

Groundwater Protection

Brookhaven National Laboratory (BNL) 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 2017, BNL collected groundwater samples from 651 permanent monitoring wells and 27 temporary wells during 1,430 individual sampling events. Eight groundwater remediation systems removed 71 pounds of volatile organic compounds (VOCs) and returned approximately 861 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 7,526 pounds of VOCs by treating over 26.3 billion gallons of groundwater. Also during 2017, two groundwater treatment systems removed approximately 0.5 millicurie of strontium-90 (Sr-90) while remediating approximately 25 million gallons of groundwater. Since 2003, BNL has removed approximately 32.2 millicuries of Sr-90 from the groundwater while remediating nearly 215 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 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 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 25 years and continues to make progress in achieving its goal of preventing new impacts to groundwater quality and to remediate 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 Polyfluoroalkyl Substances (PFAS) were detected in water samples collected from three BNL water supply wells. The Suffolk County Department of Health Services conducted the analyses as part of the Safe Drinking Water Act program known

as the Third Unregulated Contaminant Monitoring Rule. Preliminary assessment of possible sources for the PFAS contaminants indicates that they are related to the historical use of fire-fighting foam at the BNL site. Characterization of potential sources of the PFAS contamination will be conducted in 2018.

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 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 725 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 650 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: the 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 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 2017, the Facility Monitoring program monitored 93 permanent wells during 121 individual sampling events. The CERCLA groundwater monitoring program monitored 558 permanent wells during 1,309 individual groundwater sampling events. Twenty-seven 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 2017 include:

- Monitoring conducted at BNL's major research facilities (e.g., AGS, RHIC, NSLS-II, and BLIP) and support facilities (STP, WMF, MPF, and vehicle maintenance facilities) did not identify any new impacts to groundwater quality.

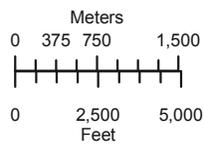
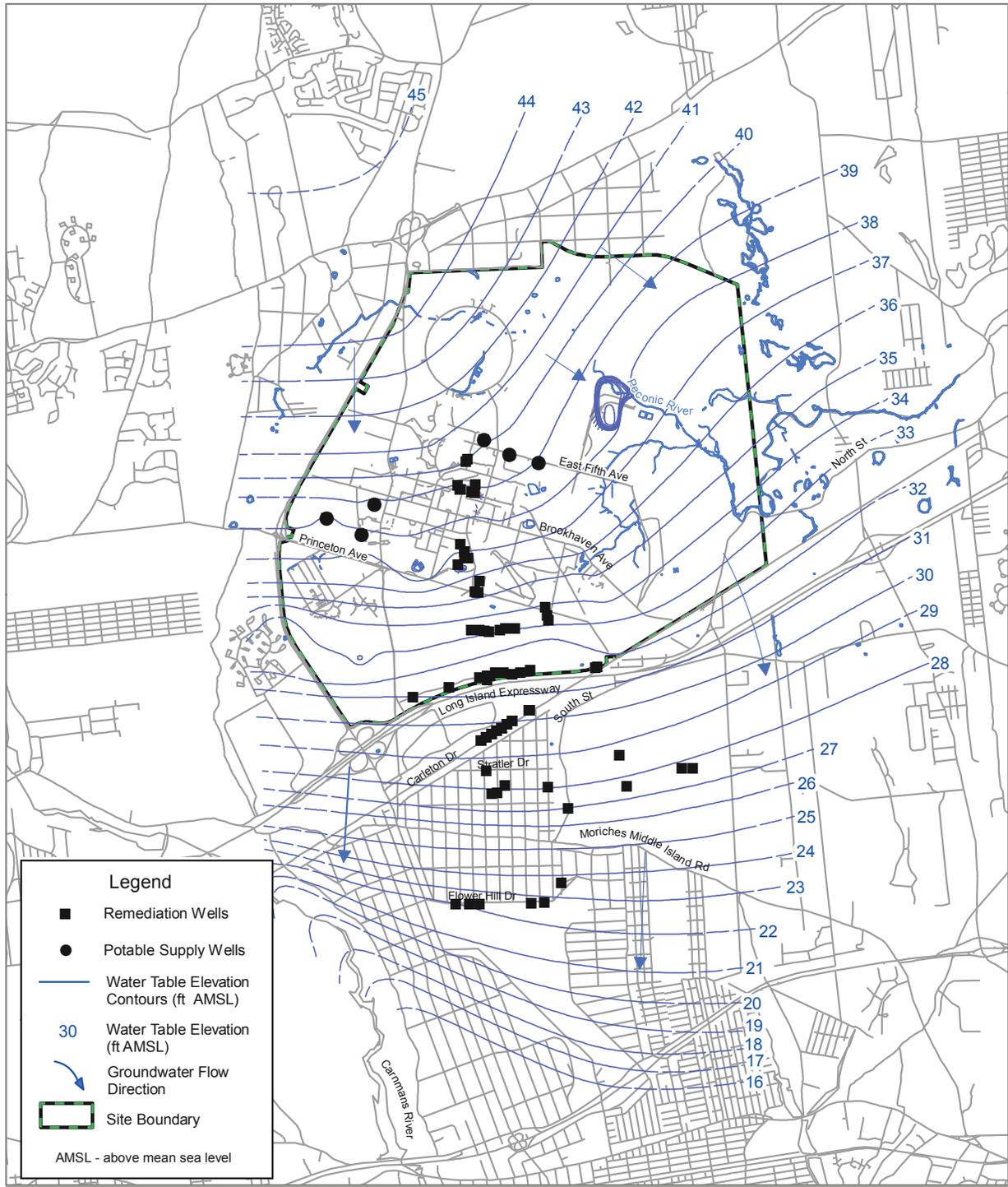


Figure 7-1. Groundwater Flow and Water Table Elevation (December 2017) with Supply and Remediation Wells Shown.



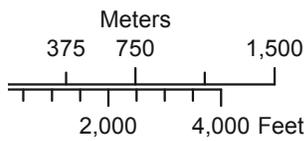
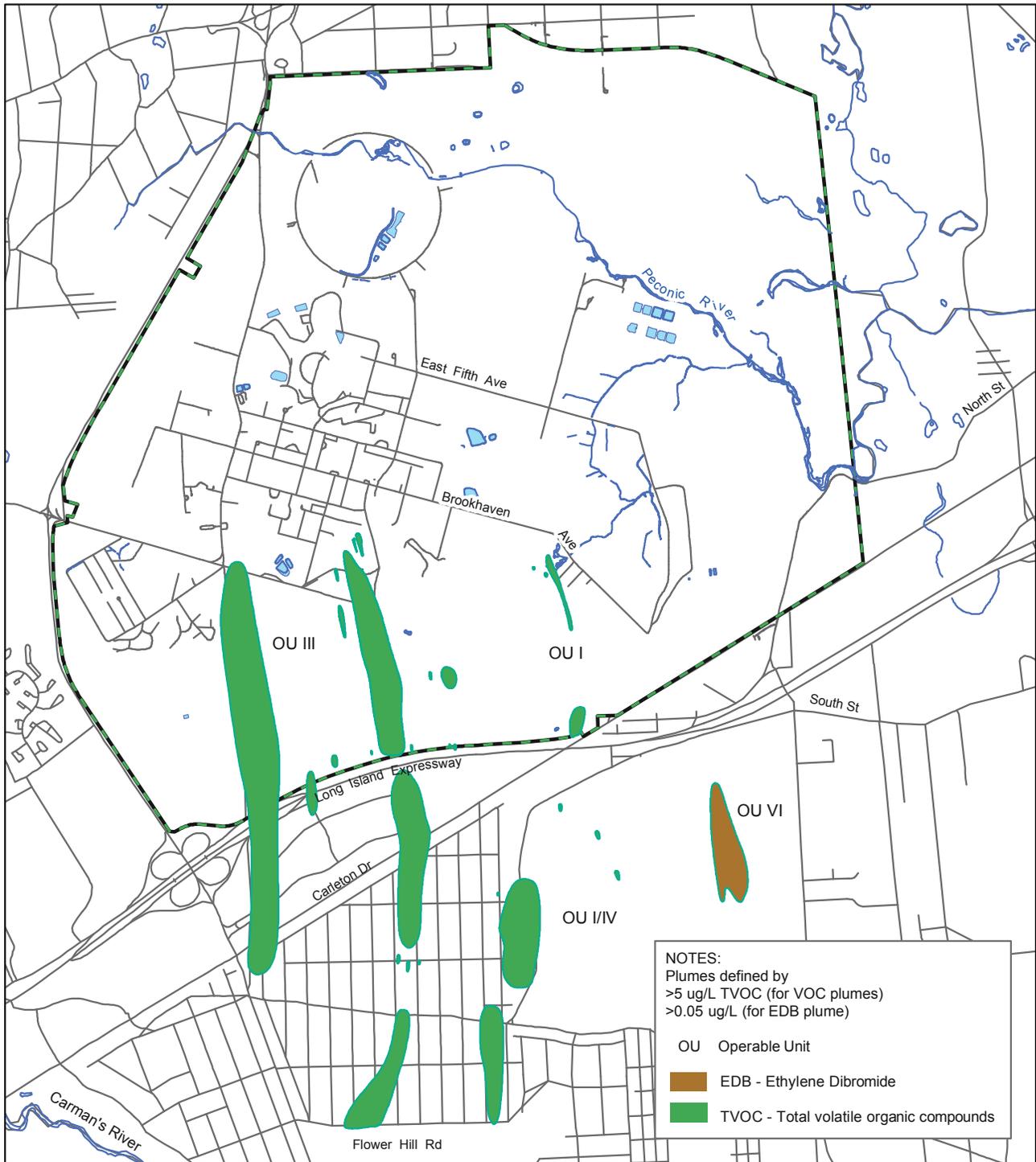


Figure 7-2. Extent of VOC Plumes.



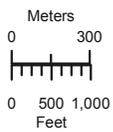
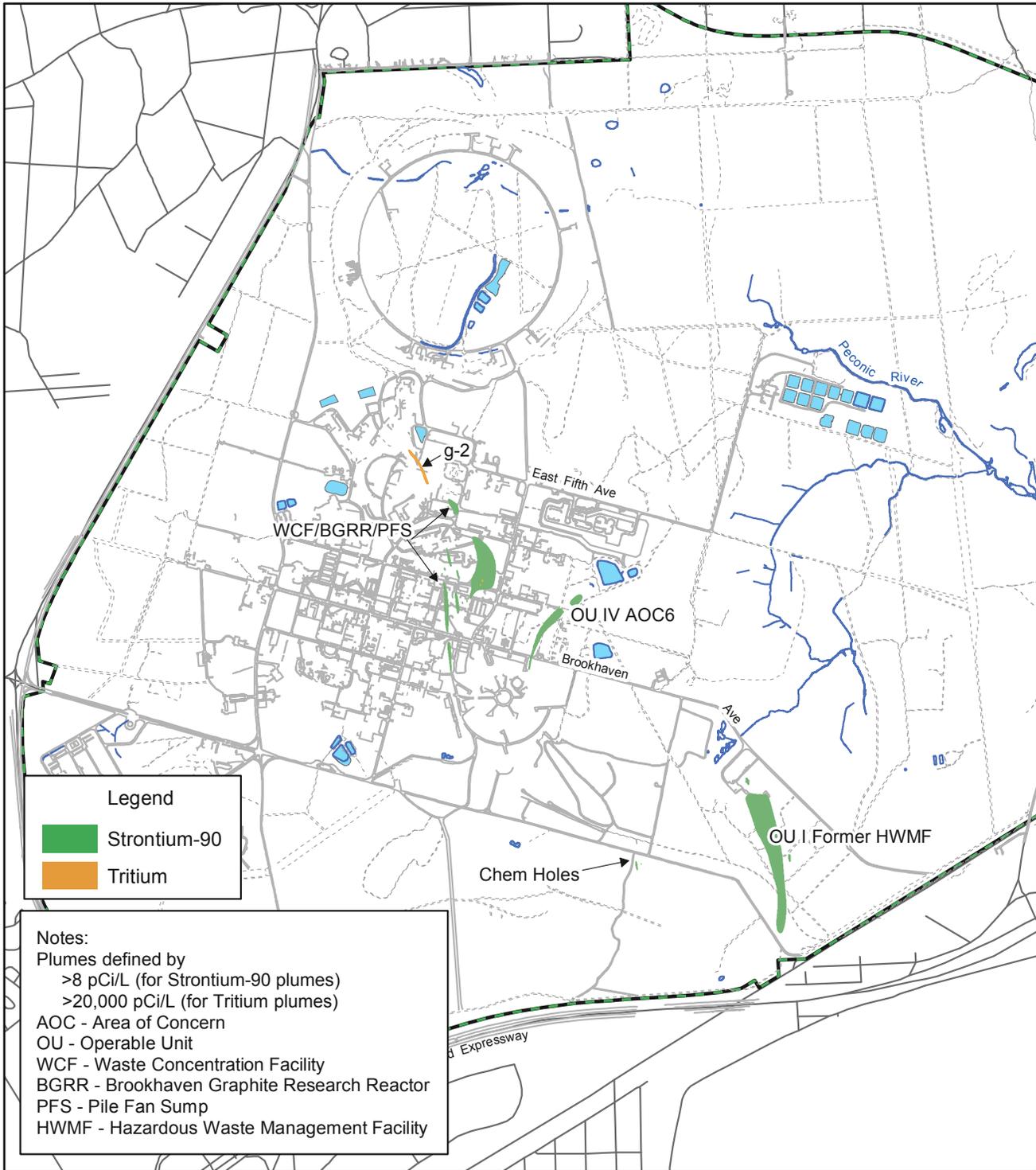


Figure 7-3. Extent of Radionuclide Plumes.



- During 2016-2017, 21 temporary wells were installed to better define VOC concentrations in the Western South Boundary plume. 1,1,1-trichloroethane, 1,1-dichloroethylene, and Freon-12 were detected at unexpected high levels in several areas, with total VOC concentrations in one well reaching 286 µg/L. Because of these higher than expected VOC concentrations, it was determined that four new extraction wells are required to achieve the cleanup goal of meeting Maximum Contaminant Levels (MCLs) in the Upper Glacial aquifer by 2030. The new extraction wells will be installed in 2018.
- The Building 452 Freon-11 treatment system was placed in standby mode in March 2016 following regulatory agency approval of a *Petition for Shutdown*. However, a rebound in Freon-11 concentrations above the 50 µg/L capture goal necessitated the reactivation of the treatment system from November 2016 through February 2017. Freon-11 concentrations remained below the 50 µg/L capture goal for the remainder of 2017.
- Ethylene dibromide (EDB) has been detected in an off-site monitoring well in the North Street East plume since 2015 above the 0.05 µg/L DWS. During the fourth quarter of 2017, EDB was detected at a concentration of 1.06 µg/L in this well. The continued presence of EDB in this well will require additional groundwater characterization of this area in 2018.
- The North Street Treatment System remained in standby mode during 2017. If VOC concentrations remain below the capture goal during 2018, a *Petition for Closure* will be submitted to the regulatory agencies in 2019.
- Sr-90 concentrations downgradient of the former Chemical Holes area have continued to decline and two of three extraction wells are now in standby mode. Because the Sr-90 treatment system has met its cleanup objectives, a *Petition for Shutdown* will be submitted to the regulatory agencies in 2018.
- Sr-90 concentrations downgradient of the BGRR continue to be close to the 8 pCi/L DWS. However, some uncertainty remains about whether the reductions in concentrations are due to lower than normal water table position over the past several years.
- Tritium concentrations downgradient of the HFBR were slightly above the 20,000 pCi/L DWS in one monitoring well, with a maximum concentration of 23,200 pCi/L. Tritium continued to be detected in g-2 source area monitoring wells at concentrations above the 20,000 pCi/L DWS, with a maximum concentration of 33,200 pCi/L.
- Following a 2016 request from NYSDEC, a sampling event for the solvent stabilizing compound 1,4-dioxane was conducted in January 2017 at 22 on- and off-site monitoring wells. Although 1,4-dioxane was detected up to 18.6 µg/L in 17 of the 22 wells, all concentrations were below the current New York State standard of 50 µg/L for unspecified organic contaminants. In December 2017 and January 2018, BNL collected samples from seven additional monitoring wells, and the effluent from five groundwater treatment facilities and the STP. 1,4-Dioxane was detected in five of the seven monitoring wells at concentrations up to 9.1 µg/L, and in four of the six effluent samples at concentrations up to 7.1 µg/L. 1,4-Dioxane was not detected in the STP effluent.

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 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

Table 7-1. BNL Groundwater Remediation Systems Treatment Summary for 1997 through 2017.

Remediation System	Start Date	1997-2016		2017	
		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	4,934,766,950	3,027	72,384,330	14
OU III Industrial Park	09/1999	2,362,923,330	1,071	116,738,200	3
OU III Carbon Tetrachloride (d)	10/1999	153,538,075	349	Decommissioned	0
OU III Building 96	01/2001	463,688,416	140	15,008,540	1
OU III Middle Road	10/2001	3,097,517,790	1,195	179,029,460	34
OU III Western South Boundary	09/2002	1,587,387,000	135	104,668,000	5
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	0	0
OU III North Street East (h)	06/2004	1,009,798,000	44	0	0
OU III LIPA/Airport	08/2004	2,924,751,240	425	196,393,810	13
OU III Building 452 Freon-11 (i)	03/2012	118,521,000	105	6,476,400	1
OU IV AS/SVE (b)	11/1997	(c)	35	Decommissioned	0
OU VI EDB	10/2004	1,936,811,300	(g)	170,246,000	(g)
Total		25,527,105,101	7,455	860,944,740	71

Remediation System	Start Date	2003–2016		2017	
		Water Treated (Gallons)	Sr-90 Removed (mCi)	Water Treated (Gallons)	Sr-90 Removed (mCi)
OU III Chemical Holes Sr-90	02/2003	63,387,436	4.92	1,575,120	0.013
OU III BGRR/WCF Sr-90	06/2005	126,427,800	26.8	23,375,000	0.5
Total		189,815,236	31.72	24,950,120	0.513

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 2013.
- (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 2016. System was restarted in November 2016 for a period of five months.

- (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

Holes in the Upper Glacial aquifer by 2040.

- During 2017, BNL continued to make significant progress in restoring groundwater quality. Figure 7-4 shows the locations of ten groundwater treatment systems

currently in 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 2017, approximately 71 pounds of

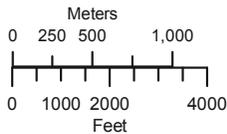
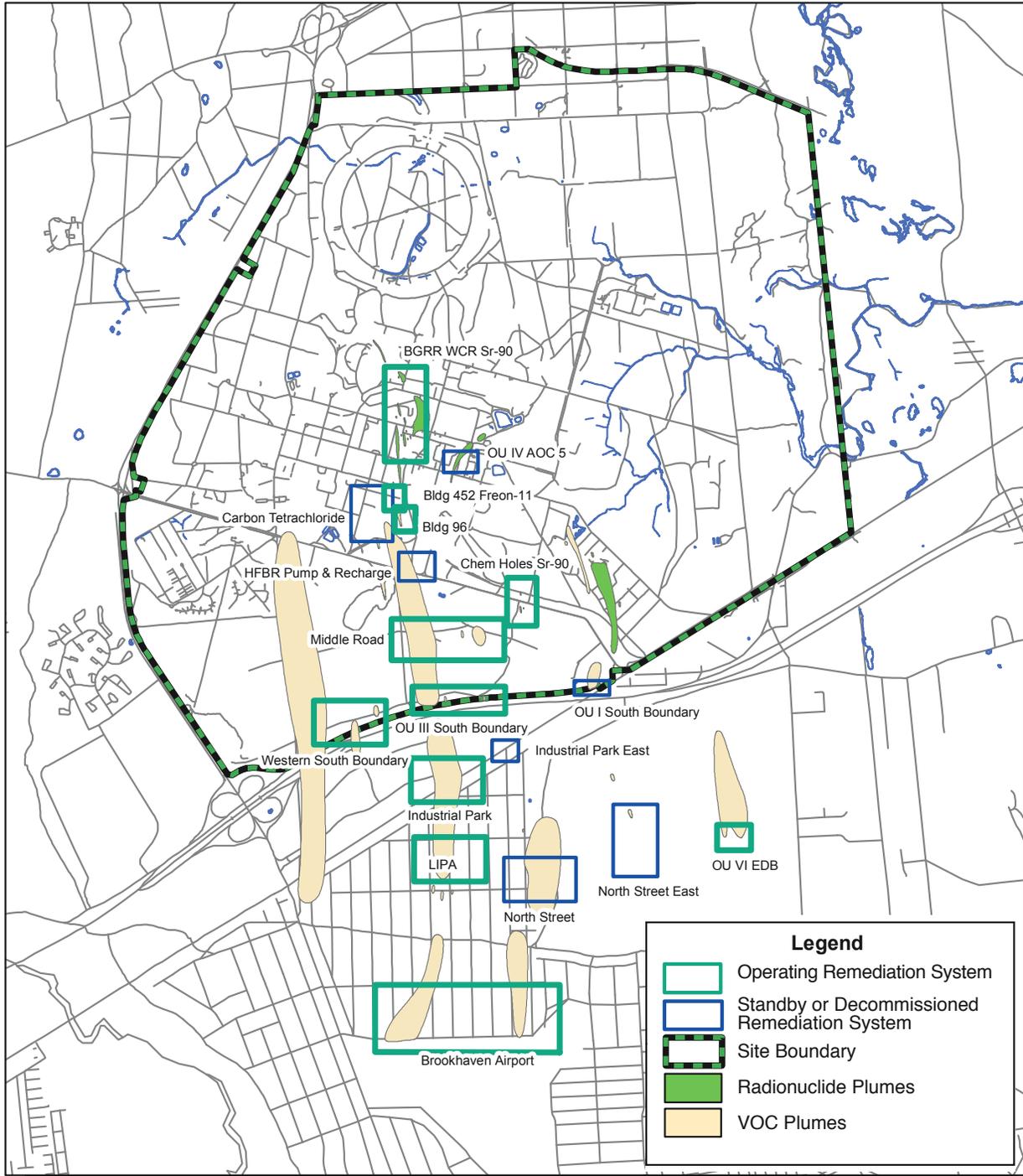


Figure 7-4. Locations of BNL Groundwater Remediation Systems.



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VOCs and 0.5 mCi of Sr-90 were removed from the groundwater, and nearly 861 million gallons of treated groundwater were returned to the aquifer.

To date, 7,526 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 32.3 mCi of Sr-90.

During 2017, the North Street Treatment System, North Street East Treatment 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 which had been

placed in standby mode in March 2016, was reactivated in November 2016 due to a short-term rebound in Freon-11 concentrations. The system was returned to standby mode in March 2017. 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 2013. Groundwater Protection Contingency Plan – Response to Unexpected Monitoring Results. Environmental Monitoring Procedure EM-SOP-309. Brookhaven National Laboratory, Upton, NY. August 2013.