7 Groundwater Protection

Brookhaven National 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. During 2012, BNL collected groundwater samples from 796 permanent monitoring wells and 44 temporary wells during 1,791 individual sampling events. Twelve groundwater remediation systems removed 239 pounds of volatile organic compounds (VOCs) and returned approximately 1.5 billion gallons of treated water to the Upper Glacial aquifer. Since the beginning of active groundwater remediation in December 1996, the treatment systems have removed 6,948 pounds of VOCs by treating nearly 21 billion gallons of groundwater. During 2012, two groundwater treatment systems removed approximately 1.9 millicuries of strontium-90 (Sr-90) while remediating approximately 15 million gallons of groundwater. Since 2003, BNL has removed approximately 27 millicuries of Sr-90 from the groundwater while remediating 104 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 various New York State operating permits, DOE Order 458.1, Radiation Protection of the Public and Environment, and DOE Order 436.1, Departmental Sustainability. This program also satisfies the requirements of several Comprehensive Environmental Response, Compensation and Liability (CERCLA) Records of Decision (RODs). 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, 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. 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, designed to satisfy DOE and New York State monitoring requirements for active research and support facilities, and 2) 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. 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, 32 separate Areas of Concern (AOC) were grouped into six Operable Units (OUs). Remedial actions have been implemented for each OU, and the focus is currently on operating and maintaining cleanup systems. Contaminant sources (e.g., contaminated soil and underground storage tanks) have been 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, The Laboratory has developed a Groundwater Protection Contingency Plan (BNL 2008) that provides formal processes to promptly communicate off-normal or unusual monitoring results to BNL 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 over the past 15 years and continues to make progress in achieving its goal of preventing new groundwater impacts and to remediate previously contaminated groundwater. No new impacts to groundwater quality were discovered during 2012. The Laboratory will continue efforts to prevent new groundwater impacts and is vigilant in measuring and communicating its performance.

7.3 GROUNDWATER MONITORING PROGRAMS

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 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 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 775 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 BNL facilities have groundwater monitoring programs: the Sewage Treatment Plant (STP), Waste Management Facility (WMF), Major Petroleum Facility (MPF), Alternating Gradient Synchrotron (AGS), Relativistic Heavy Ion Collider (RHIC), National Synchrotron Light Source II (NSLS-II), 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 the Brookhaven Medical Research Reactor (BMRR). Maps showing the main VOC and radionuclide plumes are provided as Figures 7-2 and 7-3, respectively.

7.4 GROUNDWATER MONITORING RESULTS

During 2012, the Facility Monitoring program monitored 134 wells during 230 individual sampling events. Forty-four temporary wells were also installed as part of this program. No new impacts to groundwater quality were discovered during the year. The CERCLA groundwater monitoring program monitored 662 monitoring wells during 1,561 individual groundwater sampling events. Thirty-three temporary wells were also installed as part of this program. Detailed descriptions and maps related to the groundwater monitoring programs can be found in SER Volume II, Groundwater Status Report.

Highlights of the groundwater monitoring programs for 2012 include:

- Groundwater monitoring results for 2012 indicate that there has been significant progress in remediating groundwater contamination in a number of on- and off-site areas. As noted in Section 7.5, BNL will submit Petitions for Shutdown to the regulatory agencies for four groundwater treatment systems and a Petition for Closure (decommissioning) for one system.
- Proposed remedial actions were documented in an Explanation of Significant Differences under the OU III ROD (BNL 2012) for the Building 452 Freon-11 plume discovered in 2011. During 2012, approximately 71 pounds of Freon-11 were removed from the aquifer, and significant reductions in Freon-11 concentrations were observed in the source area and downgradient portions of the plume. Compared to 2011, when Freon-11 concentrations up to 38,000 µg/L were detected in source area wells, concentrations decreased to less than 1,150 µg/L by November 2012. The detection of low levels of Freon-11 in Building 96 treatment well RTW-2 indicates that

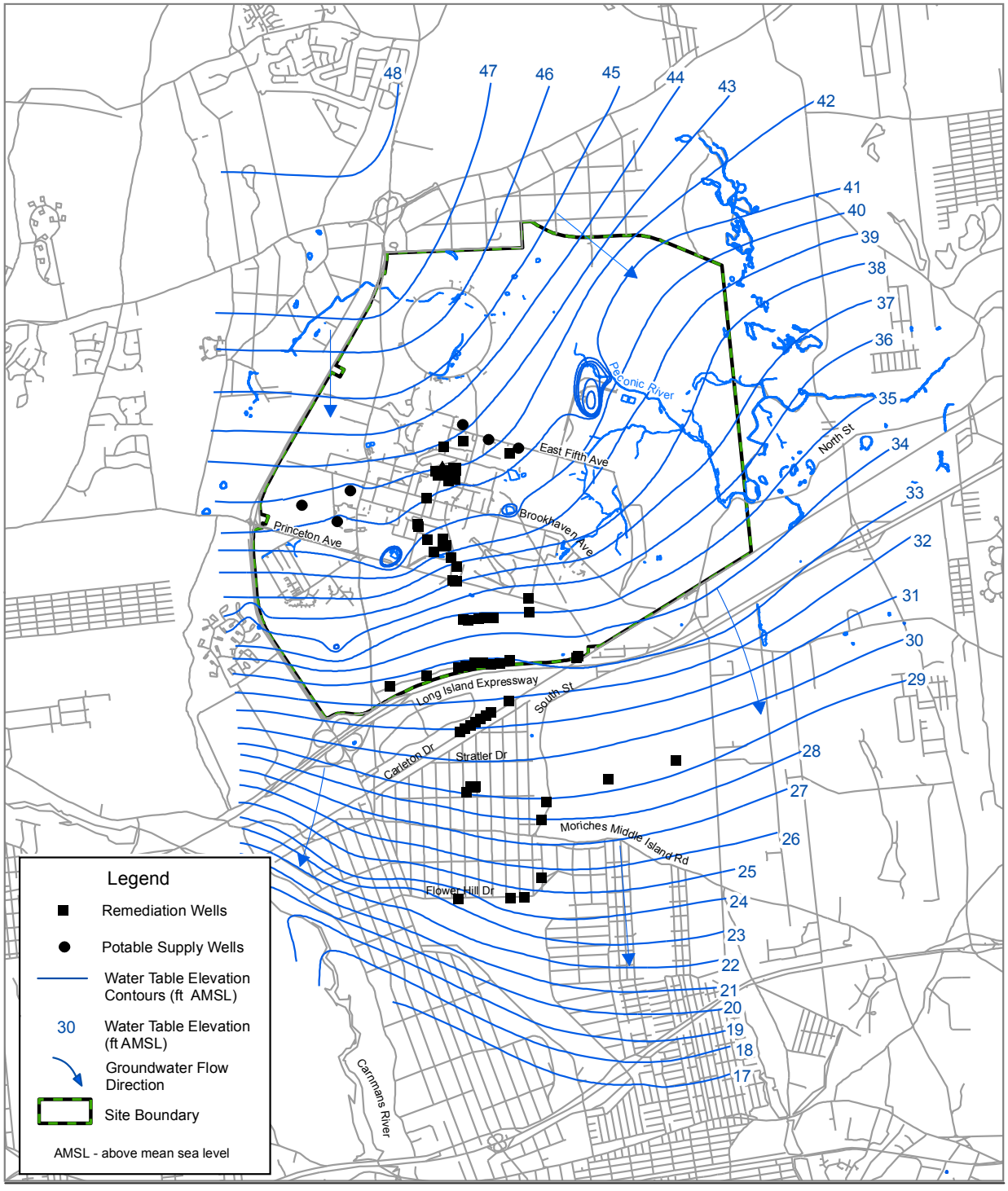

Figure 7-1. Groundwater Flow and Water Table Elevation with Supply and Remediation Wells Shown.

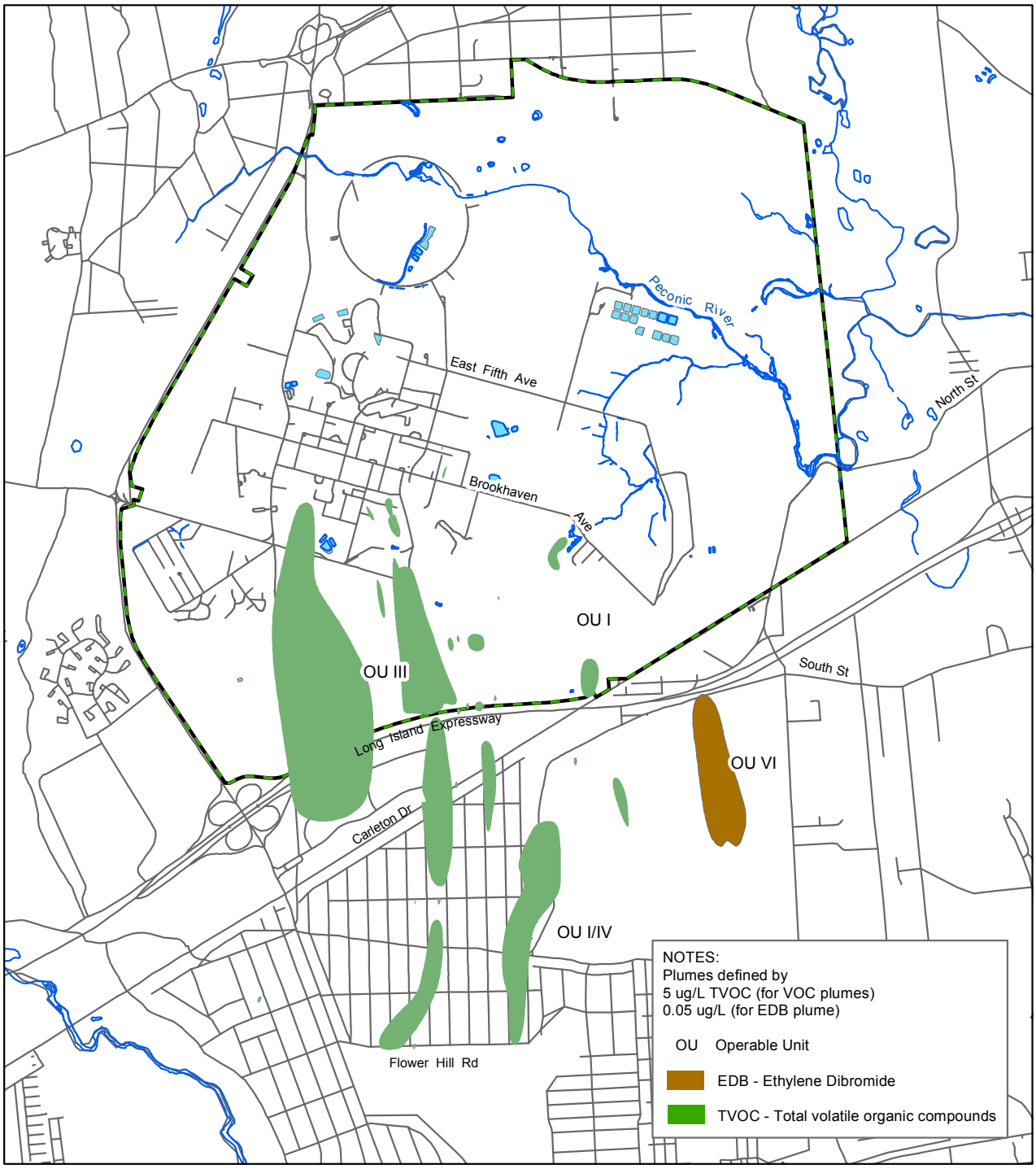

Figure 7-2. Extent of VOC Plumes.

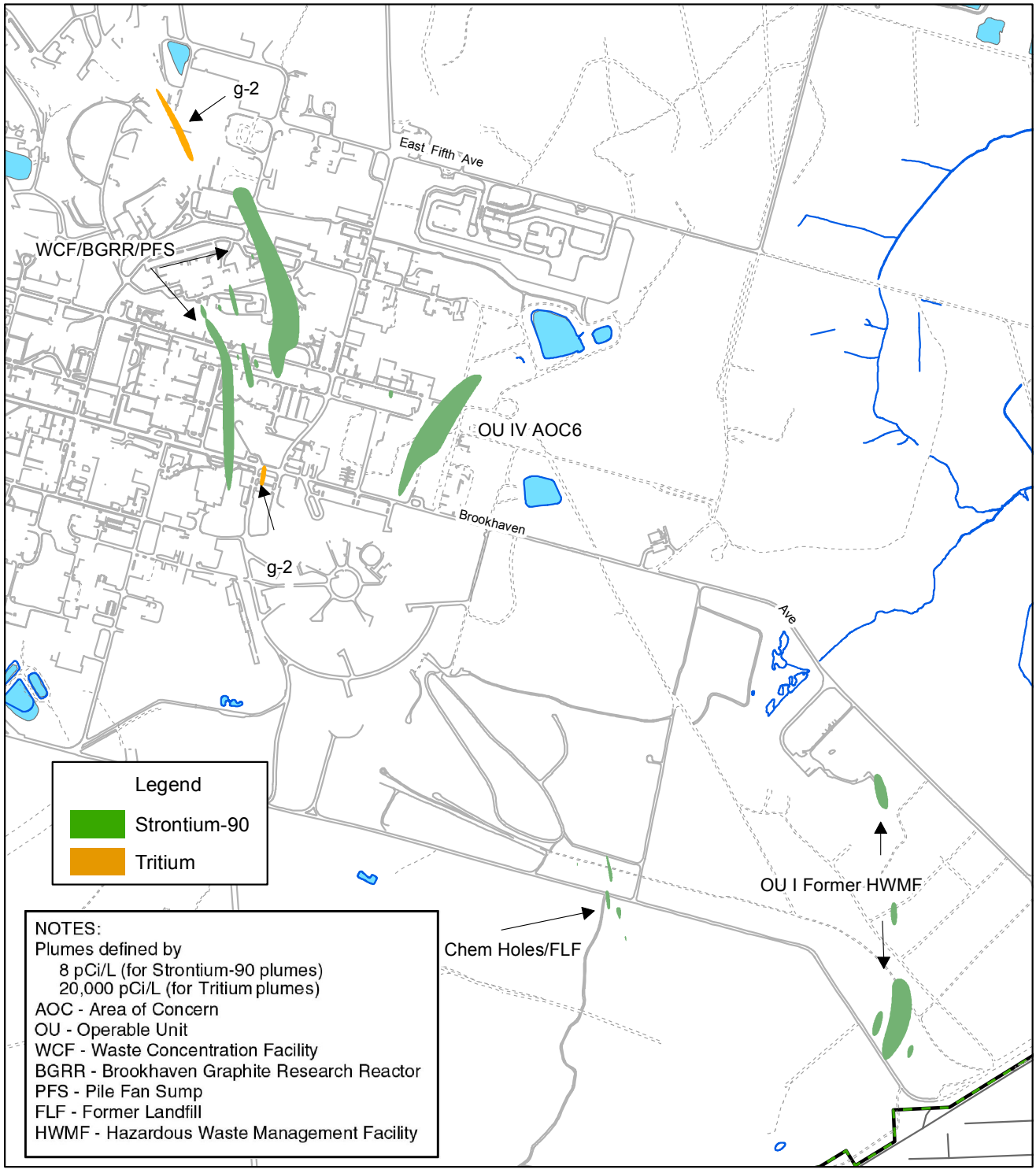

Figure 7-3. Extent of Radionuclide Plumes.

the southward migration of Freon-11 was greater than identified during the 2011 characterization of the plume.

- The OU III South Boundary Treatment System was modified in 2012 to include the addition of a new extraction well. The new extraction well has been effective in capturing and treating VOC contamination in the deep Upper Glacial aquifer at the site boundary. The extent to which these deeper VOCs have migrated off-site will be evaluated during 2013.
- Significant reductions in VOC concentrations have been observed in the Building 96 source area monitoring wells following the 2010 excavation of contaminated source area soils. In a monitoring well located immediately downgradient of the excavation, total VOC concentrations decreased from a maximum of 2,435 µg/L in early 2011, to 161 µg/L in late 2012.
- Although all VOC concentrations in the OU V monitoring wells were below the DWS from 2008 through 2010, trichloroethylene (TCE) was detected at slightly above the 5 µg/L standard in a single off-site monitoring well (000-122) during 2011 and 2012. A petition to conclude the OU V monitoring program was approved by the regulatory agencies in 2012, and it was proposed to continue monitoring this single well on an annual basis (BNL 2012b).
- Following the 2010 detection of Sr-90 concentrations up to 491 pCi/L in the groundwater immediately downgradient of the BGRR, Sr-90 levels were significantly lower during 2011 and 2012, with concentrations dropping to less than 10 pCi/L by December 2012. Continued monitoring is required to determine the long-term effectiveness of the engineered cap installed in 2011. The cap is designed to prevent rainwater infiltration into the contaminated soils below the BGRR.
- Tritium concentrations in the groundwater immediately downgradient of the HFBR remained below the 20,000 pCi/L DWS during 2012.
- The HFBR Pump and Recharge system was operational during all of 2012. Monitoring data for 2010 through 2012 indicate that tritium concentrations in the downgradient segment of the plume have remained below the 20,000 pCi/L DWS. A petition for shutdown of the pump and recharge system will be prepared in early 2013.
- Tritium continues to be detected in the g-2 source area monitoring wells at concentrations above the 20,000 pCi/L DWS, with a maximum concentration of 88,200 pCi/L in January 2012. By October 2012, the maximum tritium concentration was 37,700 pCi/L. The overall reduction in tritium concentrations observed over the past 10 years indicates that the engineered stormwater controls are effectively protecting the activated soil shielding at the source area.
- As a result of natural radioactive decay and dispersion in the aquifer, the downgradient portion of the g-2 tritium plume has been reduced to several hundred feet in length, and is presently located entirely south of the NSLS facility. During 2012, the highest observed tritium concentration was 50,000 pCi/L in a temporary well installed immediately south of Brookhaven Avenue. Because the plume segment has migrated south of Brookhaven Avenue, a ROD contingency action was triggered in late 2011. In response, a plan was developed to monitor this plume segment on a more frequent basis (DOE 2012). Tritium concentrations in the small plume segment are expected to naturally attenuate to less than the 20,000 pCi/L DWS within several years.
- 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 2012 was 4,360 pCi/L. These results indicate that the engineered stormwater controls are effectively protecting the activated soil shielding.
- At the on-site Upton Service Station, VOCs associated with petroleum products and the solvent tetrachloroethylene (PCE) continue to be detected in the groundwater directly downgradient of the facility. Total

VOC concentrations in one well reached 269 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 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 2012, 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 7-1 provides a summary of the amount of VOCs and Sr-90 removed from the aquifer since the start of active remediation in December 1996. During 2012, approximately 239 pounds of VOCs and approximately 1.9 mCi of Sr-90 were removed from the groundwater, and approximately 1.5 billion gallons of treated groundwater were returned to the aquifer.

To date, 6,948 pounds of VOCs have been removed from the aquifer and noticeable improvements in groundwater quality are evident in a number of on- and off-site areas. Furthermore, two of the treatment systems have removed approximately 27 mCi of Sr-90. Based on progress that has been made to remediate groundwater contamination, in early 2013, Petitions for Shutdown will be submitted to the regulatory agencies for the OU I South Boundary System, Industrial Park System, North Street System, and the HFBR Pump and Recharge System. In addition, a Petition for Closure will be submitted for the Industrial Park East System. Detailed information on the groundwater treatment systems can be found in SER Volume II, Groundwater Status Report.

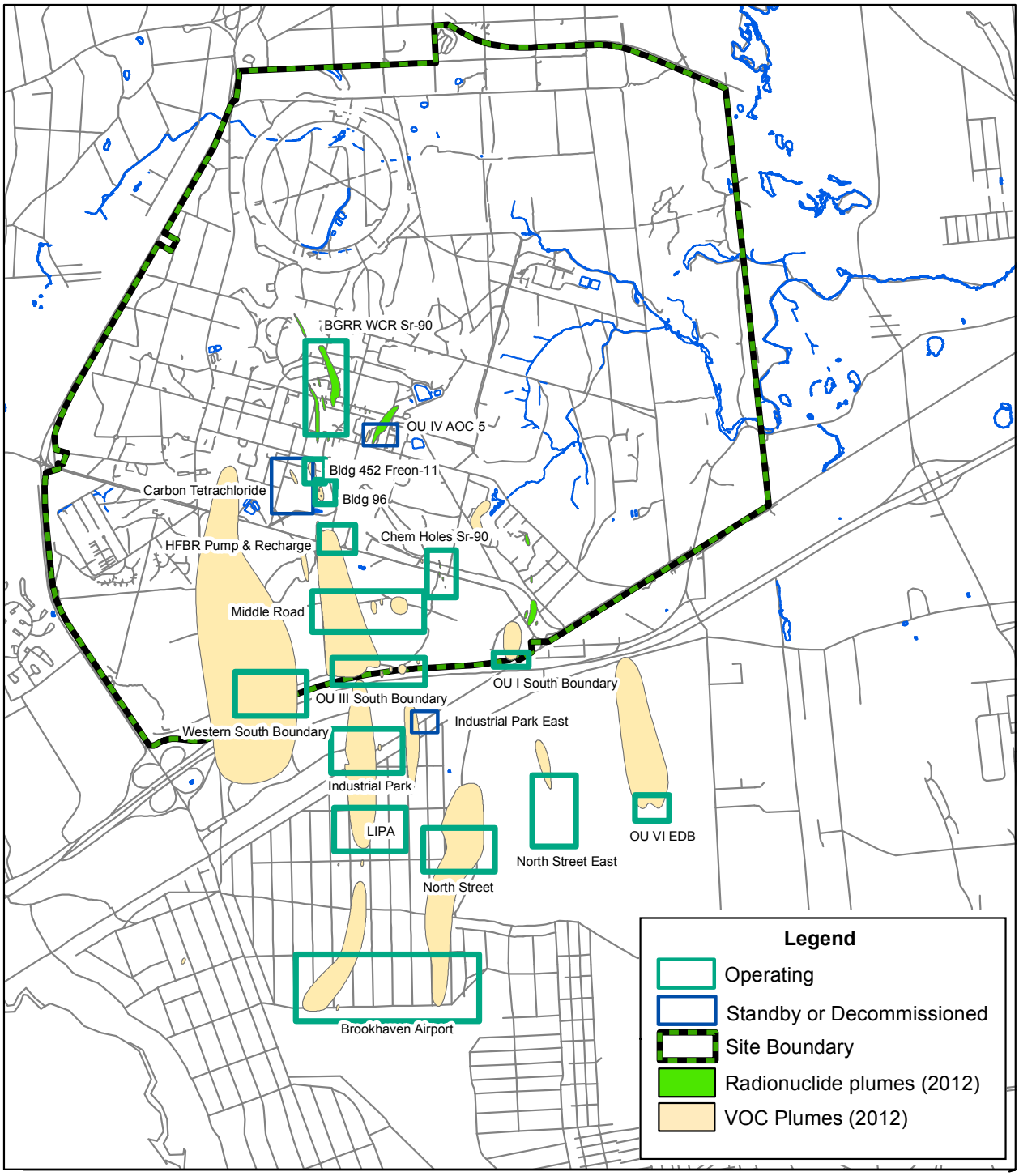

Figure 7-4. Locations of BNL Groundwater Remediation Systems.

Table 7-1. BNL Groundwater Remediation Systems Treatment Summary for 1997 through 2012.

Remediation System	Start Date	1997-2011		2012	
		Water Treated (Gallons)	VOCs Removed (Pounds) (e)	Water Treated (Gallons)	VOCs Removed (Pounds) (e)
OU I South Boundary	12/1996	3,853,732,000	363	112,201,000	5
OU III HFBR Tritium Plume (a)	05/1997	537,129,000	180	74,311,000	0
OU III Carbon Tetrachloride (d)	10/1999	153,538,075	349	Decommissioned	0
OU III Building 96	01/2001	248,822,416	108	44,292,000	9
OU III Middle Road	10/2001	1,859,388,550	971	243,376,000	55
OU III South Boundary	06/1997	3,690,854,850	2,834	223,969,000	66
OU III Western South Boundary	09/2002	911,116,000	92	125,245,000	12
OU III Industrial Park	09/1999	1,740,962,330	1,057	112,011,000	2
OU III Industrial Park East	06/2004	357,192,000	38	0	0
OU III North Street	06/2004	1,179,193,000	321	122,441,000	5
OU III North Street East	06/2004	683,772,000	38	100,663,000	3
OU III LIPA/Airport	08/2004	1,621,542,000	323	211,336,000	11
OU III Building 452 Freon-11	03/2012	0	0	26,812,000	71
OU IV AS/SVE (b)	11/1997	(c)	35	Decommissioned	0
OU VI EDB	10/2004	960,709,000	(f)	129,133,000	(f)
Total		**19,295,173,221**	**6,709**	**1,525,790,000**	**239**

Remediation System	Start Date	2003–2011		2012	
		Water Treated (Gallons)	Sr-90 Removed (mCi)	Water Treated (Gallons)	Sr-90 Removed (mCi)
OU III Chemical Holes Sr-90	02/2003	38,162,826	4.4	6,673,000	0.18
OU III BGRR/WCF Sr-90	06/2005	51,563,000	21.2	8,019,000	1.7
Total		**89,725,826**	**25.6**	**14,692,000**	**1.88**

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 of air 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

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