7 Groundwater Protection

Brookhaven National Laboratory has implemented aggressive pollution prevention measures to protect groundwater resources, and an extensive groundwater monitoring well network is used to verify that prevention and restoration activities are effective. During 2015, BNL collected groundwater samples from 732 permanent monitoring wells and 76 temporary wells during 1,517 individual sampling events. Nine groundwater remediation systems removed 94 pounds of volatile organic compounds (VOCs) and returned approximately 1.2 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 7,370 pounds of VOCs by treating nearly 25 billion gallons of groundwater. Also during 2015, two groundwater treatment systems removed approximately 1 millicurie of strontium-90 (Sr-90) while remediating approximately 24 million gallons of groundwater. Since 2003, BNL has removed approximately 31 millicuries of Sr-90 from the groundwater while remediating 167 million gallons of groundwater. As a result of the successful operation of these treatment systems, significant reductions in contaminant concentrations have been observed in a number of on- and off-site areas.

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 monitoring and remediation requirements defined in Comprehensive Environmental Response, Compensation and Liability Act (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 chemi-cals 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 Stakeholder and Community Relations Office works with the Groundwater Protection Program to ensure that the Laboratory communicates groundwater protection issues and cleanup progress 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 2013) 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 20 years and continues to make progress in achieving its goal of preventing new impacts to groundwater quality and to remediate previously contaminated groundwater. No new impacts to groundwater quality were discovered during 2015. 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 even 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 730 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 725 of the 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, former Waste Concentration Facility (WCF) area, 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 2015, the Facility Monitoring program monitored 118 permanent wells during 189 individual sampling events. Seven 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 614 permanent wells during 1,328 individual groundwater sampling events. Sixty-nine 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 and remediation programs for 2015 include:

- Two new extraction wells installed in the Industrial Park went into operation in January 2015. These wells are capturing deeper VOCs in this area observed at the interface between the deep Upper Glacial and Magothy aquifers.
- Additional characterization of Sr-90 groundwater contamination in the former HWMF identified higher than expected levels of Sr-90, with concentrations up to 302 pCi/L. The plume was found to extend approximately 800 feet downgradient of the former facility.
- A soil vapor survey conducted to the west of the main PCE plume at Building 96 did not identify a separate source of PCE detected in several area monitoring wells.
- Following the reduction of Freon-11 concentrations to less than the 50 µg/L capture goal,

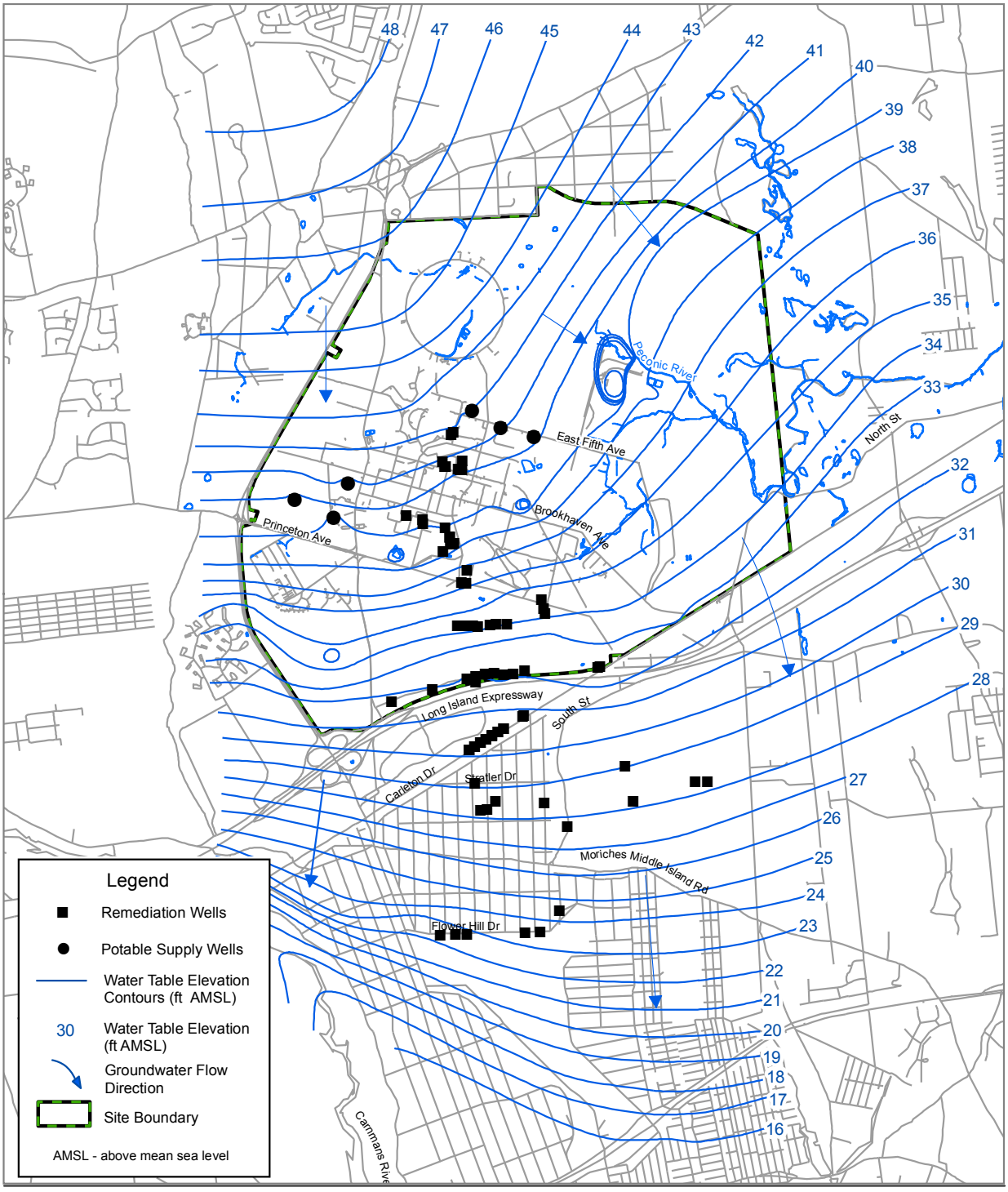

Figure 7-1. Groundwater Flow and Water Table Elevation (December 2015) with Supply and Remediation Wells Shown.

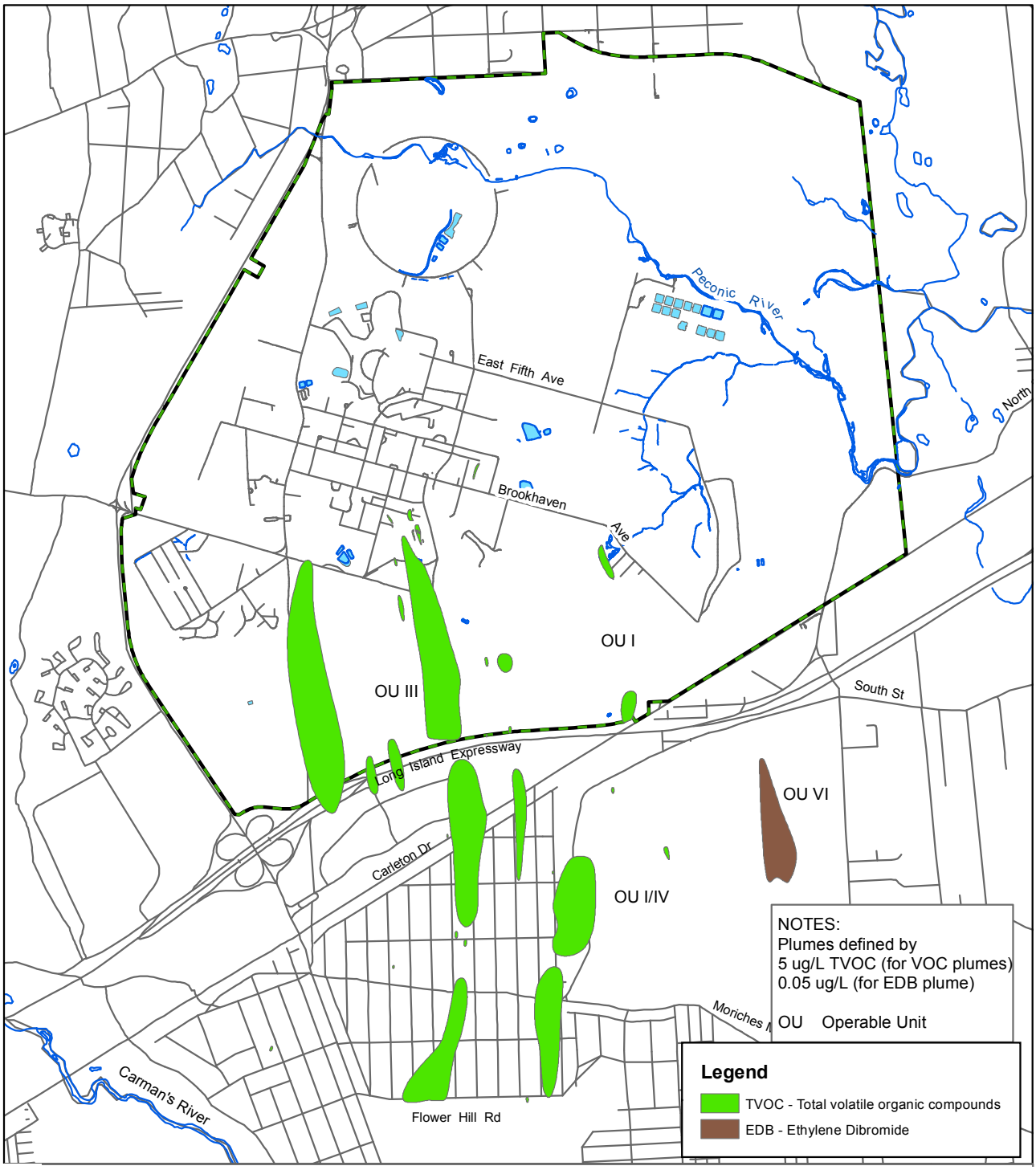

Figure 7-2. Extent of VOC Plumes.

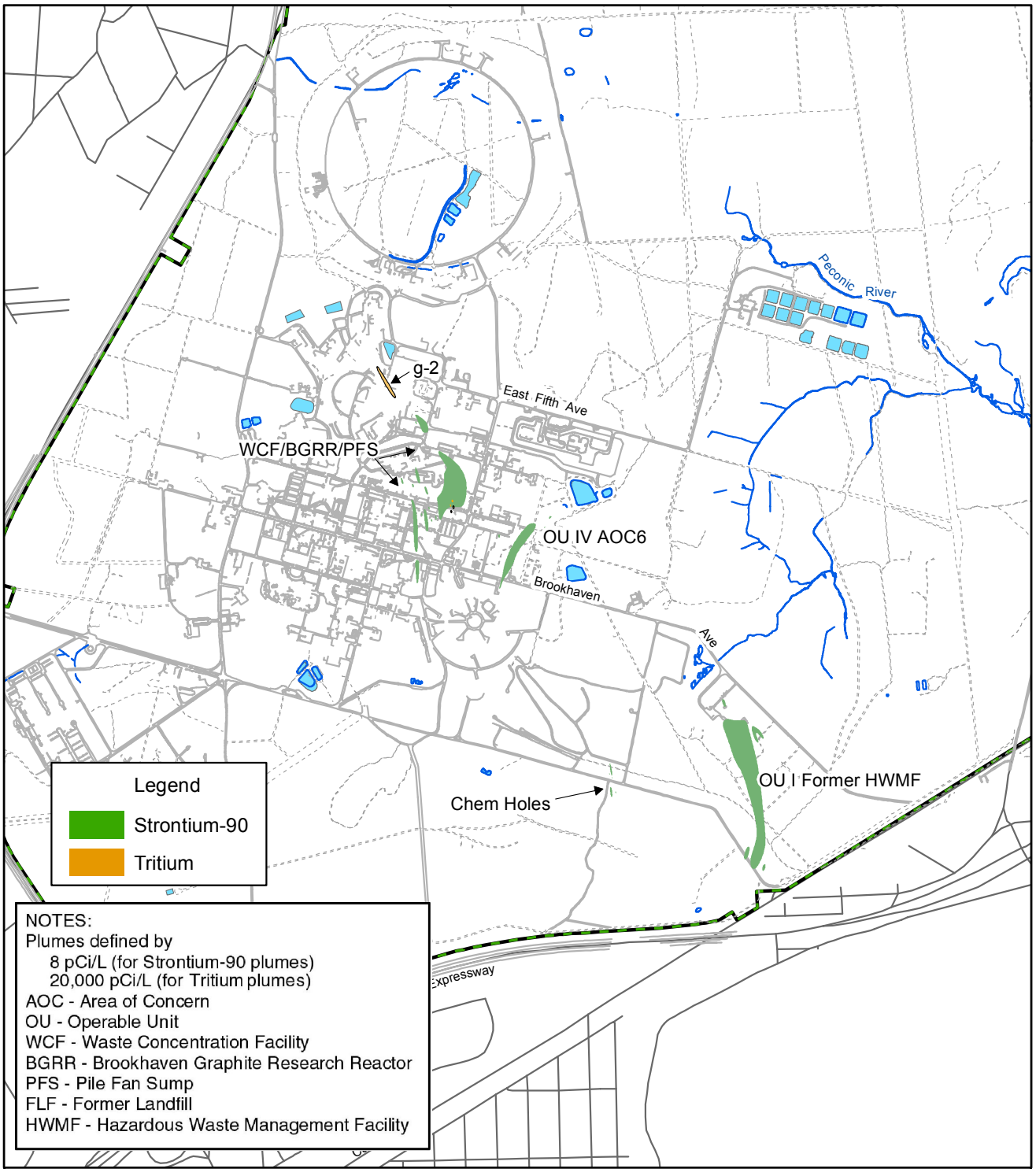

Figure 7-3. Extent of Radionuclide Plumes.

the Building 452 Freon-11 Treatment System was placed in standby mode in March 2016 following the regulatory approval of a petition for shutdown (BNL 2016).

- Two temporary wells were installed to address a data gap associated with tracking Freon-12 contamination in the Western South Boundary area. Although only trace amounts of Freon-12 were detected, DCE and TCA were detected at maximum concentrations of 96 µg/L and 79 µg/L, respectively, with total VOC concentrations in one of the wells reaching 182 µg/L. Additional characterization will be required to define the extent of this contamination, which is present at a greater depth than these constituents have previously been observed in this area.
- North Street Treatment System, which was placed in shut down mode in 2013, had extraction wells NS-1 placed back in operation during August 2015 due to rebounding VOC concentrations above the capture goal in nearby monitoring wells. Operation will continue until concentrations decrease to levels below the capture goal.
- Ethylene dibromide (EDB) was detected at up to 0.49 µg/L in a North Street East monitoring well. EDB has a standard of 0.05 µg/L. Although EDB had not been detected in the off-site NSE plume, there have been several historical detections (up to 1.5 µg/L) upgradient of this well on site.
- The anticipated rebound of Sr-90 concentrations in the BGRR/Building 701 source area monitoring wells was observed during 2013. The concentrations were both of a shorter duration and lower in value than seen in previous rebound scenarios. The rebound of Sr-90 concentrations was not observed during 2014 or 2015 in extraction well SR-3, which is located approximately 60 feet south of the source area monitoring wells.
- Although elevated Sr-90 concentrations (up to 96 pCi/L) were identified during 2015 in the former source area upgradient of the Chemical Holes extraction well EW-1, concentrations dropped off to less than the 8 pCi/L DWS by the end of the year. In addition, characterization of the unsaturated zone soils and groundwater at the water table in late 2015 confirmed the reduction of Sr-90 concentrations in this area.
- Although tritium continued to be detected in g-2 source area monitoring wells at concentrations above the 20,000 pCi/L DWS, tritium concentrations in the small plume segment that is located near the National Synchrotron Light Source II (NSLS-II) facility were found to have attenuated to less than the 20,000 pCi/L DWS.

7.5 GROUNDWATER TREATMENT SYSTEMS

The primary mission of the CERCLA program is to operate and maintain groundwater treatment systems to remediate contaminant plumes both on- and off-site. Modifications to groundwater remediation systems are implemented, as necessary, based upon a continuous evaluation of monitoring data and system performance. 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 2015, BNL continued to make significant progress in restoring groundwater quality. Figure 7-4 shows the locations of 11 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 2015, approximately 94 pounds of VOCs and 1 mCi of Sr-90 were removed from the groundwater, and nearly 1.2 billion gallons of treated groundwater were returned to the aquifer.

To date, 7,370 pounds of VOCs have been removed from the aquifer and noticeable

Table 7-1. BNL Groundwater Remediation Systems Treatment Summary for 1997 through 2015.

Remediation System	Start Date	1997-2014		2015	
		Water Treated (Gallons)	VOCs Removed (Pounds) (f)	Water Treated (Gallons)	VOCs Removed (Pounds) (f)
OU I South Boundary (a)	12/1996	4,177,473,000	369	0	0
OU III HFBR Tritium Plume (a)	05/1997	721,795,000	180	0	0
OU III South Boundary	06/1997	4,650,670,850	2,989	190,013,000	22
OU III Industrial Park	09/1999	2,044,912,330	1,064	140,289,000	3
OU III Carbon Tetrachloride (d)	10/1999	153,538,075	349	Decommissioned	0
OU III Building 96	01/2001	418,603,416	134	32,383,000	5
OU III Middle Road	10/2001	2,796,719,550	1,140	194,112,000	28
OU III Western South Boundary	09/2002	1,376,529,000	122	106,091,000	7
OU III Industrial Park East (e)	06/2004	357,192,000	38	Decommissioned	0
OU III North Street	06/2004	1,547,180,000	338	98,506,000	3
OU III North Street East	06/2004	1,008,558,000	44	1,240,000	0
OU III LIPA/Airport	08/2004	2,492,816,000	390	228,164,000	20
OU III Building 452 Freon-11	03/2012	95,796,000	96	15,957,000	6
OU IV AS/SVE (b)	11/1997	(c)	35	Decommissioned	0
OU VI EDB	10/2004	1,587,166,000	(g)	177,686,300	(g)
Total		**23,428,949,221**	**7,288**	**1,184,441,300**	**94**

Remediation System	Start Date	2003–2014		2015	
		Water Treated (Gallons)	Sr-90 Removed (mCi)	Water Treated (Gallons)	Sr-90 Removed (mCi)
OU III Chemical Holes Sr-90	02/2003	55,737,826	4.78	4,052,610	0.09
OU III BGRR/WCF Sr-90	06/2005	87,832,000	25.12	19,501,000	0.9
Total		**143,569,826**	**29.9**	**23,553,610**	**0.99**

Notes:
(a) System placed in standby mode in 2013.
(b) System 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 decommissioned in 2010.
(e) System decommissioned in 2014.
(f) Values are rounded to the nearest whole number.
(g) 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 = volatile organic compounds
WCF = Waste Concentration Facility

improvements in groundwater quality are evident in a number of on- and off-site areas. Furthermore, two of the treatment systems have removed approximately 31 mCi of Sr-90.

During 2015, the North Street East System, OU I South Boundary Treatment System, and the HFBR Tritium Pump and Recharge System remained in standby mode because they met their active remediation goals for reduction of contaminant concentrations. The Building 452 Freon-11 Groundwater Treatment System was placed in standby mode in March 2016. A

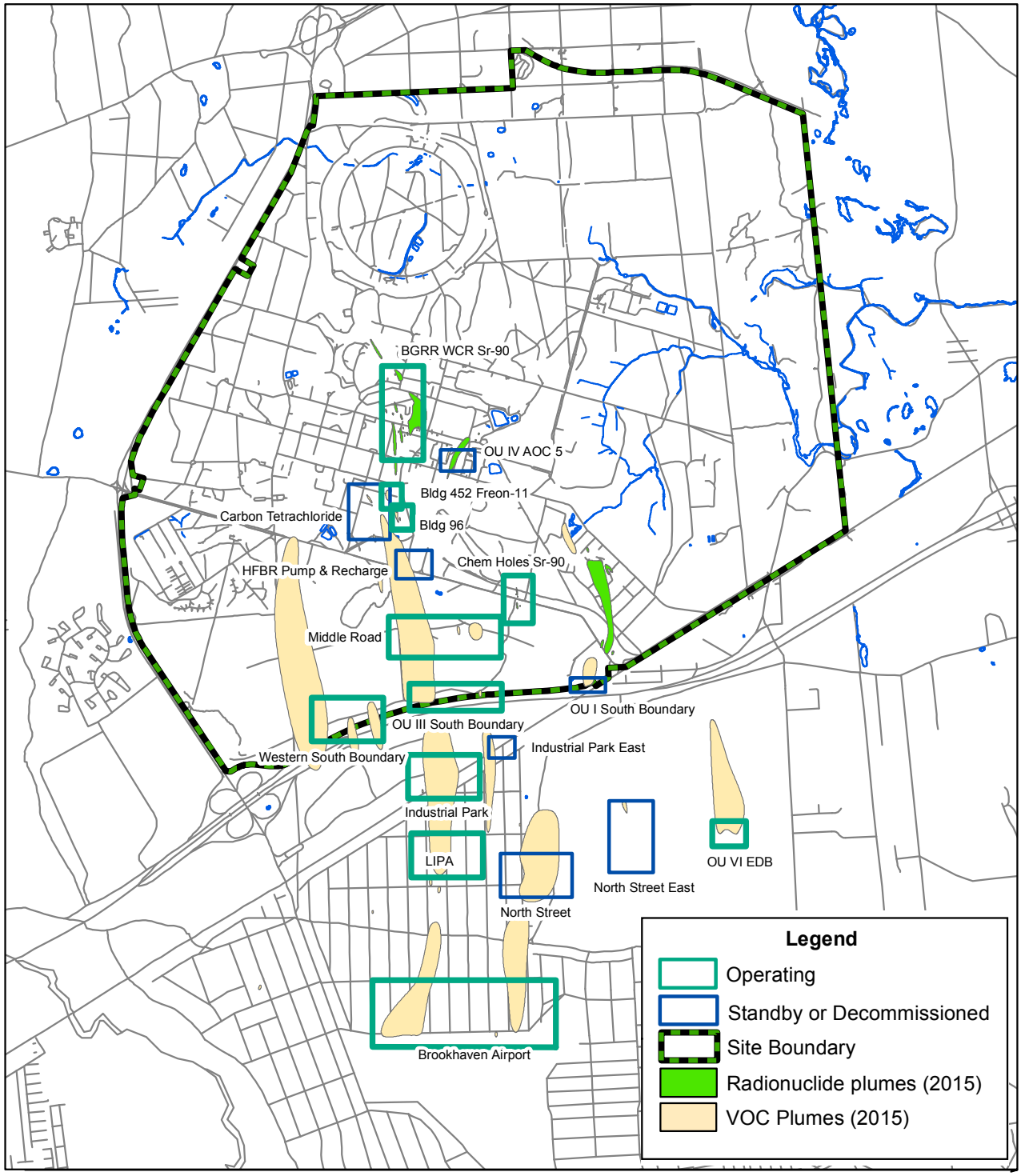

Figure 7-4. Locations of BNL Groundwater Remediation Systems.

period of standby monitoring for the plumes associated with these treatment systems will be performed to detect any rebound of contaminant concentrations. Detailed information on the groundwater contaminant plumes and treatment systems can be found in SER Volume II, Groundwater Status Report.

REFERENCES AND BIBLIOGRAPHY

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