# 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, and 2) reduce contaminant concentrations in the Upper Glacial aquifer to below regulatory standards within 30 years. The extent of volatile organic compound (VOC) and radionuclide contamination in groundwater in the central and southern areas of BNL is shown on Figure 1.

Since the beginning of active groundwater remediation in 1997, more than 2,948 pounds of VOCs have been removed from the groundwater and over four billion gallons of treated water has been returned to the aquifer (Table 1). It is expected to take up to 10 years of aquifer treatment before widespread improvements in groundwater quality at BNL are achieved. Even so, some noticeable improvements in groundwater quality are evident by the successful cleanup of the Operable Unit (OU) IV VOC 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.

## Treatment System Capacity

To restore groundwater quality in the Upper Glacial aquifer within the 30-year cleanup timeframe, BNL has plans to construct seventeen groundwater treatment systems with a total treatment capacity of about 4,500 gpm. Fourteen of these systems are designed to treat VOC contamination, whereas the remaining three will treat or control radionuclide contamination (e.g., strontium-90 and tritium). To date, eight of the seventeen planned groundwater treatment plants have been constructed, with a total groundwater cleanup treatment capacity of 2,575 gpm. Six groundwater remediation systems are currently in operation. In 2000 and 2001, two treatment systems (the OU IV Air Sparging/Soil Vapor Extraction (AS/SVE) system, and the HFBR Pump & Recharge System) were placed in standby mode, because they substantially met their cleanup goals. Figure 1 shows the locations of the current and planned groundwater treatment systems.

**Figure 1**: Extent of groundwater contamination and locations of current and planned groundwater treatment systems (Note: the OU V eastern VOC plume and HFBR tritium plume are not shown).

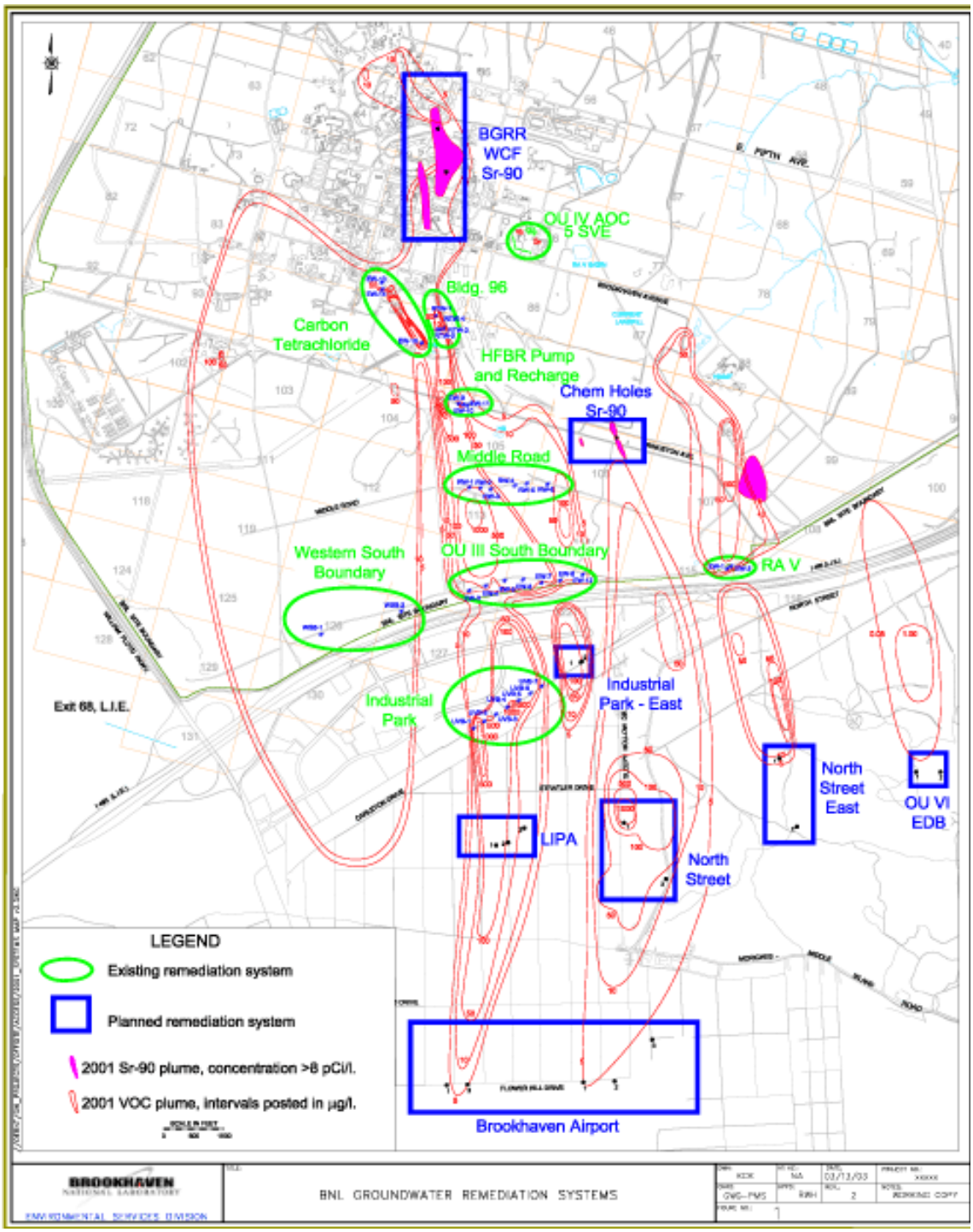

**Table 1:** Groundwater Remediation Systems Treatment Summary for 1997 – 2001.

| Remediation System | Water Treated (Gallons) | VOCs Removed (Pounds) |
|---|---|---|
| OU III South Boundary | 1,558,436,850 | 1,709 |
| OU III Industrial Park [(a)] | 390,693,000 | 448 |
| Carbon Tetrachloride [(a)] | 88,337,300 | 236 |
| OU I South Boundary | 1,740,939,000 | 254 |
| HFBR Tritium Plume [(b)] | 241,528,000 | 180 |
| OU IV AS/SVE [(d)] | (c) | 47 |
| Building 96 | 24,238,416 | 35 |
| Middle Road | 55,353,550 | 39 |
| **Total** | **4,099,526,116** | **2,948** |

Notes:

[(a)] Treatment system not installed/operational until 1999.

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

[(c)] Air Sparging/Soil Vapor Extraction system performance measured by pounds of VOC removed per cubic feet of air treated.

[(d)] System was shut down and placed in standby mode in January 2001.

## 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 or to be employed at each of the operating and planned 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 an 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. This system consisted of 48 air sparge wells and 23 vapor extraction wells. Air is introduced into the AS wells (screened below the water table) via a two-staged rotary lobe blower. The air strips 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, Oxygen Release Compound (ORC) was injected into the groundwater to enhance the biodegradation of residual petroleum hydrocarbons.

## Treatment Methods for Radionuclides

The remediation of radiologically contaminated groundwater began soon after the 1997 discovery of the HFBR tritium plume, and an engineering study is currently being conducted to determine the feasibility of treating several strontium-90 plumes.

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 stand-by 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 the 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 wells in twenty-one separate pumping events. The water was transported off-site for disposal at an Environmental Protection Agency approved facility. (Note: Tritium cannot be removed from groundwater using conventional treatment methods.)

Remediation of strontium-90 contaminated groundwater is planned for the Brookhaven Graphite Research Reactor/Waste Concentration Facility (BGRR/WCF) area and the Chemical/Animal Holes area. A pilot study scheduled for 2003 at the Chemical/Animal Holes will test the feasibility of remediating groundwater containing high concentrations of strontium-90 by extracting it, treating it with synthetic zeolite

resin, and recharge the treated water to the aquifer via dry wells. If the pilot study is successful, this technology could be used for strontium-90 contaminated water in the BGRR/WCF area.

**Table 2.** Summary of current and planned BNL groundwater treatment systems.

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