GROUNDWATER REMEDIATION PROGRAM AT BROOKHAVEN NATIONAL LABORATORY UPTON, NEW YORK

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Introduction

The primary mission of BNL's Environmental Restoration Program is to remediate soil and groundwater contamination, and to prevent additional contamination from migrating off the BNL site. The cleanup goals for groundwater are to: 1) prevent or minimize plume growth; 2) reduce volatile organic compound (VOC) and tritium concentrations in the Upper Glacial aquifer to below regulatory standards within 30 years; 3) reduce VOC concentrations in the Magothy aquifer to below regulatory standards within 65 years; and 4) reduce strontium-90 concentrations in the Upper Glacial aquifer to below regulatory standards within 70 years. The extent of VOC and radionuclide contamination in groundwater at the BNL site and downgradient areas is shown on Figure 1.

Since the beginning of active groundwater remediation in 1997, more than 5,200 pounds of VOCs and 6 millicuries of strontium-90 have been removed from the groundwater, and over 10 billion gallons of treated water has been returned to the aquifer (Table 1). Some noticeable improvements in groundwater quality are evident by the successful cleanup of the Operable Unit (OU) IV VOC plume, the OU III Carbon Tetrachloride Plume, and the reduction in size of the OU I and OU III VOC plumes and the High Flux Beam Reactor (HFBR) tritium plume. Active groundwater remediation activities are expected to continue until the year 2025. Following active treatment, monitored natural attenuation will be used to further reduce contaminant concentrations to below regulatory standards.

Treatment System Capacity

BNL has constructed fourteen groundwater treatment systems to restore groundwater quality in the Upper Glacial aquifer within the 30-year cleanup timeframe, and two treatment systems to restore groundwater quality within the Magothy aquifer within the 65-year timeframe. The systems have a total treatment capacity of about 4,500 gpm. Thirteen of these systems are designed to treat VOC contamination, whereas the remaining three treat or control radionuclide contamination (e.g., strontium-90 and tritium). Thirteen of the groundwater remediation systems are currently in operation. The OU IV Air Sparging/Soil Vapor Extraction (AS/SVE) system completed its operations and was fully decommissioned in 2003. The OU III HFBR Pump & Recharge System and the OU III Carbon Tetrachloride treatment systems were placed in standby mode because they substantially met their cleanup goals in 2000 and 2004, respectively. Figure 1 shows the locations of the groundwater treatment systems.

Figure 1: Extent of Groundwater Contamination and Locations of the Groundwater Treatment Systems.

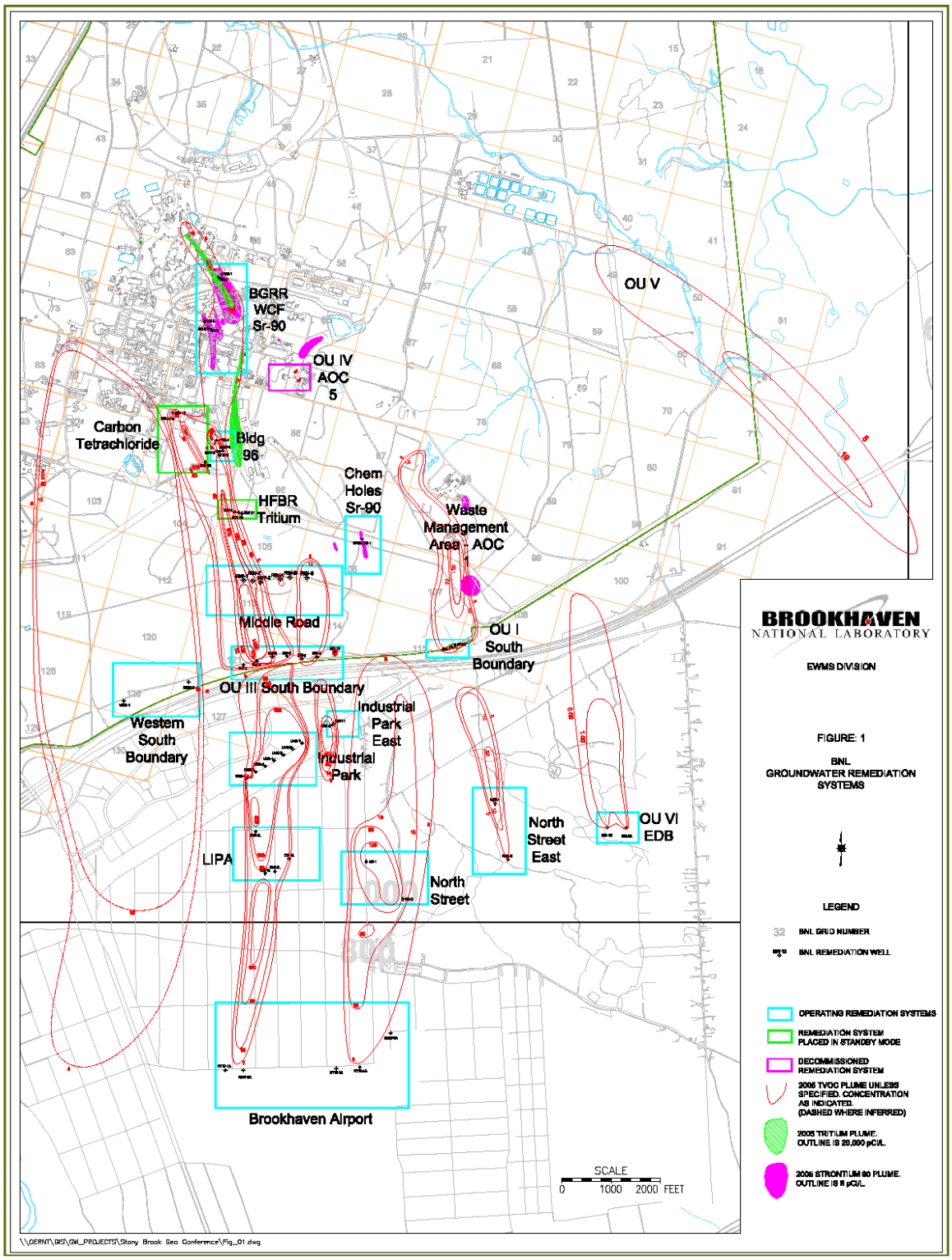

Table 1: Groundwater Remediation Systems Treatment Summary for 1997 – 2005.

		1997 - 2004		2005	
Remediation System	Start Date	Water Treated (Gallons)	VOCs Removed (Pounds) (e)	Water Treated (Gallons)	VOCs Removed (Pounds) (e)
OU I South Boundary	12/1996	2,696,275,000	313	196,974,000	10
OU III HFBR Tritium Plume (a)	05/1997	241,528,000	180	Not in Service	0
OU III Carbon Tetrachloride (d)	10/1999	150,164,075	348	3,374,000	1
OU III Building 96	02/2001	122,865,416	67	9,692,000	2
OU III Middle Road	10/2001	808,353,550	520	157,297,000	88
OU III South Boundary	06/1997	2,564,859,850	2,276	248,240,000	133
OU III Western South Boundary	09/2002	357,048,000	32	120,115,000	7
OU III Industrial Park	09/1999	966,928,330	838	116,370,000	63
OU III Industrial Park East	05/2004	57,113,000	17	86,485,000	7
OU III North Street	06/2004	144,702,000	115	201,139,000	72
OU III North Street East	06/2004	84,000,000	5	162,900,000	6
OU III LIPA/Airport	06/2004	134,444,000	62	302,238,000	83
OU IV AS/SVE (b)	11/1997	(c)	35	Decommissioned	0
OU VI EDB	08/2004	20,000,000	<1	157,652,000	<1
Total		8,348,281,221	4,808	1,763,476,000	472

		2003–2004		2005	
Remediation System	Start Date	Water Treated (Gallons)	Sr-90 Removed (mCi)	Water Treated (Gallons)	Sr-90 Removed (mCi)
OU III Chemical Holes Sr-90	02/2003	5,060,826	1.17	1,552,000	0.57
OU III BGRR/WCF Sr-90	06/2005	Not in Service	0	3,576,000	4.15
Total		5,060,826	1.17	5,128,000	4.72

Notes:

(a) System was shut down and placed in standby mode on September 29, 2000.

(b) System was shut down on January 10, 2001 and decommissioned in 2003.

(c) Air Sparging/Soil Vapor Extraction (AS/SVE) system performance is 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.

(e) Values are rounded to the nearest whole number.

Treatment Methods for VOCs

In general, three types of remediation systems are used to treat VOC contaminated groundwater at BNL: 1) conventional pump and treat systems; 2) re-circulation systems with in-well air stripping or carbon treatment; and 3) air sparging/soil vapor extraction. Table 2 provides a summary of treatment methods being used at each of the groundwater remediation systems.

Pump and treat remediation consists of pumping groundwater from the plume up to the surface and piping it to a treatment system. The two types of treatment utilized at BNL are air stripping and granular activated carbon. Treated water then is introduced back into the aquifer via recharge basins, injection wells or dry wells. Pump and treat is a standard environmental cleanup industry technology, and particularly lends itself to on-site applications at BNL where noise generated by conventional air stripper towers and space limitations for the recharge of treated water is not an issue.

Re-circulation wells with in-well air stripping are an innovative groundwater remediation technology. Re-circulation wells are particularly attractive as a treatment alternative in some off-site residential areas, where methods for the recharge of treated water by conventional treatment systems are important limiting factors. This technology is based on a remediation well with two hydraulically isolated screen zones set some distance apart. Contaminated water is pumped up from the deeper zone in the contaminant plume, and treated below the ground surface with a shallow tray air stripper. The treated water then is returned to the aquifer via the shallow recharge screen. Off gas generated by the air stripping process is passed through granular activated carbon and is sent back to the in well air strippers for reuse.

Soil and groundwater contaminated by a 1977 fuel oil/solvent spill at BNL's major petroleum storage facility were treated utilizing an air sparge/soil vapor extraction (AS/SVE) system. The system was in operation from 1997 until January 2001. Following a two-year standby period, the AS/SVE system was decommissioned in 2003. This system consisted of 48 air sparge wells and 23 vapor extraction wells. Air was introduced into the AS wells (screened below the water table) via a two-staged rotary lobe blower. The air stripped VOCs from the soils and groundwater, and the VOCs were then removed from the unsaturated zone by the SVE wells. The extracted air was passed through granular activated carbon to remove the VOCs before it was released to the atmosphere. In addition to AS/SVE, an Oxygen Release Compound (ORC) was injected into the groundwater to enhance the biodegradation of residual petroleum hydrocarbons.

Treatment Methods for Radionuclides

Hydraulic control was employed for the leading edge of the HFBR tritium plume beginning in 1997 using a pump and recharge system. This system pumped groundwater from the leading edge of the tritium plume, removed commingled VOC contamination by means of an air stripping tower, then it discharged the low-level tritiated water to an upgradient recharge basin. The goal was to prevent the plume from continuing to move downgradient, thereby ensuring that the plume remained on site to naturally decay and disperse. The system was placed on standby in September 2000 when continued groundwater characterization efforts verified that tritium concentrations in the southern segment of the plume were well below the 20,000 pCi/L drinking water standard. During 2000 and early 2001, low flow extraction of highly contaminated groundwater from a segment of the tritium plume that is closer to the reactor facility (source area) was undertaken to accelerate cleanup of the plume. A total of 95,000 gallons of groundwater were pumped from ten temporary wells during twenty-one separate

pumping events. The water was transported off-site for disposal at an US Environmental Protection Agency approved facility. (Note: Tritium cannot be removed from groundwater using conventional treatment methods.)

Strontium-90 contaminated groundwater originating from the Brookhaven Graphite Research Reactor/Waste Concentration Facility areas and the Chemical/Animal Holes area is being remediated using ion exchange by passing the water through a series of filter vessels filled with clinoptilolite, a naturally occurring zeolite. The treated water is recharged to the aquifer via dry wells.

Table 2: Summary of BNL Groundwater Treatment Systems.

Operable Unit	**System Status**	**Project**	**System Type**	**Recharge Method**
OU I	Operational	South Boundary	Pump and treat (A)	Recharge basin
OU III	Operational	North Street East (O)	Pump and treat (C)	Recharge wells
	Stand by	Carbon tetrachloride	Pump and treat (C)	Recharge basin
	Stand by	Building 96	Re-circulation (C)	In-well recharge
	Operational	Middle Road	Pump and treat (A)	Recharge basin
	Operational	W. South Boundary	Pump and treat (A)	Recharge basin
	Operational	Industrial Park (O)	Re-circulation (C)	In-well recharge
	Operational	LIPA (O)	Pump and treat (C)	Recharge wells
	Operational	North Street (O)	Pump and treat (C)	Recharge wells
	Operational	Industrial Park East (O)	Pump and treat (C)	Recharge wells
	Operational	Airport (O)	Re-circulation (C)	In-well recharge
	Operational	BGRR/WCF Sr-90	Pump and treat (I)	Dry wells
	Operational	Chemical Holes Sr-90	Pump and treat (I)	Dry wells
	Operational	South Boundary	Pump and treat (A)	Recharge basin
	Stand-by	HFBR Tritium	Pump and recharge (*)	Recharge basin
OU IV	Completed	1977 Spill	AS/SVE (C)	Not applicable
OU VI	Operational	Ethylene dibromide (O)	Pump and treat (C)	Recharge wells

(A): Water treated using air stripping tower.
(C): Water or off-gas treated using activated carbon.
(I): Water treated using ion exchange.
(O): Treatment system located off site.
(*): Tritium cannot be removed from groundwater using conventional treatment methods. VOCs commingled with HFBR tritium plume were treated by air stripping.