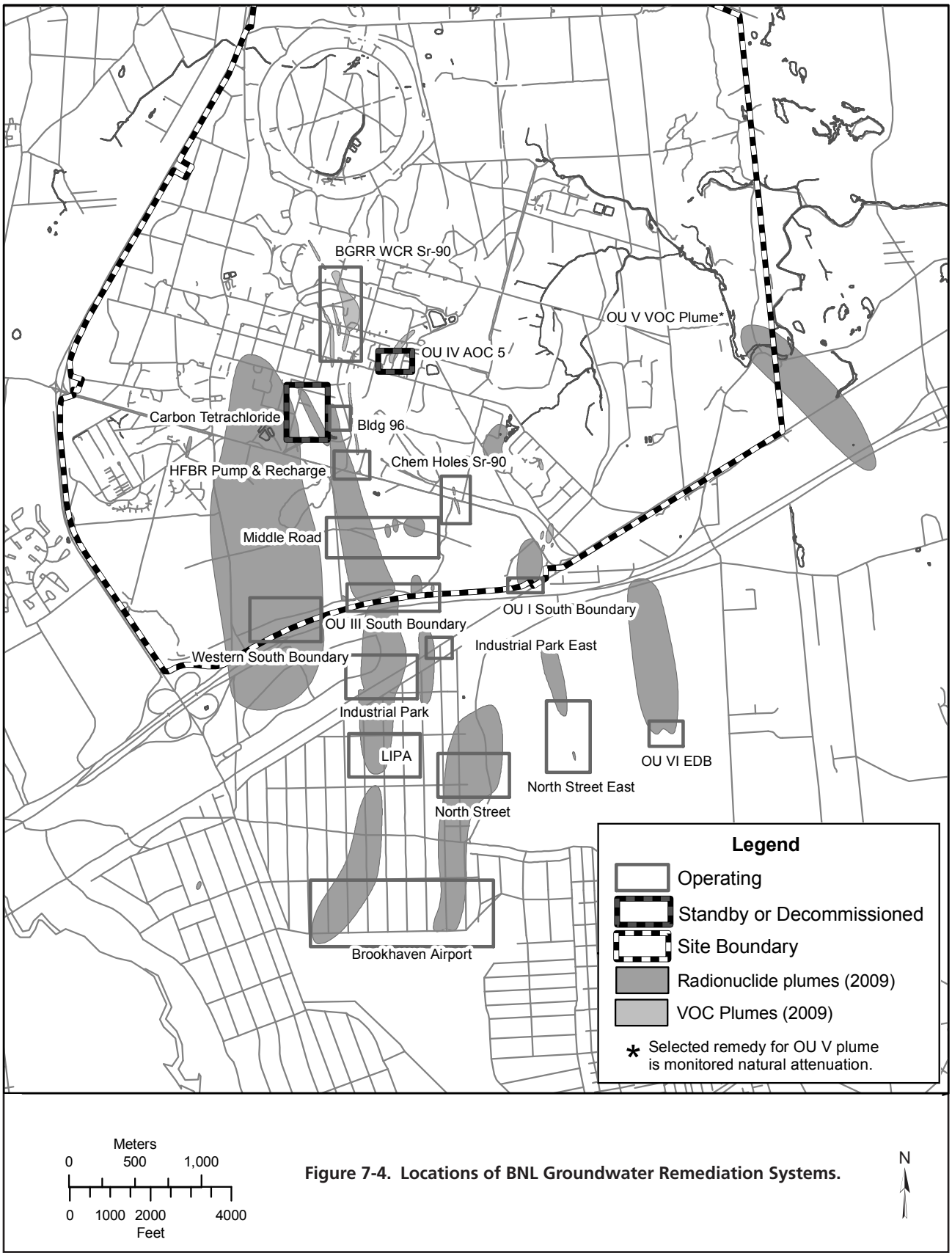

Figure 7-4. Locations of BNL Groundwater Remediation Systems.

Table 7-2. BNL Groundwater Remediation Systems Treatment Summary for 1997 through 2009.

		1997-2008		2009	
Remediation System	**Start Date**	**Water Treated** (Gallons)	**VOCs Removed** (Pounds) (e)	**Water Treated** (Gallons)	**VOCs Removed** (Pounds) (e)
OU I South Boundary	12/1996	3,442,314,000	347	172,000,000	6
OU III HFBR Tritium Plume (a)	05/1997	334,987,000	180	103,000,000	0
OU III Carbon Tetrachloride (d)	10/1999	153,538,075	349	Decommissioned	0
OU III Building 96	01/2001	172,297,416	98	50,000,000	9
OU III Middle Road	10/2001	1,417,411,550	799	177,500,000	63
OU III South Boundary	06/1997	3,319,952,850	2,630	201,000,000	85
OU III Western South Boundary	09/2002	667,647,000	54	115,300,000	12
OU III Industrial Park	09/1999	1,492,478,330	1,033	148,000,000	12
OU III Industrial Park East	06/2004	320,172,000	35	37,000,000	3
OU III North Street	06/2004	869,122,000	290	135,000,000	10
OU III North Street East	06/2004	492,976,000	24	74,000,000	6
OU III LIPA/Airport	08/2004	1,072,887,000	260	266,000,000	23
OU IV AS/SVE (b)	11/1997	(c)	35	Decommissioned	0
OU VI EDB	10/2004	624,711,000	(f)	164,000,000	(f)
Total		**14,380,485,221**	**6,134**	**1,642,800,000**	**229**

		2003–2008		2009	
Remediation System	**Start Date**	**Water Treated** (Gallons)	**Sr-90 Removed** (mCi)	**Water Treated** (Gallons)	**Sr-90 Removed** (mCi)
OU III Chemical Holes Sr-90	02/2003	18,404,826	3.33	6,200,000	0.46
OU III BGRR/WCF Sr-90	06/2005	30,951,000	16.1	8,500,000	1.4
Total		**49,355,826**	**19.43**	**14,700,000**	**1.86**

Notes:
(a) System was reactivated in late 2007 as a contingency action.
(b) System was shut down on January 10, 2001 and decommissioned in 2003.
(c) Air Sparging/Soil Vapor Extraction (AS/SVE) system performance was measured by pounds of VOCs removed per cubic feet ofair treated.
(d) System was shut down and placed in standby mode in August 2004 and decommissioned in 2009.
(e) Values are rounded to the nearest whole number.
(f) Because EDB has only been detected at trace levels in the treatment system influent, no removal of VOCs is reported.

BGRR = Brookhaven Graphite Research Reactor
EDB = ethylene dibromide
HFBR = High Flux Beam Reactor
LIPA = Long Island Power Authority
OU = Operable Unit
VOCs = volitile organic compounds
WCF = Waste Concentration Facility

aquifer since the start of active remediation in December 1996. During 2009, 229 pounds of VOCs and approximately 1.9 mCi of Sr-90 were removed from the groundwater, and more than 1.6 billion gallons of treated groundwater were returned to the aquifer. To date, 6,363 pounds of VOCs have been removed from the aquifer, and noticeable improvements in groundwater quality are evident in the OU I South Boundary, OU III South Boundary, OU III Industrial Park, OU III Industrial Park East, OU III North Street, OU IV, Building 96, and Carbon Tetrachloride areas. Also to date, two of the treatment systems have removed approximately 21 mCi of Sr-90.

Detailed information on the groundwater treatment systems can be found in SER Volume II, Groundwater Status Report.

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