

# Groundwater Protection

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*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. In 2011, BNL collected groundwater samples from 796 permanent monitoring wells and over 60 temporary wells during 2,041 individual sampling events. Thirteen groundwater remediation systems removed 156 pounds of volatile organic compounds 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 Laboratory has removed 6,709 pounds of volatile organic compounds by treating nearly 19 billion gallons of groundwater. During 2011, two groundwater treatment systems removed approximately 2.9 millicuries of strontium-90 while remediating 10 million gallons of groundwater. Since 2003, BNL has removed approximately 26 millicuries of strontium-90 from the groundwater while remediating 90 million gallons of groundwater.*

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## **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. 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 (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. 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, 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

Although 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, during 2011, a plume of trichlorofluoromethane (also known by the trade name Freon-11) was discovered in the area of the Laboratory's Site Maintenance Facility, Building 452. In response, the BNL Groundwater Protection Contingency Plan was followed to assure that the appropriate characterization, stakeholder notifications, and corrective actions were implemented. The Laboratory will continue efforts to prevent new groundwater impacts and is vigilant in measuring and communicating its performance.

## 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 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

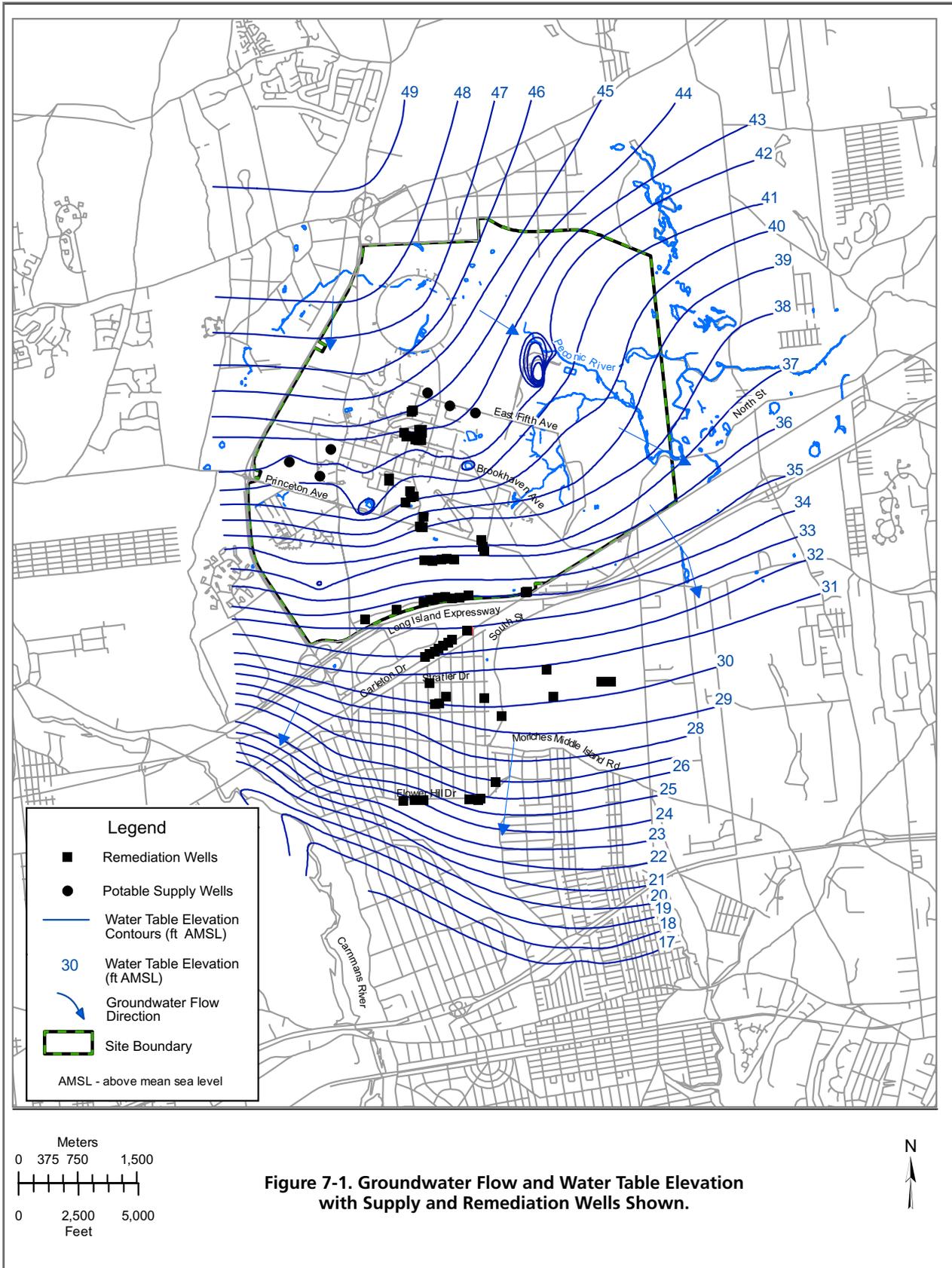
former Hazardous Waste Management Facility (HWMF), two former landfill areas, Waste Concentration Facility (WCF), Brookhaven Graphite Research Reactor (BGRR), High Flux Beam Reactor (HFBR), and the Brookhaven Medical Research Reactor (BMRR). Maps showing the main VOC and radionuclide plumes are provided as Figures 7-2 and 7-3, respectively.

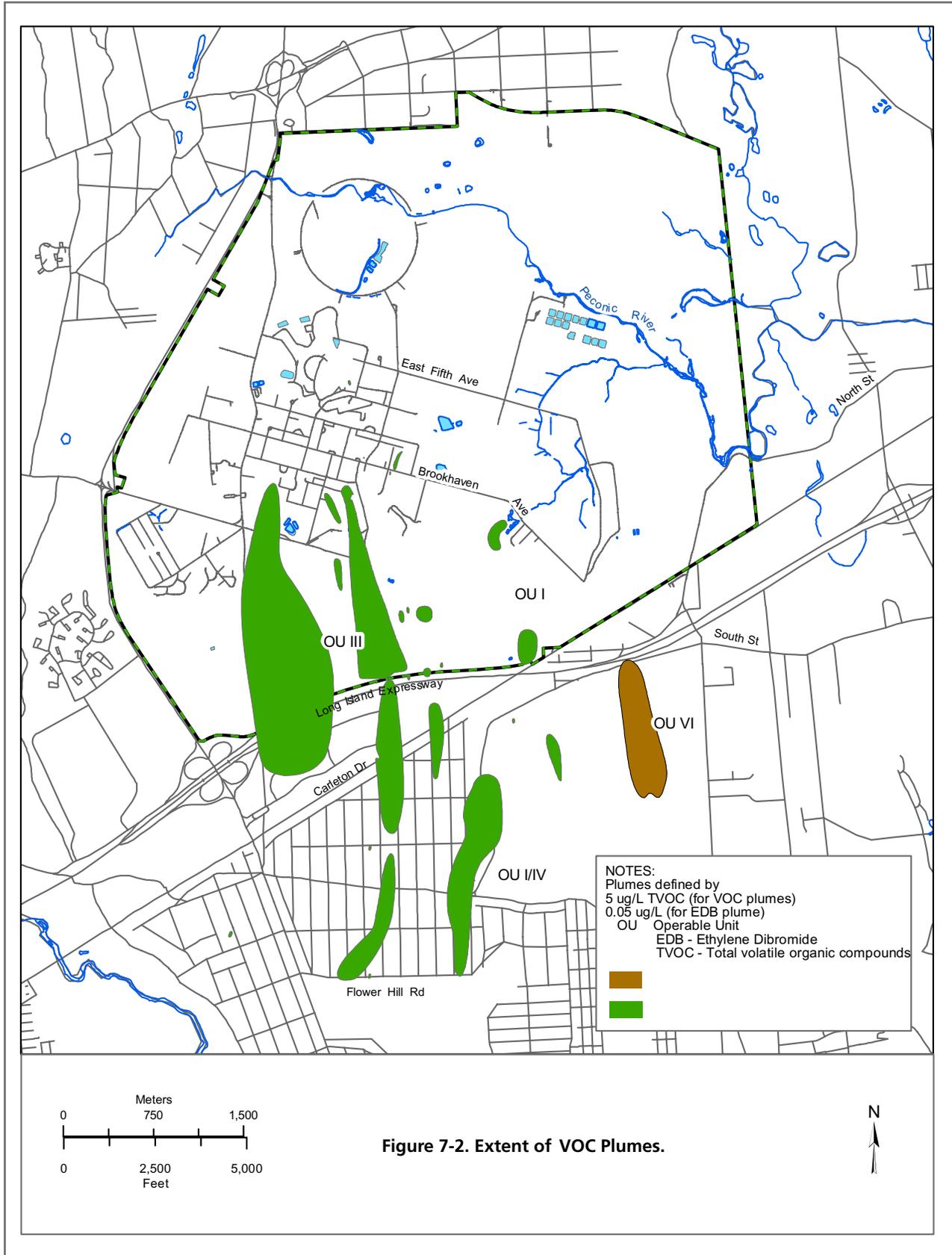
#### 7.4 FACILITY MONITORING PROGRAM

BNL's Facility Monitoring program includes groundwater monitoring at 12 active research facilities (e.g., accelerator beam stop and target areas) and support facilities (e.g., fuel storage and waste management facilities). During 2011, groundwater samples were collected from 134 wells during 230 individual sampling events. Fifty temporary wells were also installed as part of this program. Detailed descriptions and maps related to the FM groundwater monitoring program can be found in SER Volume II, Groundwater Status Report.

Highlights of the surveillance program in 2011 include:

- Tritium continues to be detected in the g-2 source area monitoring wells at concentrations above the 20,000 pCi/L Federal DWS, with a maximum concentration of 119,000 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.
- 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 approximately 200 feet in length, and is presently located entirely south of the NSLS facility. During 2011, the highest observed tritium concentration was 58,600 pCi/L in a temporary well installed immediately south of Brookhaven Avenue. Because the plume segment has migrated south of Brookhaven Avenue, an ROD contingency action was triggered.





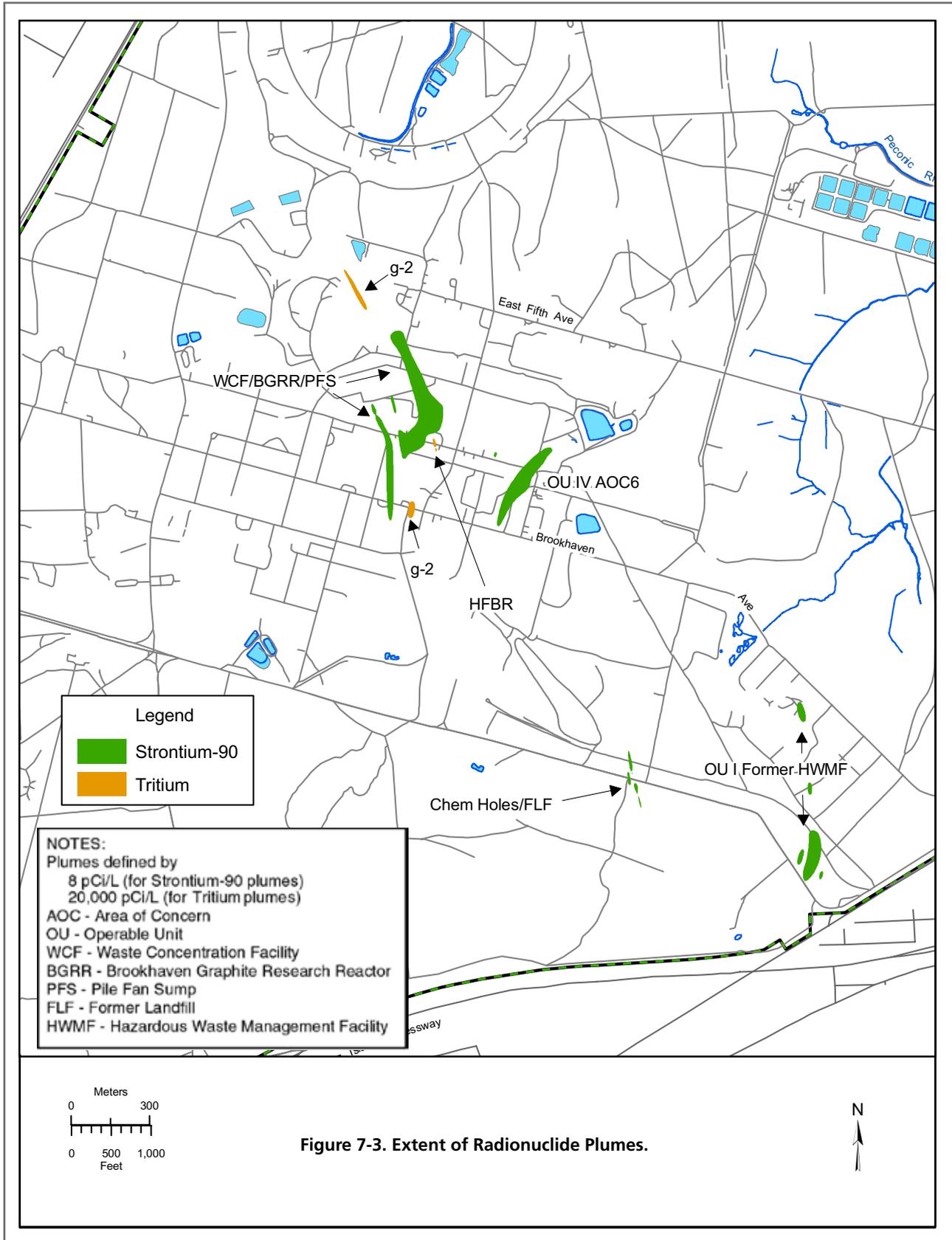


Figure 7-3. Extent of Radionuclide Plumes.

In response, BNL has developed a plan to monitor this plume segment on a more frequent basis. 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 2011 was 2,000 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 1,229 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.
- During 2011, a plume of trichlorofluoromethane (also known by the trade name Freon-11) was discovered in the area of the Site Maintenance Facility, Building 452. The full extent of the plume was characterized using 41 temporary wells. The plume was found to extend from Building 452 to approximately 600 feet downgradient. The maximum Freon-11 concentration was 38,000 µg/L. Based on

the high levels of Freon-11 in the groundwater, BNL began to install a new treatment system in late 2011 to remediate the plume. The treatment system is expected to begin operation in March 2012. During 2012, an Explanation of Significant Differences will be prepared to incorporate this remedial action under the OU III ROD.

## 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 2011, the CERCLA program monitored 662 monitoring wells during 1,470 individual groundwater sampling events. Twenty-eight 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.

Highlights of the program include:

- During 2011, groundwater treatment system capture goals were met for the OU I South Boundary, Industrial Park, and North Street systems. Petitions to shut down these systems will be submitted to the regulatory agencies in 2012.
- The HFBR Pump and Recharge system was operational during all of 2011. Monitoring data for 2010 and 2011 indicate that the tritium concentrations have dropped below the 20,000 pCi/L DWS in the downgradient segment of the plume. A petition for shut-down of the pump and recharge system will be prepared during 2012.
- Although tritium concentrations in groundwater monitoring wells immediately downgradient of the HFBR were below the DWS throughout all of 2009 and early 2010, tritium concentrations increased to 50,800 pCi/L during the fourth quarter of 2010, and increased further to 142,000 pCi/L by the third quarter of 2011. This increase is associated with the historically high water table levels observed at the site in early 2010, which flushed residual tritium from the deep vadose zone beneath the HFBR. The overall

reduction in tritium concentrations over the past few years indicates that the inventory of tritium remaining in the deep vadose zone is diminishing.

- During 2011, high levels of PCE were detected in groundwater monitoring wells located within and immediately downgradient of the Building 96 PCE contaminated soils area that was excavated in 2010. Although PCE was detected at concentrations up to 3,000 µg/L in a well located in the remediated source area during the first quarter of 2011, PCE levels decreased to less than 625 µg/L by the end of the year. The Building 96 Groundwater Treatment System will continue to operate until the cleanup goal is achieved.
- Groundwater monitoring and characterization of the deep Upper Glacial aquifer at the OU III South Boundary identified a deeper zone of VOC contamination that is migrating off site. During 2012, a new extraction well will be installed to capture and remediate this contamination.
- The North Street East extraction wells, which were scheduled to be shut down during 2011, will remain in operation to address a persistent zone of VOC contamination that was found to be slightly above the cleanup goals.
- Sr-90 concentrations in the groundwater immediately downgradient of the BGRR decreased from a high of 491 pCi/L in late 2010 to less than 25 pCi/L in late 2011. During 2011, an engineered cap was installed in the BGRR area to prevent rainwater infiltration into previously identified areas of underground soil contamination, including the Below Ground Ducts and Canal House areas. Due to continued periodic detection of high levels of Sr-90 in the groundwater, BNL is planning to evaluate the applicability of additional source area stabilization/control techniques.
- Although all VOC concentrations in the OU V monitoring wells were below the DWS from 2008 through 2010, during 2011, TCE was detected at slightly above the 5 µg/L standard in a single off-site monitoring well. A petition to conclude the

OU V monitoring program will be submitted to the regulatory agencies in 2012.

## 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 2011, BNL continued to make significant progress in restoring groundwater quality. Figure 7-4 shows the locations of 13 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 2011, approximately 156 pounds of VOCs and approximately 2.9 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, 6,709 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, and OU III North Street areas. Also to date, two of the treatment systems have removed approximately 26 mCi of Sr-90. Detailed information on the groundwater treatment systems can be found in SER Volume II, Groundwater Status Report.

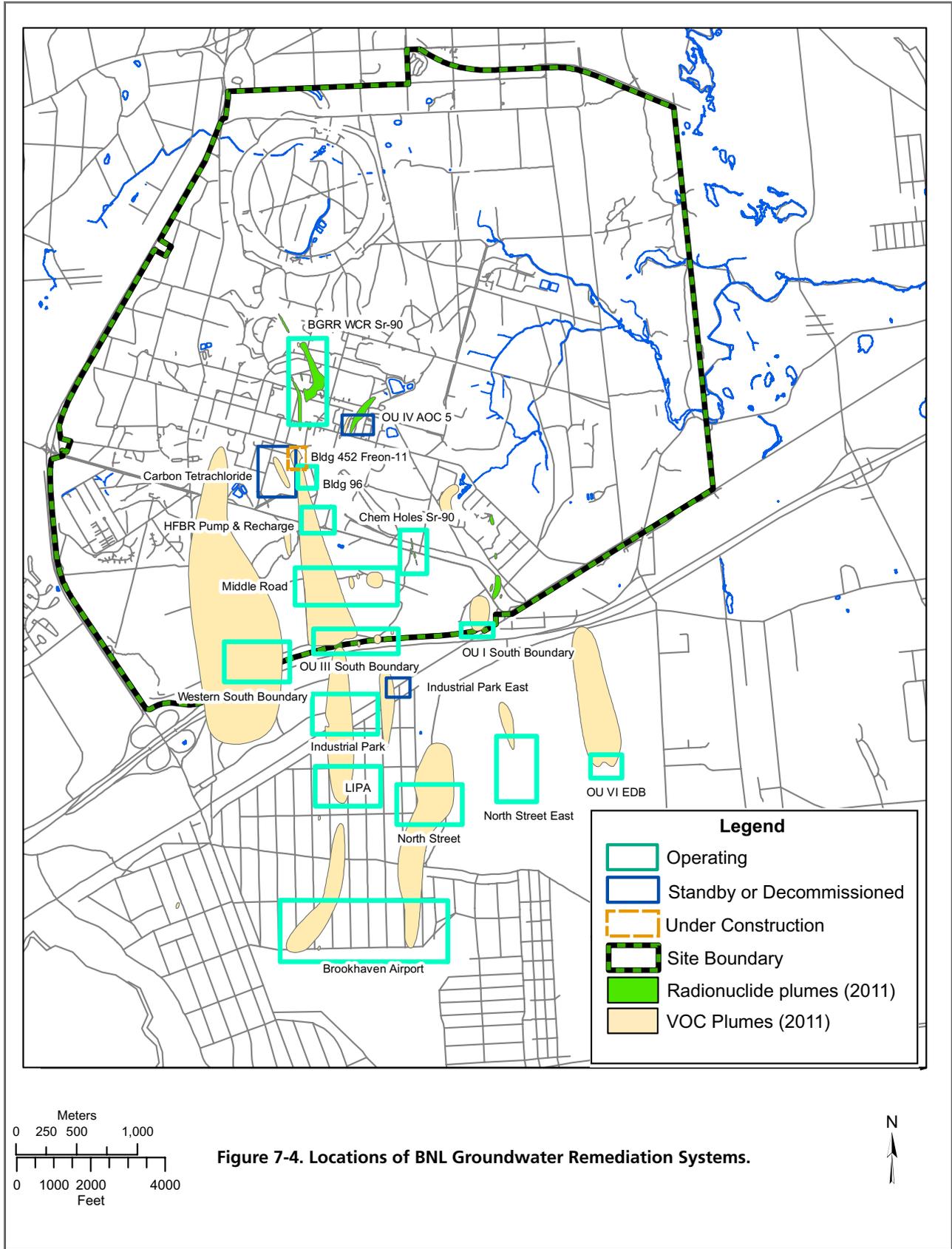


Figure 7-4. Locations of BNL Groundwater Remediation Systems.

CHAPTER 7: GROUNDWATER PROTECTION

Table 7-1. BNL Groundwater Remediation Systems Treatment Summary for 1997 through 2011.

Remediation System	Start Date	1997-2010		2011	
		Water Treated (Gallons)	VOCs Removed (Pounds) (e)	Water Treated (Gallons)	VOCs Removed (Pounds) (e)
OU I South Boundary	12/1996	3,853,732,000	359	172,540,000	3.5
OU III HFBR Tritium Plume (a)	05/1997	537,129,000	180	87,855,000	0
OU III Carbon Tetrachloride (d)	10/1999	153,538,075	349	Decommissioned	0
OU III Building 96	01/2001	248,822,416	99	46,488,000	9
OU III Middle Road	10/2001	1,859,388,550	920	220,584,000	51
OU III South Boundary	06/1997	3,690,854,850	2,786	192,928,000	48
OU III Western South Boundary	09/2002	911,116,000	80	116,423,000	12
OU III Industrial Park	09/1999	1,740,962,330	1,052	87,825,000	5
OU III Industrial Park East	06/2004	357,192,000	38	0	0
OU III North Street	06/2004	1,179,193,000	313	139,983,000	8
OU III North Street East	06/2004	683,772,000	36	68,123,000	2
OU III LIPA/Airport	08/2004	1,621,542,000	306	173,651,000	17
OU IV AS/SVE (b)	11/1997	(c)	35	Decommissioned	0
OU VI EDB	10/2004	960,709,000	(f)	163,822,000	(f)
<b>Total</b>		<b>17,797,951,221</b>	<b>6,553</b>	<b>1,470,222,000</b>	<b>155.5</b>

Remediation System	Start Date	2003-2010		2011	
		Water Treated (Gallons)	Sr-90 Removed (mCi)	Water Treated (Gallons)	Sr-90 Removed (mCi)
OU III Chemical Holes Sr-90	02/2003	31,242,826	4.1	6,920,000	0.33
OU III BGRR/WCF Sr-90	06/2005	47,939,000	18.6	3,624,000	2.6
<b>Total</b>		<b>79,181,826</b>	<b>23</b>	<b>10,544,000</b>	<b>2.93</b>

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 = volatile organic compounds  
 WCF = Waste Concentration Facility

REFERENCES AND BIBLIOGRAPHY

BNL 2008. *Groundwater Protection Contingency Plan – Response to Unexpected Monitoring Results*. Environmental Monitoring Procedure EM-SOP-309. Brookhaven National Laboratory, Upton, NY. September 2008.