7 Groundwater Protection

Brookhaven National Laboratory (BNL) implements aggressive pollution prevention measures to protect groundwater resources, and uses an extensive groundwater monitoring well network to verify that prevention and restoration activities are effective. During 2019, BNL collected groundwater samples from 625 permanent monitoring wells and 32 temporary wells during 1,704 individual sampling events. Seven groundwater remediation systems removed 61 pounds of volatile organic compounds (VOCs) and returned approximately 750 million gallons of treated water to the Upper Glacial aquifer. Since the beginning of active groundwater remediation in December 1996, the treatment systems have removed 7,650 pounds of VOCs by treating over 28 billion gallons of groundwater. Also, one groundwater treatment system removed approximately 0.8 millicurie of strontium-90 (Sr-90) while remediating approximately 14 million gallons of groundwater. Since 2003, BNL has removed approximately 33.6 millicuries of Sr-90 from the groundwater while remediating approximately 245 million gallons of groundwater. As a result of the successful operation of these treatment systems, significant reductions in contaminant concentrations have occurred in several 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; Department of Energy (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 remediating existing contaminated groundwater.

7.1.1 Prevention

As part of BNL's Environmental Management System, the Laboratory has implemented several 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 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 the Environmental Protection Agency (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. Several 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 2018) 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 30 years and continues to make progress in achieving its goal of preventing new impacts to groundwater quality and remediating previously contaminated groundwater. The Laboratory will continue efforts to prevent new groundwater impacts and is vigilant in measuring and communicating its performance. During 2017, several Per-and Poly-fluoroalkyl Substances (PFAS) were detected in water samples collected from three BNL water supply wells. In response to these detections, BNL conducted a search of available records to determine a source of PFAS

in 2018. As a result, BNL identified eight areas where firefighting foam had been used for firefighter training or fire suppression system maintenance from 1966 until 2008. Groundwater characterization confirmed the presence of PFAS in each of the eight areas, with the highest concentrations detected near BNL's former firehouse (in operation from 1947-1985) and near the current firehouse (1986-present). In both areas, the combined concentrations of perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) significantly exceeded the current U.S. EPA Health Advisory Level (HAL) of 70 ng/L. At the former firehouse area, the maximum combined PFOS and PFOA concentration was 5,371 ng/L, whereas the maximum combined concentrations at the current firehouse area was 12,440 ng/L. In addition to PFAS, BNL has been characterizing the extent of 1,4-dioxane, which was used as a chemical stabilizer for the solvent 1,1,1-trichloroethane (TCA). BNL has confirmed the presence of 1,4-dioxane in several on-site and off-site areas that have been impacted by TCA contamination.

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, comply with regulatory permit requirements, monitor active research and support facilities, and 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 for Class GA groundwater are used as goals for groundwater protection and remediation. BNL evaluates the potential impact of radiological and non-radiological contamination by comparing analytical results to the regulatory 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.

BNL maintains an extensive network of groundwater monitoring wells that are located on- and off-site. Water levels are routinely measured in about 170 of the wells to assess variations in the direction and velocity of groundwater flow. Groundwater flow directions near the Laboratory are shown in Figure 7-1. The Laboratory also routinely collects groundwater samples from approximately 625 of the wells to test for various contaminants that may be in the water (see SER Volume II, Groundwater Status Report, for details).

The following active BNL facilities have groundwater monitoring programs: Sewage Treatment Plant (STP), Waste Management Facility (WMF), Major Petroleum Facility (MPF), Alternating Gradient Synchrotron (AGS), Brookhaven Linac Isotope Producer (BLIP), Relativistic Heavy Ion Collider (RHIC), National Synchrotron Light Source II (NSLS-II), and several vehicle maintenance and petroleum storage facilities. Inactive and remediated facilities are also monitored, including 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 2019, the Facility Monitoring program monitored 91 permanent wells during

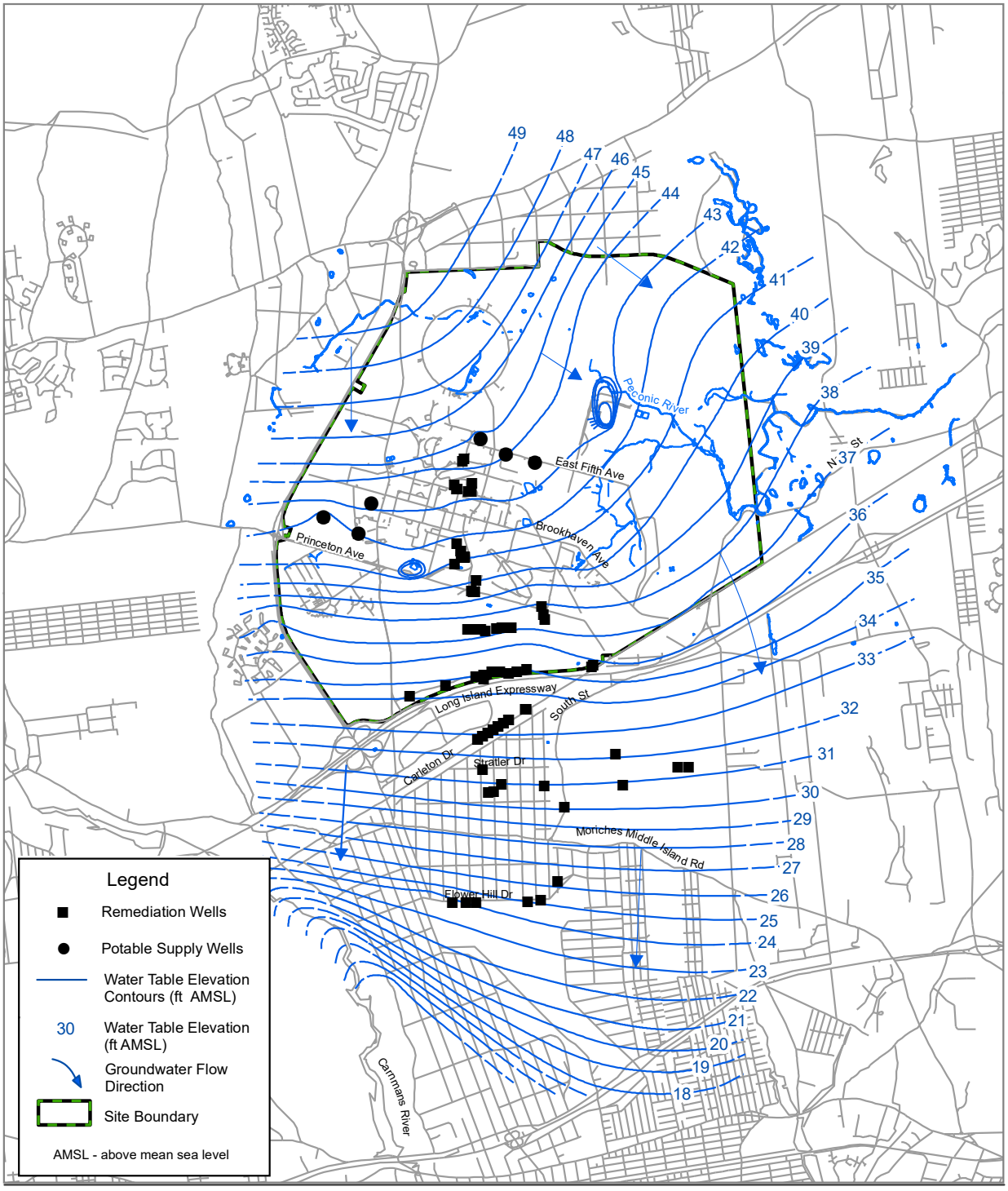

Figure 7-1. Groundwater Flow and Water Table Elevation (January 2020) with Supply and Remediation Wells Shown.

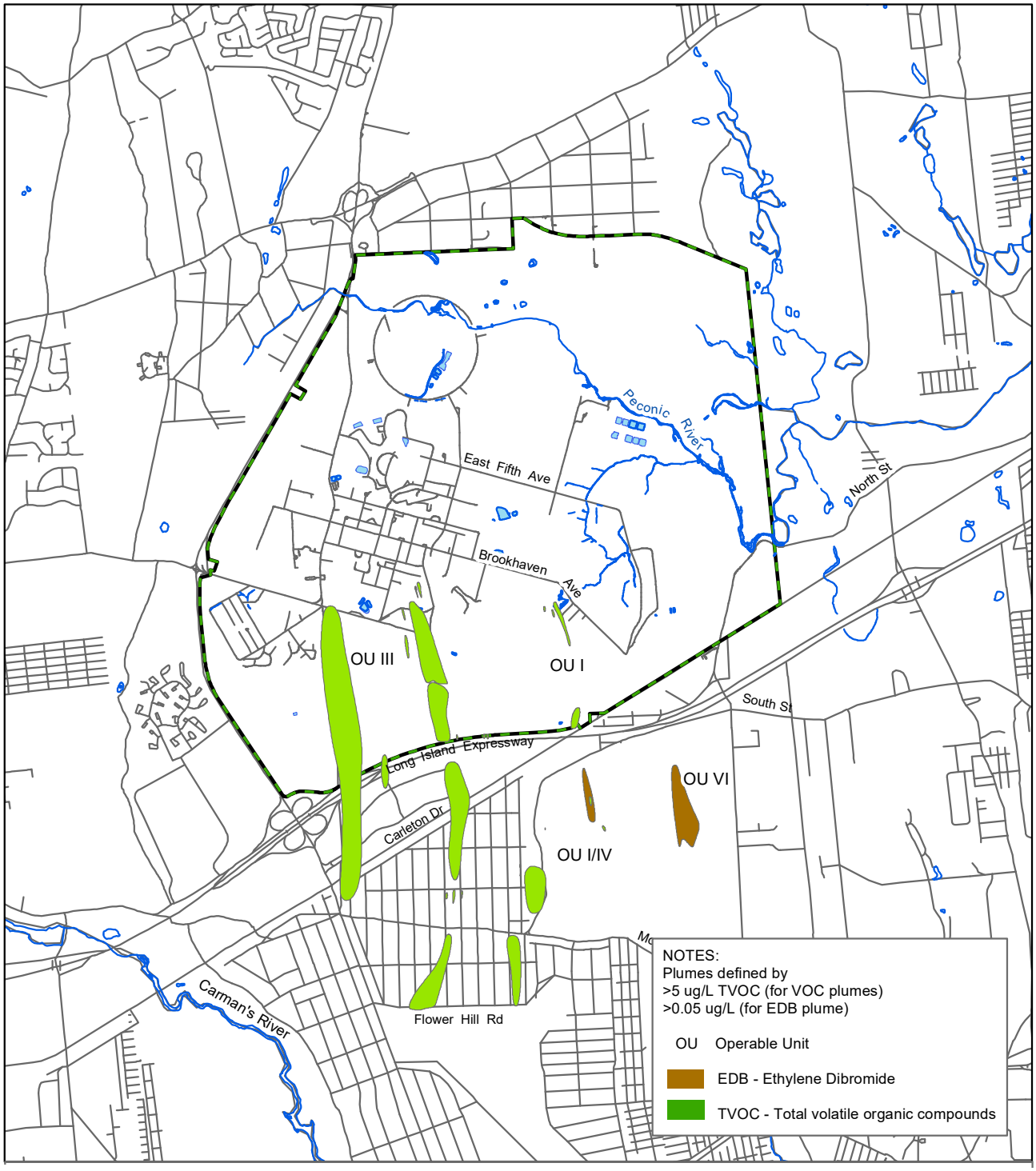

Figure 7-2. Extent of VOC Plumes.

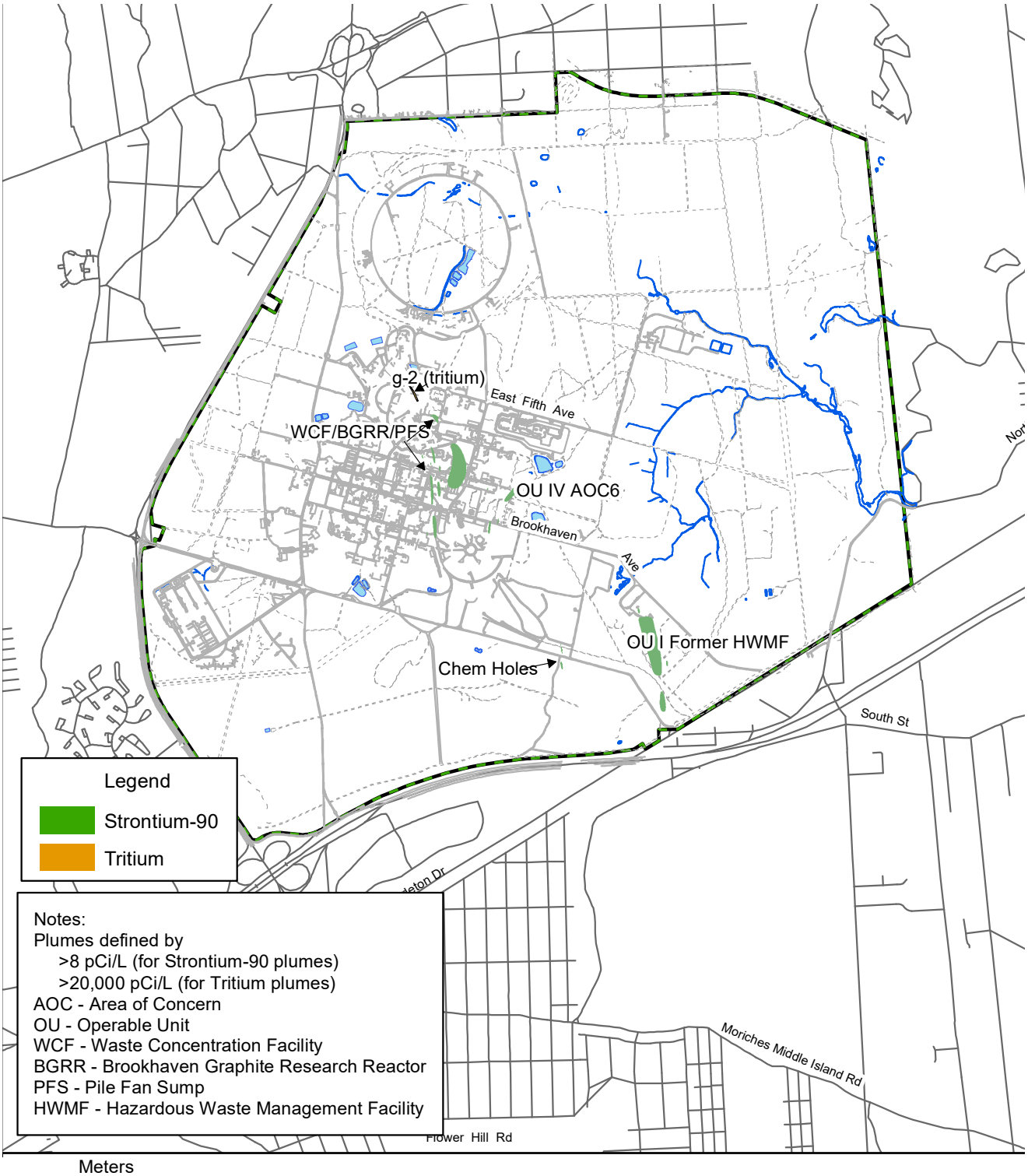

Figure 7-3. Extent of Radionuclide Plumes.

121 individual sampling events. The CERCLA groundwater monitoring program monitored 534 permanent wells during 1,583 individual groundwater sampling events. Thirty-two temporary wells were also installed as part of the CERCLA 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 2019 include:

- Monitoring conducted at BNL's major research facilities (e.g., AGS, RHIC, NSLS-II, and BLIP) and support facilities (e.g., STP, WMF, MPF, and vehicle maintenance facilities) did not identify any new impacts to groundwater quality resulting from current operations.
- During 2016-2018, BNL characterized a plume of deeper than previously defined VOC contamination in the Western South Boundary area. Four new extraction wells were installed to remediate the deeper contamination and allow for achievement of the cleanup goal of meeting Maximum Contaminant Levels (MCLs) in the Upper Glacial aquifer by 2030. The new extraction wells began full-time operation in March 2019.
- Due to the detection of ethylene dibromide (EDB) in the North Street East area at concentrations above the 0.05 µg/L DWS since 2015, in 2019 BNL began making modifications to the treatment system that will allow the EDB plume to be remediated within the OU III ROD-specified 2030 cleanup timeframe for the Upper Glacial aquifer. The modified treatment system is expected to be fully operational by mid-2020.
- After meeting its cleanup objectives, in 2019 BNL submitted Petitions for Closure for the HFBR pump and recharge system, the Building 452 Freon-11 groundwater treatment system, and the OU I South Boundary groundwater treatment system. The regulatory agencies approved these petitions in March, August, and September 2020, respectively. Furthermore, because the North Street treatment system has also met its cleanup objectives, BNL will submit a petition for its closure in early 2020. These treatment systems, and their associated monitoring wells, will be maintained for potential future use in addressing the emerging contaminants of concern, PFAS, and 1,4-dioxane.
- Continued monitoring of the HFBR facility is now conducted using a network of monitoring wells located immediately downgradient of the facility. During 2019, tritium was detected above the 20,000 pCi/L DWS, with a maximum concentration of 35,900 pCi/L.
- During 2019, a significant increase in Sr-90 concentrations were observed in BGRR facility monitoring wells, increasing from less than 1 pCi/L DWS in 2018 to 1,170 pCi/L in October 2019. This increase appears to have resulted from the rising water table leaching residual Sr-90 from contaminated soils beneath the building and adjacent below ground duct area.
- In early 2019, BNL continued its effort to characterize the extent of PFAS by sampling 33 permanent wells and installing 11 temporary wells along the southern site boundary. PFAS were detected in several south boundary area wells, with a maximum combined concentration of PFOS and PFOA of 69.2 ng/L, slightly below the current 70 ng/L HAL. For 2020, BNL is planning on conducting a comprehensive sampling of approximately 350 on-site and off-site monitoring wells for PFAS and 1,4-dioxane, as well as conducting detailed characterization of the PFAS plumes originating from the former and current firehouse facilities.

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:

Table 7-1. BNL Groundwater Remediation Systems Treatment Summary for 1997 through 2019.

Remediation System	Start Date	1997-2018		2019	
		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	Shutdown	0
OU III HFBR Tritium Plume (a)	05/1997	721,795,000	180	Shutdown	0
OU III South Boundary	06/1997	5,112,151,000	3,048	87,000,000	6
OU III Industrial Park	09/1999	2,547,662,000	1,076	30,000,000	1
OU III Carbon Tetrachloride (d)	10/1999	153,538,075	349	Decommissioned	0
OU III Building 96	01/2001	495,697,000	143	31,000,000	2
OU III Middle Road	10/2001	3,448,547,000	1,261	164,000,000	25
OU III Western South Boundary	09/2002	1,769,555,000	143	143,000,000	13
OU III Industrial Park East (e)	06/2004	357,192,000	38	Decommissioned	0
OU III North Street (j)	06/2004	1,680,942,000	342	Shutdown	0
OU III North Street East (h)	06/2004	1,009,798,000	44	Shutdown	0
OU III LIPA/Airport	08/2004	3,324,145,000	455	204,000,000	14
OU III Building 452 Freon-11 (i)	03/2012	124,997,400	106	Shutdown	0
OU IV AS/SVE (b)	11/1997	(c)	35	Decommissioned	0
OU VI EDB	10/2004	2,269,057,000	(g)	91,000,000	(g)
Total		**27,192,549,000**	**7,589**	**750,000,000**	**61**

Remediation System	Start Date	2003–2018		2019	
		Water Treated (Gallons)	Sr-90 Removed (mCi)	Water Treated (Gallons)	Sr-90 Removed (mCi)
OU III Chemical Holes Sr-90	02/2003	65,663,000	4.94	Shutdown	0
OU III BGRR/WCF Sr-90	06/2005	164,803,000	27.9	14,000,000	0.8
Total		**230,466,000**	**32.84**	**14,000,000**	**0.8**

Notes:
(a) System placed in standy mode in 2013. Approved for closure in 2019.
(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.
(h) System placed in standby mode in 2014.
(i) System placed in standby mode in March 2017. Approved for closure in 2019.
(j) System placed in standby mode in August 2016.
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

- Achieve 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 2019, BNL continued to make significant progress in restoring groundwater quality. Figure 7-4 shows the locations of eight groundwater treatment systems currently in

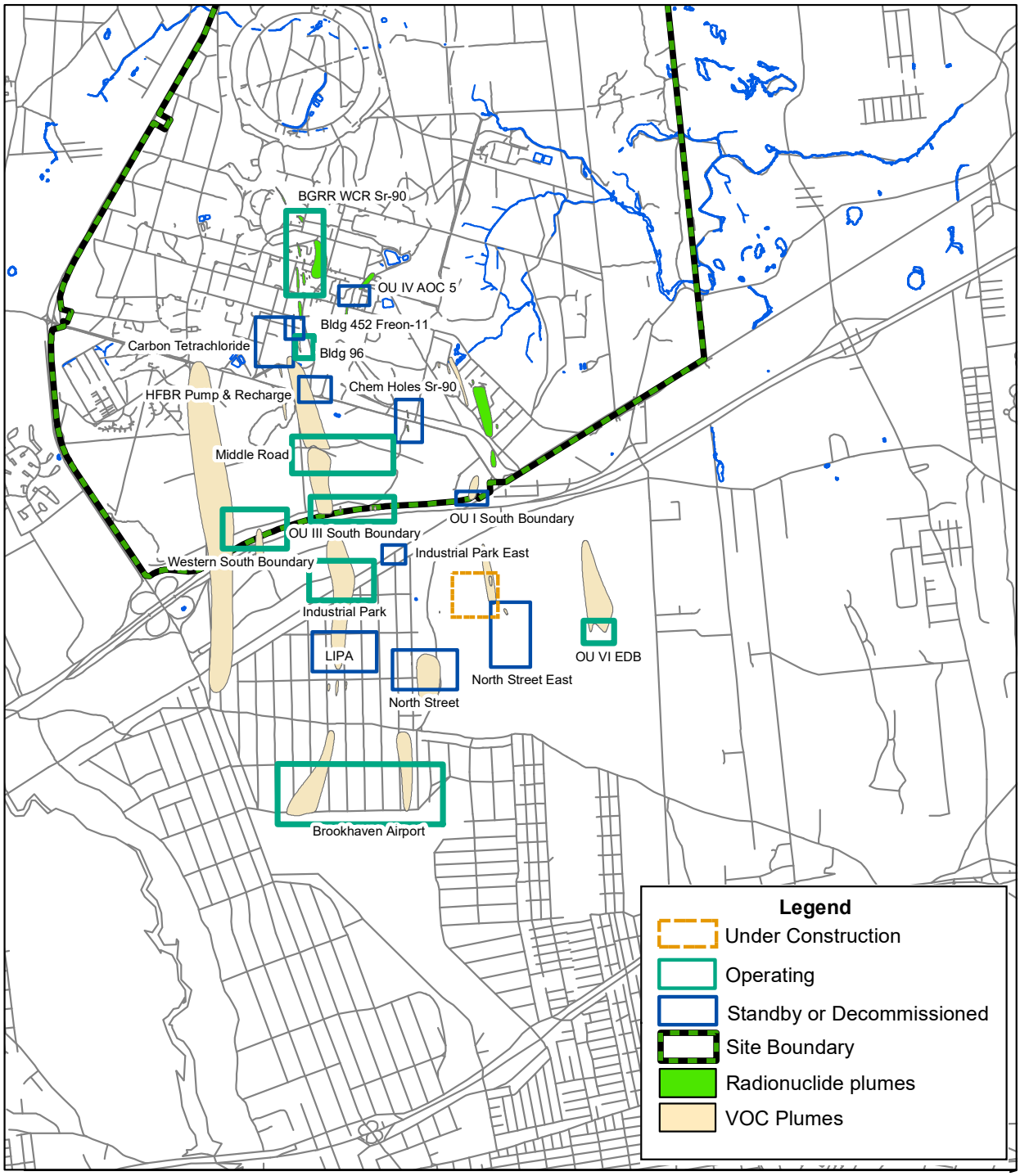

Figure 7-4. Locations of BNL Groundwater Remediation Systems.

operation. Table 7-1 provides a summary of the amounts of VOCs and Sr-90 removed from the aquifer since the start of active remediation in December 1996. During 2019, approximately 61 pounds of VOCs and 0.8 mCi of Sr-90 were removed from the groundwater and nearly 820 million gallons of treated groundwater were returned to the aquifer. To date, 7,650 pounds of VOCs have been removed from the aquifer and noticeable improvements in groundwater quality are evident in several on- and off-site areas. Furthermore, two of the treatment systems have removed approximately 34 mCi of Sr-90.

During 2019, the North Street Treatment System, North Street East Treatment System, OU I South Boundary Treatment System, OU III Building 452 Freon-11 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. A 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

BNL 2018. Groundwater Protection Contingency Plan – Response to Unexpected Monitoring Results. Environmental Monitoring Procedure EM-SOP-309.Brookhaven National Laboratory, Upton, NY. August 2018.