Volume II

Groundwater Status Report

2005 Site Environmental Report

BROOKHAVEN NATIONAL LABORATORY

2005
SITE ENVIRONMENTAL REPORT
VOLUME II
GROUNDWATER STATUS REPORT

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Environmental and Waste Management Services Division
Long Term Environmental Operations, Safety, and Security Group

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Acronyms and Abbreviations

These acronyms and abbreviations reflect the typical manner in which terms are used in Volume II of this document, and may not apply to all situations.

AGS	Alternating Gradient Synchrotron
AOC	Area of Concern
AS/SVE	Air Sparge/Soil Vapor Extraction
ASL	Analytical Services Laboratory
ASTM	American Society for Testing and Materials
AWQS	Ambient Water Quality Standards
BERA	Brookhaven Employees Recreation Association
BGRR	Brookhaven Graphite Research Reactor
BLIP	Brookhaven LINAC Isotope Producer
BLS	below land surface
BMRR	Brookhaven Medical Research Reactor
BNL	Brookhaven National Laboratory
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CFR	Code of Federal Regulations
COC	Chain of Custody
CRDL	Contract Required Detection Limit
CSF	Central Steam Facility
CY	calendar year
DCA	1,1-dichloroethane
DCE	1,1-dichloroethene
DCG	Derived Concentration Guide
DMR	Discharge Monitoring Report
DOE	U.S. Department of Energy
DQO	Data Quality Objective
DTW	Depth to Water
DWS	Drinking Water Standard
EDB	ethylene dibromide
EDD	Electronic Data Deliverable
EE/CA	Engineering Evaluation/Cost Analysis
EIMS	Environmental Information Management System
EM	Environmental Management
EMS	Environmental Management System
EPA	United States Environmental Protection Agency
ER	Environmental Restoration
ERP	Emissions Rate Potential
ES	Environmental Surveillance
ESD	Explanation of Significant Differences
EWMSD	Environmental and Waste Management Services Division
FFA	Federal Facility Agreement
FRP	Facility Response Plan
FFS	Focused Feasibility Study
FS	Feasibility Study
ft msl	feet above mean sea level
GAC	granular activated carbon
gal/hr	gallons per hour
GeV	giga electron volt
GPM	gallons per minute
HFBR	High Flux Beam Reactor
HWMF	Hazardous Waste Management Facility
IAG	Inter Agency Agreement
ID	identification
K gal	thousand gallons
lb/gal	pounds per gallon
lbs	pounds
LEL	Lower Explosive Limit
LIE	Long Island Expressway
LINAC	Linear Accelerator
LIPA	Long Island Power Authority
LOAEL	Lowest Observed Adverse Effects Level
MCL	Maximum Contaminant Level
MDL	Minimum Detection Limit
mg/L	milligrams per liter
MGD	millions of gallons per day
MNA	Monitored Natural Attenuation
MPF	Major Petroleum Facility
MS/MSD	Matrix Spike/Matrix Spike Duplicate
msl	mean sea level
MTBE	methyl tertiary butyl ether
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
NSRL	NASA Space Radiation Laboratory
NYCRR	New York Code of Rules and Regulations
NYS	New York State

NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
O&M	Operation and Maintenance
OU	Operable Unit
PCBs	polychlorinated biphenyls
PCE	tetrachloroethylene
pCi/L	pico Curies per liter
PE	Plant Engineering
PLC	programmable logic controller
ppb	parts per billion
QA/QC	Quality Assurance and Quality Control
RA V	Removal Action V
RCRA	Resource Conservation and Recovery Act
RHIC	Relativistic Heavy Ion Collider
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RPD	Relative Percent Difference
RTW	Recirculating Treatment Well
SCDHS	Suffolk County Department of Health Services
SCGs	Standards, Criteria and Guidances
SCWA	Suffolk County Water Authority
SDG	Sample Delivery Group
SDWA	Safe Drinking Water Act
SOP	Standard Operating Procedure
SPCC	Spill Prevention Control and Countermeasures
SPDES	State Pollutant Discharge Elimination System
Sr-90	strontium-90
µg/L	micrograms per liter

2005 BROOKHAVEN NATIONAL LABORATORY GROUNDWATER STATUS REPORT

Executive Summary

The mission of the Laboratory's Groundwater Protection Program is to protect and restore the aquifer system at Brookhaven National Laboratory (BNL). Four key elements make up the program:

- **Pollution prevention** – preventing the potential pollution of groundwater at the source
- **Monitoring** – monitoring the effectiveness of pollution-prevention efforts, as well as progress in restoring contaminated groundwater
- **Restoration** – restoring groundwater quality that BNL has impacted
- **Communication** – communicating the findings and the results of the program to regulators and other stakeholders

The *2005 BNL Groundwater Status Report* is a comprehensive summary of data collected during the calendar year, and an evaluation of Groundwater Protection Program performance. This is the tenth annual groundwater status report issued by BNL. This document examines the performance of the program on a project-by-project basis, as well as comprehensively in a "watershed-like" analysis.

How to Use This Document. This detailed technical document includes summaries of laboratory data, as well as data interpretations. It is intended for internal BNL users, regulators, and other technically oriented stakeholders. Less technical summaries of this information can be obtained through the BNL website, BNL Community Relations office, as well as Chapter 7 of this *Site Environmental Report*. Environmental Restoration (ER) refers to work being performed under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), including measuring and monitoring of groundwater remediation performance, and efforts in achieving cleanup goals. Environmental Surveillance (ES) refers to the monitoring of groundwater quality at active research and support facilities, primarily in response to Department of Energy (DOE) Order 450.1, Environmental Protection. Data are presented in five key subject areas:

- Improvements to the understanding of the hydrogeologic environment beneath BNL and surrounding areas
- Identification of any new impacts on groundwater quality due to BNL's active operations
- Progress in cleaning up the groundwater contamination
- Performance of individual groundwater remediation systems
- Recommended changes to the groundwater protection program

This document satisfies BNL's requirement to report groundwater data under the Interagency Agreement (IAG) and partially fulfills the commitment of BNL's Groundwater Protection Program to communicate the findings and progress of the program to regulators and stakeholders.

Chapter 1 summarizes the drivers of the data collection work in 2005, the site's groundwater classification, and the objectives of the groundwater monitoring efforts. Chapter 2 discusses improvements to our understanding of the hydrogeologic environment at BNL and its surrounding area. It also summarizes the dynamics of the groundwater flow system in 2005. Chapter 3 summarizes the groundwater cleanup data, progress towards achieving the site's cleanup goal, and recommended modifications to the remediation systems or monitoring programs. Chapter 4 summarizes the groundwater surveillance data used to verify that operational and engineering controls are preventing further contamination from the site's active experimental and support facilities. The recommended changes to the Groundwater Protection Program are summarized in Chapter 5.

HYDROGEOLOGIC DATA

The following were important hydrogeologic findings in 2005.

- Groundwater flow directions in the central portion of the site during much of 2005 had a significant easterly component due to changes in supply well pumping. Due to equipment problems and increased demand, the eastern supply well field pumped greater than 50% of the total volume during February-March and again from June-August. This change from the desired 75% supply well pumpage from the western well field resulted in this shift. Normal supply well pumping distribution resumed in late September 2005 and normal flow conditions were again observed.
- Total precipitation in 2005 was recorded as 50.1 inches, above the annual average of 48.5 inches. The first nine months of 2005 featured below normal average monthly precipitation, continuing a below normal trend begun in 2004. This run of below average precipitation ended in October of 2005 when BNL recorded a record monthly total precipitation in October of 22.1 inches. In an average year, it is estimated that 24 inches of rainfall recharge the Upper Glacial aquifer. The recharge rate for 2005 was estimated at approximately 25 inches.

PROGRESS IN GROUNDWATER RESTORATION ACTIONS (CERCLA)

Table E-1 summarizes the status and progress of groundwater cleanup at BNL under the provisions of CERCLA. In 2005, 472 pounds of volatile organic compounds (VOCs) were removed from the aquifers by the treatment systems. To date, 5,280 of the estimated 25,000 to 30,000 pounds of VOCs in the aquifer have been removed. The Operable Unit (OU) III Chemical Holes Strontium-90 System has removed 1.75 mCi of strontium-90 (Sr-90) from the Upper Glacial aquifer to date out of a projected 19.6 mCi total. The Operable Unit (OU) III BGRR Strontium-90 system was started up in early 2005 and removed 4.15 mCi of strontium-90 during the year out of a projected 63.8 mCi total.

Groundwater remediation is expected to be a long-term process for most of the plumes. Noticeable improvements in groundwater quality are evident in the OU I South Boundary, OU III Carbon Tetrachloride, OU III LIPA, and OU III South Boundary areas. Groundwater remediation activities are expected to continue until approximately 2030 to meet the ultimate cleanup objective for most of the plumes (i.e., to reduce VOC contaminant levels in the Upper Glacial aquifer to below maximum contaminant levels [MCLs]). The specific goals are as follows:

- Achieve MCLS for VOC in Upper Glacial aquifer by 2030
- Achieve MCLs for VOCs in Magothy aquifer by 2065
- Achieve MCLs for Sr-90 at BGRR in Upper Glacial aquifer by 2070
- Achive MCLs for Sr-90 at Chemical Holes in Upper Glacial aquifer by 2040

The cleanup objectives will be met by a combination of active treatment and natural attenuation. The comprehensive groundwater monitoring program will guide the remediation progress.

The locations and extent of the primary VOC and radionuclide plumes at BNL as of December 2005 are summarized in Figures E-1 and E-2, respectively. Significant items of interest during 2005 were the following.

- 739 wells were sampled as part of the Long Term Environmental Operations Safety and Security (LEOSS) Groundwater Monitoring Program in 2005, comprising a total of 2,282 groundwater samples. BNL continued to make significant progress in characterizing and restoring groundwater quality at the site. By the end of 2005, twelve VOC groundwater remediation systems were in operation, as well as the Chemical Holes Strontium-90 Treatment System. The second Sr-90 treatment system, for the Brookhaven Graphite Research Reactor/Waste Concentration Facility (BGRR/WCF) plumes began operation in early 2005. The High Flux Beam Reactor (HFBR) Tritium Pump and Recharge System remained in standby mode in 2005. A petition to shut down the Building 96 Treatment System was approved by the regulators, and the system was subsequently placed in standby mode in 2005. Due to increasing VOCs, the northern-most extraction well was restarted in October 2005.

- During 2005, 1.7 billion gallons of groundwater were treated. 14 of the 16 groundwater treatment systems were operational in 2005 (**Table E-1**).
- Tritium concentrations directly downgradient from the HFBR have remained relatively low since the first quarter of 2004 when a concentration of 378,000 pCi/L was detected in well 075-43. The highest concentration detected in this area during 2005 was 243,000. The downgradient extent of the higher concentration segment of the HFBR tritium plume was extensively characterized in early 2006. The OU III ROD contingency trigger value of 25,000 pCi/L at Chilled Water Facility Road was exceeded during this characterization which required BNL to evaluate the possibility of reactivating the HFBR tritium pump and recharge wells. Additional groundwater characterization was performed in the vicinity of Weaver Drive where tritium concentrations were observed below the OU III ROD trigger level of 20,000 pCi/L, which requires reactivation of the pump and recharge wells. An evaluation of the data including a recommendation to keep the wells in standby mode and increase monitoring in the downgradient area of the plume are included in **Section 3.2.17** of this report.
- The second and third injection of potassium permanganate in the Building 96 source area were performed in April 2005 and January 2006, respectively. Groundwater monitoring continues to determine the effectiveness of this source remediation. Progress of the groundwater restoration program is summarized in Table E-2.
- The BGRR Strontium-90 system was started in January 2005. The system has been operating effectively and a total of 4.15 mCi of strontium-90 were removed from the aquifer.

Other progress highlights include:

- The OU I South Boundary system began pulse pumping in September 2005 due to low VOC concentrations.
- The OU III Carbon Tetrachloride system remained on standby as per the petition for shutdown with the exception of operating EW-15 from April to May 2005.
- OU III Middle Road extraction wells EW-4 and EW-5 remained on standby due to low VOC concentrations.
- OU III South Boundary extraction well EW-12 remained on standby due to low VOC concentrations.
- OU III Western South Boundary system began pulse pumping in September 2005 due to low VOC concentrations.
- The OU III Airport system began pulse pumping in September 2005 due to low VOCs.
- The clinptillolite resin was utilized at both Sr-90 treatment systems and proved to work effectively.

INSTITUTIONAL CONTROLS

Institutional controls are in place at BNL to ensure effectiveness of all groundwater remedies. During 2005, the institutional controls continue to be effective in protecting human health and the environment. In accordance with the *BNL Land Use Controls Management Plan*, dated August 2005, the following institutional controls continued to be implemented for the groundwater remediation program.

- Groundwater monitoring, including BNL potable supply systems and Suffolk County Department of Health Services (SCDHS) monitoring of Suffolk County Water Authority (SCWA) well fields closest to BNL
- 5-year reviews, as required by CERCLA, until cleanup goals are met and to determine the effectiveness of the groundwater monitoring program
- Controls on the installation of new supply wells and recharge basins on BNL property
- Public water service in plume areas south of BNL
- Prohibitions on the installation of new potable water supply wells where public water service exists (Suffolk County Sanitary Code Article 4)
- Property access agreements for treatment systems off of BNL property.

Table E-1.
BNL Groundwater Remediation System Treatment Summary for 1997 – 2005.

Remediation System (start date)	1997 – 2004 Water Treated (gallons)	1997 – 2004 VOCs Removed (pounds)(c)	2005 Water Treated (gallons)	2005 VOCs Removed (pounds)(c)
OU III South Boundary (June 1997)	2,564,859,850	2,276	248,240,000	133
OU III Industrial Park (Sept. 1999)	966,928,330	838	116,370,000	63
OU III W. South Boundary (Sept. 2002)	357,048,000	32	120,115,000	7
OU III Carbon Tetrachloride (Oct. 1999)	150,164,075	348	3,374,000	1
OU I South Boundary (Dec. 1996)	2,696,275,000	313	196,974,000	10
OU III HFBR Tritium Plume (May 1997) (a)	241,528,000	180	0	0
OU IV AS/SVE (Nov. 1997) (b)	--	35	0	0
OU III Building 96 (Feb. 2001)	122,865,416	67	9,692,000	2
OU III Middle Road (Oct. 2001)	808,353,550	520	157,297,000	88
OU III Industrial Park East (May 2004)	57,113,000	17	86,485,000	7
OU III North Street (June 2004)	144,702,000	115	201,139,000	72
OU III North Street East (June 2004)	84,000,000	5	162,900,000	6
OU III LIPA/Airport (June 2004)	134,444,000	62	303,238,000	83
OU VI EDB (August 2004)	20,000,000	<1	157,652,000	<1
VOC System Total	8,348,281,221	4,808	1,763,476,000	472
OU III Chemical Holes Sr-90 (Feb 2003)	5,060,826	1.17(d)	1,552,000	0.57 (d)
OU III BGRR Sr-90 (June 2005)	-	-	3,576,000	4.15 (d)
Sr-90 SystemTotal	5,060,826	1.17(d)	5,128,000	4.72 (d)
Grand Total	8,353,342,047		1,768,604,000	

Notes:

(a) System was shut down and placed in standby mode on Sept. 29, 2000.
(b) Air Sparging/Soil Vapor Extraction system performance measured by pounds of VOC removed. System was dismantled in December 2003.
(c) Values rounded to the nearest whole number.
(d) Sr-90 removal expressed in mCi.

ENVIRONMENTAL SURVEILLANCE (FACILITY) MONITORING RESULTS

During 2005, the Environmental Surveillance (ES) Program monitored groundwater quality at 10 active research and support facilities. Groundwater samples were collected from 125 wells during 285 individual sampling events. Although no new impacts to groundwater quality were discovered during 2005, groundwater quality continues to be impacted at four facilities: continued high levels of tritium at the g-2/VQ-12 area of the Alternating Gradient Synchrotron (AGS) facility, tritium at the Brookhaven Linac Isotope Producer (BLIP), and low-level VOCs at the Motor Pool/Facility Maintenance area and the Upton Service Station. Highlights are as follows.

- Tritium continues to be detected in wells located approximately 200 feet downgradient of the g-2/VQ-12 source area, but at much lower concentrations than those observed in 2002, when tritium concentrations up to 3,440,000 pCi/L were observed. Since June 2004, tritium concentrations in wells directly downgradient of the source area have been less than 150,000 pCi/L, with samples from six of eight quarterly monitoring periods being less than 100,000 pCi/L. In the last quarter of 2005, the maximum tritium concentration was 86,000 pCi/L. The highest tritium concentration observed during 2005 was 150,000 pCi/L in a temporary well south of the Waste Concentration Facility, located approximately 1,000 feet downgradient of the source area. Although the engineered stormwater controls are effectively protecting the activated soil shielding at the source area, monitoring data suggest that the continued release of tritium appears to be related to the flushing of residual tritium from the vadose zone following significant natural periodic fluctuations in the local water table.

- During 2005, tritium concentrations exceeded the 20,000 pCi/L drinking standard in one well immediately downgradient of BLIP, with a concentration of 46,500 pCi/L in July. Similar to the g-2/VQ-12 source area discussed above, the periodic release of tritium at the BLIP facility appears to be related to the flushing of residual tritium from the vadose zone following natural periodic fluctuations in the local water table.

- At the Motor Pool/Site Maintenance area, the solvents TCA and DCA continue to be detected at concentrations greater than the typical New York State Ambient Water Quality Standards (NYS AWQS) of 5 µg/L. TCA was detected at concentrations up to 32.7 µg/L, and DCA was detected at concentrations up to 11.9 µg/L. Concentrations of the gasoline additive methyl tertiary butyl-ether (MTBE), declined from a maximum concentration of 18 µg/L in 2004, to a maximum of 3.9 µg/L in 2005. The NYS AWQS for MTBE is 10 µg/L. No VOCs or floating petroleum was detected in the two monitoring wells downgradient of the gasoline USTs.

- At the Service Station, VOCs associated with petroleum products and solvents continue to be detected in several monitoring wells directly downgradient of the station. Petroleum-related compounds included m/p xylene at 30 µg/L, o-xylene at 15 µg/L, 1,2,4-trimethylbenzene at 20 µg/L, and 1,3,5-trimethylbenzene at 5.5 µg/L. The solvent tetrachloroethylene (PCE) was detected in several wells at a maximum concentration of 5.5 µg/L. The gasoline additive MTBE, which had been detected at a maximum concentration of 14 µg/L during 2004, dropped to a maximum concentration of 0.6 µg/L in 2005. No floating petroleum was detected in the monitoring wells.

- Monitoring of the leak detection systems at both vehicle maintenance facilities indicates that the gasoline storage tanks and associated distribution lines are not leaking. Furthermore, evaluation of current vehicle maintenance operations indicates that all waste oils and used solvents are being properly stored and recycled. Therefore, it is believed that the contaminants detected in groundwater at these facilities originate from historical vehicle maintenance activities, and are not related to current operations.

PROPOSED CHANGES TO THE GROUNDWATER PROTECTION PROGRAM

The data summarized in this report are the basis for several significant operational and groundwater monitoring changes to the groundwater protection and cleanup programs. A summary of those significant changes follows (more details of which are provided in Chapter 5).

- **OU I South Boundary System** – Continue pumping reduction and pulsing begun in 2005. Install an additional permanent monitoring well upgradient of the extraction wells to continue to track the remaining plume concentrations as they migrate to the extraction wells during the spring of 2006. Continue O&M mode sampling frequency.
- **Carbon Tetrachloride System** – Maintain system in standby mode and restart extraction well(s), if necessary.
- **Building 96** – No additional potassium permanganate injections are recommended for 2006. Groundwater monitoring will continue and if VOC concentrations do not show a decline in the source area wells, alternative methods for remediating the contamination in the silty zone upgradient from extraction well RTW-1 will be evaluated. Place extraction well RTW-1 back on standby due to absence of VOCs in this well.
- **Middle Road System** – Shut down extraction well RW-6 due to low VOC concentrations (below MCLs in 2005).Continue extraction wells RW-4 and RW-5 in standby mode during 2006. Install one or two temporary wells near the HFBR tritium extraction wells to monitor the high VOC concentration portion of the plume as recommended in the 2004 Groundwater Status Report. Based on the results from the temporary wells, a monitoring well may be installed.
- **OU III South Boundary** – Shut down extraction well EW-8, due to low VOC concentrations in this well. Continue EW-12 in standby mode due to low VOC concentrations. Install a temporary well into the Magothy aquifer downgradient of the Middle Road treatment system to enhance the monitoring well network as recommended in the 2004 Groundwater Status Report. This will help determine the extent of VOCs in the Magothy aquifer between the Middle Road and South Boundary plume monitoring networks, as well as provide additional hydrogeologic data.
- **Western South Boundary** – Due to the low influent concentrations and because five out of seven plume core wells have reached the cleanup objective of 20 µg/L TVOCs, it is recommended that pulse pumping the extraction wells continue.
- **Industrial Park System** – The system should continue operations at 60 gpm per well except for well UVB-1, which is to remain in a standby mode.
- **Industrial Park East** – Install an additional deeper monitoring well adjacent to well 000-495, to more accurately define the VOC plume.
- **North Street** - Change the monitoring well sampling schedule from the startup to O&M phase sampling frequency.
- **North Street East** - Begin pulse pumping of both extraction wells since the system influent concentrations have remained very low over the past year, and 90% of the monitoring wells are already below the capture goal of 50 µg/L TVOC.
- **Airport System** – Continue pulse pumping of treatment system wells due to the absence of VOC concentrations above MCLs in monitoring wells or extraction wells.
- **EDB System** - Due to the detection of EDB in well 000-498, which is near the western edge of the capture zone for extraction well EW-1E, increase the pumping rate at EW-1E to increase the capture zone.
- **HFBR Tritium Plume –** Modify the monitoring program to incorporate semi-annual geoprobes at Chilled Water Plant Road and Weaver Drive and reduce monitoring in the western portion of the

permanent monitoring well network (see Section 3.2.17 for details). Evaluate the location of the HFBR pump and recharge wells on Princeton Avenue with respect to the tritium plume as it is presently configured. Make recommendation for the addition of an extraction well further to the east if necessary. Evaluate plume data with regulators on a semi-annual basis with respect to the OU III ROD contingency triggers at Chilled Water Plant Road and Weaver Drive.

- **Chemical Holes Sr-90 –** Evaluate the data obtained in April and May 2006 from several temporary wells in the plume segment downgradient of the extraction well and further define the leading edge of the plume and evaluate the need for system changes.
- **OU V Plume Monitoring** – It is recommended that eight monitoring wells (049-05, 049-06, 050-01, 050-02, 061-04, 061-05, 000-122, and 000-123) continue to be analyzed for perchlorate in 2006.

Table E-2.
Groundwater Restoration Progress.

Unit	Project	Target	Mode	Treatment Type	Treatment Progress	Years of Operation	Groundwater Quality Highlights
OU I	OU I South Boundary (RA V)	VOCs	Operational (pulse)	Pump and Treat (P&T) with air stripping (AS)	323 lb of VOCs treated to date	9 of 14	The decline in VOCs leveled off. Hot spot near the former HWMF showed a total VOC decrease from 64 µg/Lin 2004 to 6 µg/L in 2005.
	Current Landfill	VOCs tritium	Long Term Monitoring & Maintenance	Landfill capping	Cap is maintained and stable	10 of 30	VOCs and tritium stable or slightly decreasing.
	Former Landfill	VOCs Sr-90 tritium	Long Term Monitoring & Maintenance	Landfill capping	Cap is maintained and stable.	9 of 30	Continued decline in Sr-90. VOCs have been below NYS AWQS since 1998.
	Former HWMF	Sr-90	Long Term Response Action	Monitoring	NA	NA	Sr-90 detected at 12 pCi/L in well 088-26 in 2005, down from 21.6 in 2003.
OU III	Chemical/Animal Holes	Sr-90	Operational	P&T with ion exchange (IE)	1.75 mCi Sr-90 removed to date	3 of 10	Pilot Study completed. System operational since February 2003. Changed to clinoptilolite resin late 2004.
	Carbon Tetrachloride source control	VOCs (carbon tetra-chloride)	Standby	P&T with carbon treatment	349 lb of VOCs treated to date	Complete	Petition for shutdown approved, system placed on standby August 2004. EW-15 restarted 4/05 to 5/05 due to increased carbon tet concentrations.
	Building 96 source control	VOCs	RTW-1 operational, RTW-2,3,4 in standby	Recirculation wells with AS	69 lbs of VOCs treated to date	4 of 2 (planned)	Treatment wells RTW-2, -3, and -4 remained in standby mode as per petition for shutdown. Applications of potassium permanganate performed for silt zone in April 2005 and January 2006. Treatment well RTW-1 was shut down in June and restarted in October 2005 due to rebounding VOC concentrations.
	South Boundary	VOCs	Operational	P&T with AS	2,409 lbs of VOCs treated to date	8 of 13	Continued decline in monitoring well VOC concentrations at the site boundary with the exception of several wells in the vicinity of EW-4 and EW-5. EW-12 maintained in standby mode in 2005 due to low VOC concentrations.
	Middle Road	VOCs	Operational	P&T with AS	609 lbs of VOCs treated to date	4 of 25	Extraction wells RW-1 and -2 show moderate VOC levels. Eastern extraction wells showing low VOC concentrations. RW-4 and RW-5 remained in standby mode due to low VOCs.

continued

Table E-2 *(continued)***.**
Groundwater Restoration Progress.

Unit	Project	Target	Mode	Treatment Type	Treatment Progress	Years of Operation	Groundwater Quality Highlights
OU III (cont.)	Western South Boundary	VOCs	Operational (Pulse)	P&T with AS	39 lbs of VOCs treated to date	3 of 11	System was placed in pulse pumping mode during September 2005 due to low VOC concentrations. Maximum total VOCs in monitoring well during 2005 was 48 µg/L.
	Industrial Park	VOCs	Operational	In-well stripping	901 lbs. of VOCs treated to date.	6 of 12	Generally decreasing VOC levels with the exception of extraction wells UVB-2 and UVB-3.
	Industrial Park East	VOCs	Operational	P&T with carbon treatment	24 lbs. of VOCs treated to date.	2 of 5	Concentrations in VOC plume in this area continued a decreasing trend in 2005.
	North Street	VOCs	Operational	P&T with carbon treatment	187 lbs. of VOCs treated to date.	2 of 8	High concentration segment of plume continues to be located in the vicinity of NS-1.
	North Street East	VOCs	Operational	P&T with carbon	11 lbs. of VOCs treated to date.	2 of 10	Concentrations in plume core wells continued to decrease in 2005.
	Long Island Power Authority (LIPA) Right of Way/ Airport	VOCs	Operational	P&T and recirculation wells with carbon treatment	145 lbs. of VOCs treated to date.	2 of 10	Airport wells began pulse pumping in September 2005. Low VOC concentrations continue at Airport.
	Magothy	VOCs	Operational	P&T with carbon treatment	NA	NA	Significant mass removal which began in 2004 continued at LIPA extraction well.
	HFBR Tritium	Tritium	The pump & recharge system remained in standby	Monitoring, Contingency of pump and recharge	0.2 Ci removed for off-site disposal. 180 lb of VOCs also removed from aquifer & treated.	NA	Temporary wells installed to support plume monitoring. Peak concentration observed in 2005 was 243,000 pCi/L along Cornell Ave., down from 433,000 pCi/L along Temple Place.
	BGRR/Waste Concentration Facility (WCF)	Sr-90	Operational	P&T with IE	4.15 mCi	1 of 10	System began operation July 2005. A total of 4.15 mCi strontium-90 was removed for the year. Extraction well RW-2 was off from October 2005 until March 2006 due to the shift of the g-2 tritium plume into this area.
OU IV	AS/SVE system	VOCs	Decommis-sioned	Air sparging/ soil vapor extraction	35 lb of VOCs treated to date.	Complete	VOC concentrations in monitoring wells remain low. System decommissioned in Dec. 2003.
	AOC 6/650 sump outfall	Sr-90	Long Term Response Action	Monitored Natural Attenuation (MNA)	Plume slowly migrating south within monitoring-well network.	NA	Sr-90 plume still migrating slowly southwest from Bldg. 650 sump outfall. Highest Sr-90 detection was 21.5 pCi/L, in well 76-169 (February 2005).
OU V	STP	VOCs, tritium	Long Term Response Action	MNA	NA	NA	Low-level VOC plume concentra-tions remained stable during 2005. Tritium continues to be detected in monitor wells above detection limits but well below

Table E-2 *(continued)***.**
Groundwater Restoration Progress.

Unit	Project	Target	Mode	Treatment Type	Treatment Progress	Years of Operation	Groundwater Quality Highlights
							NYS AWQS, and continued to slowly decline.
OU VI	Ethylene Dibromide (EDB)	EDB	Operational	P&T with carbon treatment	<1 lb of VOCs treated to date (1)	2 of 10	2005 was first full year of operation. The highest EDB concentration in a monitoring well in 2005 was 3.4 µg/L. The first detections of EDB in the extraction wells were observed in 2005.

Notes:
AS = Air Stripping
AS/SVE = Air Sparging/Soil Vapor Extraction
HWMF = Hazardous Waste Management Facility (former)
IE = Ion Exchange
MNA = Monitored Natural Attenuation
NA = Not Applicable
NYS AWQS = New York State Ambient Water Quality Standards
P&T = Pump and Treat
RA = Removal Action
STP = Sewage Treatment Plant

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1.0 INTRODUCTION AND OBJECTIVES

The mission of Brookhaven National Laboratory's Groundwater Protection Program is to protect and restore the aquifer system at BNL. The program is summarized in the *BNL Groundwater Protection Management Program Description* (Paquette et al. 2002). The program is built on four key elements:

- Pollution prevention–preventing the potential pollution of groundwater at the source
- Restoration–restoring groundwater that BNL operations have impacted
- Monitoring–monitoring the effectiveness of pollution-prevention efforts, as well as progress in restoring the quality of affected groundwater
- Communication–communicating the findings and results of the program to regulators and stakeholders

The *BNL Calendar Year 2005 Groundwater Status Report* is a comprehensive summary of groundwater data collected in 2005 that provides an interpretation of information on the performance of the Groundwater Protection Program. This is the eighth annual groundwater status report issued by the Laboratory. This document is unique in that it examines performance of the program on a project-by-project (facility-by-facility) basis, as well as comprehensively in a "watershed-like" analysis.

How To Use This Document. This document is a detailed technical report that includes analytical laboratory data, as well as data interpretations conducted by BNL's groundwater group. This technical document is intended for internal users, regulators, and other technically oriented stakeholders. Generalized summaries of this information can be obtained through BNL's website, and the Community Affairs Office. Data are presented in five key subject areas:

- Improvements to the understanding of the hydrogeologic environment and surrounding areas
- Identification of any new impacts to groundwater quality due to BNL's active operations
- Progress in cleaning contaminated groundwater
- Proposed changes to the groundwater protection program

This document satisfies BNL's requirement to report groundwater data under the Interagency Agreement and partially fulfills the commitment of the Groundwater Protection Program to communicate the program's findings and progress to regulators and stakeholders.

Chapter 1 discusses the drivers of the data collection work in 2005, the site's groundwater classification, and the objectives of groundwater monitoring. **Chapter 2** discusses improvements to our understanding of the hydrogeologic environment at BNL and its surrounding area. It also summarizes the dynamics of the groundwater flow system in 2005. In **Chapter 3**, the groundwater cleanup data and progress towards achieving the site's cleanup goal are described. **Chapter 4** outlines the groundwater surveillance data used to verify that operational and engineered controls are preventing further contamination from the site's active experimental and support facilities. **Chapter 5** is a summary of the proposed recommendations to the Groundwater Protection Program identified in Chapter 3.

Appendices A and **B** include hydrogeologic data that support the discussions in **Chapter 2.** **Appendix C** contains the analytical results for each sample obtained under the Environmental Restoration monitoring program. **Appendix D** contains analytical results for each sample obtained under the Environmental Surveillance program. Due to the volume of these data, all of the report appendices are included on a CD ROM, which significantly reduces the size of this report in printed format. The CD ROM has a contents table with active links; by selecting the specific project and analytical suite, the user will be directed to the associated table of results. The results also can be printed from the CD ROM. The groundwater results are arranged by specific monitoring project and analytical group: Volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), metals, general chemistry, pesticides/PCBs, and radionuclides. The data are organized further by well identification (ID) and the date of sample collection. Chemical/radionuclide concentrations, detection limits, and uncertainties are reported, along with a data verification, validation, and/or usability qualifier (if assigned), and/or a laboratory data qualifier. If a data verification/validation qualifier was not assigned, the laboratory data qualifier is shown. Results exceeding the corresponding groundwater standard or guidance criteria (see **Section 1.1.2**) are identified by bold text. Including the complete results enables the reader to analyze the data in detail. **Appendix E** contains information on sample collection, analysis, and Quality Assurance/Quality Control. **Appendix F** consists of data supporting the remediation system discussions in Chapter 3, and **Appendix G** is a compilation of data usability report forms. **Appendix H** contains the 2005 Environmental Monitoring Report for the Current and Former Landfill areas.

1.1 Groundwater Monitoring Program

Groundwater is monitored at BNL for two reasons:

1. BNL is committed to environmental stewardship and monitoring is an integral part of ISO 14001 Environmental Management Systems.
2. To meet regulatory requirements.

1.1.1 Regulatory Drivers

Activities at BNL are driven by federal and state regulations as well as DOE orders.

Comprehensive Environmental Response, Compensation and Liability Act

On December 21, 1989, BNL was included as a Superfund Site on the National Priorities List of contaminated sites identified for priority cleanup. DOE, EPA, and NYSDEC created a comprehensive Federal Facilities Agreement that integrated DOE’s response obligations under CERCLA, RCRA (the Resource Conservation and Recovery Act), and New York State hazardous waste regulations. The interagency agreement that was finalized and signed by these parties in May 1992 (EPA 1992) includes a requirement for groundwater monitoring.

New York State Regulations, Permits, and Licenses

The monitoring programs for the Current Landfill and Former Landfill are designed in accordance with post-closure Operation and Maintenance requirements specified in 6 NYCRR (New York Code of Rules and Regulations) Part 360, *Solid Waste Management Facilities*.

BNL’s Major Petroleum Facility (MPF) is operated under NYSDEC Bulk Petroleum Storage License No. 01-1700. This license requires BNL to routinely monitor the groundwater. Together with approved engineering controls, the groundwater-monitoring program verifies that storage operations for bulk fuel have not degraded the quality of the groundwater. The engineering controls and monitoring program for the MPF are described in the *BNL Spill Prevention, Control and Countermeasures Plan* (BNL 2001).

BNL’s Waste Management Facility (WMF) is a hazardous waste storage facility operated under NYSDEC Permit No. 1-422-00032/00102-0. The permit requires groundwater monitoring as a secondary means of verifying the effectiveness of the facility’s administrative and engineered controls.

DOE Orders

DOE Order 450.1, Section 5-D-14, *Responsibilities*, states that DOE facilities are required to "Conduct environmental monitoring, as appropriate, to support the site's ISMS [Integrated Safety Management System], to detect, characterize, and respond to releases from DOE activities; assess impacts; estimate dispersal patterns in the environment; characterize the pathways of exposure to members of the public; characterize the exposures and doses to individuals, to the population; and to evaluate the potential impacts to the biota in the vicinity of the DOE activity" (DOE 2003).

1.1.2 Groundwater Quality and Classification

In Suffolk County, drinking water supplies are obtained exclusively from groundwater aquifers (e.g., the Upper Glacial aquifer, the Magothy aquifer, and, to a limited extent, the Lloyd aquifer). EPA designated the Long Island aquifer system as a sole source aquifer in 1978, pursuant to Section 1424(e) of the Safe Drinking Water Act (SDWA). Groundwater in the sole source aquifers underlying the BNL site is classified as "Class GA Fresh Groundwater" by the State of New York (6 NYCRR Parts 700–705); the best usage of Class GA groundwater is as a source of potable water. Accordingly, in establishing the goals for protecting and remediating groundwater, BNL followed federal Drinking Water Standards (DWS), NYS DWS, and NYS Ambient Water Quality Standards (AWQS) for Class GA groundwater.

For drinking water supplies, the applicable federal MCLs are set forth in 40 CFR (Code of Federal Regulations) 141 (for primary MCLs) and 40 CFR 143 (for secondary MCLs). In New York State, the SDWA requirements relating to the distribution and monitoring of public water supplies are promulgated under the NYS Sanitary Code (10 NYCRR Part 5), enforced by SCDHS as an agent for the New York State Department of Health (NYSDOH). These regulations apply to any water supply that has at least five service connections or that regularly serves at least 25 individuals. BNL supplies water to approximately 3,500 employees and visitors and therefore must comply with these regulations. In addition, DOE Order 5400.5, *Radiation Protection of the Public and Environment* (DOE 1990), establishes Derived Concentration Guides (DCGs) for radionuclides not covered by existing federal or state regulations.

BNL evaluates the potential impact of radiological and nonradiological levels of contamination by comparing analytical results to NYS and DOE reference levels. Nonradiological data from groundwater samples collected from surveillance wells usually are compared to NYS AWQS (6 NYCRR Part 703.5). Radiological data are compared to the NYS AWQS for tritium, Sr-90, and gross beta; the NYS AWQS for gross alpha, radium-226, and radium-228; and the 40 CFR 141/DOE DCGs for determining the 4 mrem/yr dose for other beta- or gamma-emitting radionuclides.

Tables 1-1, 1-2, 1-3, and **1-4** show the regulatory and DOE "standards, criteria, and guidance" used for comparisons to BNL's groundwater data.

1.1.3 Monitoring Objectives

Groundwater monitoring is driven by regulatory requirements, DOE Orders, best management practice, and BNL's commitment to environmental stewardship. The Laboratory monitors its groundwater resources for the following reasons:

Groundwater Resource Management

- To support initiatives in protecting, managing, and remediating groundwater by refining the conceptual hydrogeologic model of the site and maintaining a current assessment of the dynamic patterns of groundwater flow and water table fluctuations.
- To determine the natural background concentrations for comparative purposes. The site's background wells provide information on the chemical composition of groundwater that has not been affected by BNL's activities. These data are a valuable reference for comparison with the data

on groundwater quality from affected areas. The network of wells also can warn of any contaminants originating from potential sources that may be located upgradient of the BNL site.

- To ensure that potable water supplies meet all regulatory requirements.

Groundwater Surveillance

- To verify that operational and engineered controls effectively prevent groundwater contamination.
- To trigger early action and communication, should the unexpected happen (e.g., control failure).
- To determine the efficacy of the operational and engineered control measures designed to protect the groundwater.
- To demonstrate compliance with applicable requirements for protecting and remediating groundwater.

Groundwater Restoration

- To track a dynamic groundwater cleanup problem when designing, constructing, and operating treatment systems.
- To measure the performance of the groundwater remediation efforts in achieving cleanup goals.
- To protect public health and the environment during the cleanup period.
- To define the extent and degree of groundwater contamination.
- To provide early warning of the arrival of a leading edge of a plume, thereby triggering contingency remedies to protect public health and the environment.

The details of the monitoring are described in the *BNL Environmental Monitoring Plan* (BNL 2000a, 2005). This plan includes a description of the source area, description of groundwater quality, criteria for selecting locations for groundwater monitoring, and the frequency of sampling and analysis. **Figure 1-1** highlights BNL's OU locations designated as part of the CERCLA program, and key site features. Details on the sampling parameters, frequency, and analysis by well are listed in **Tables 1-5** and **1-6**. **Figure 1-2** shows the locations of wells monitored as part of the Laboratory's groundwater protection program. Detailed groundwater monitoring rationale can be found in BNL's Environmental Monitoring Plan. Environmental Restoration groundwater monitoring has been streamlined into five general phases of monitoring **(Table 1-7)**:

<u>Start-up</u>
A quarterly sampling frequency is implemented on all wells for a period of two years. This increased sampling frequency provides sufficient data while the system operation is in its early stages.

<u>Operations and Maintenance (O&M)</u>
This is a period of reduced monitoring during the time when the system is in a routine operational state and varies for each system. This phase is also utilized for several plume monitoring programs not requiring active remediation including the OU V Sewage Treatment Plan and HFBR Tritium Plume.

<u>Shutdown Monitoring</u>
This is a two year period of monitoring implemented just prior to petitioning for system shut down. The increased sampling frequency provides the necessary data to support the shutdown petition.

Standby Monitoring

This is a period of reduced monitoring over five year duration to identify any rebounding of contaminant concentrations. If concentrations remain below MCLs the petition for closure and decommissioning of the system is recommend.

Post Closure Monitoring

This is a monitoring period of varying length for 20% of the key wells in a given project following system closure and continues until the ROD goal of meeting MCLs in the upper Glacial Aquifer by 2030 is reached. This phase is considerably longer for the Magothy and Sr-90 cleanups due to greater length of the time to reach MCLs required for those projects.

Since 2001, BNL has been using a structured Data Quality Objective (DQO) process to review and refine the groundwater monitoring and remediation projects. The results of the DQO reviews are documented annually in updates to the *BNL Environmental Monitoring Plan*.

Table 1-7. LEOSS Groundwater Monitoring Program – Well Sampling Frequency

Project Activity Phase	Well Type	Phase Duration (yrs.)	Sampling Frequency (events/yr.)
Start-up Monitoring	Plume Core	2	4x
	Plume Perimeter	2	4x
	Sentinel	2	4x
Operations & Maintenance (O&M) Monitoring	Plume Core	End Start-up to Shutdown*	2x
	Plume Perimeter	End Start-up to Shutdown*	2x
	Sentinel	End Start-up to Shutdown*	4x
Shutdown Monitoring	Plume Core	2	4x
	Plume Perimeter	2	4x
	Sentinel	2	4x
System Standby Monitoring	Key Plume Core	5	2x
	Plume Perimeter	5	1x
	Sentinel	5	2x
Post Closure Monitoring ***	20% of key wells	To 2030**	1x

Notes:
*- Varies by project, see schedule.
** - Magothy: 2070, BGRR Sr-90: 2075, S. Boundary Rad: 2038, Background: 2070, Chem Holes Sr-90: 2044
*** - verification monitoring for achieving MCLs.

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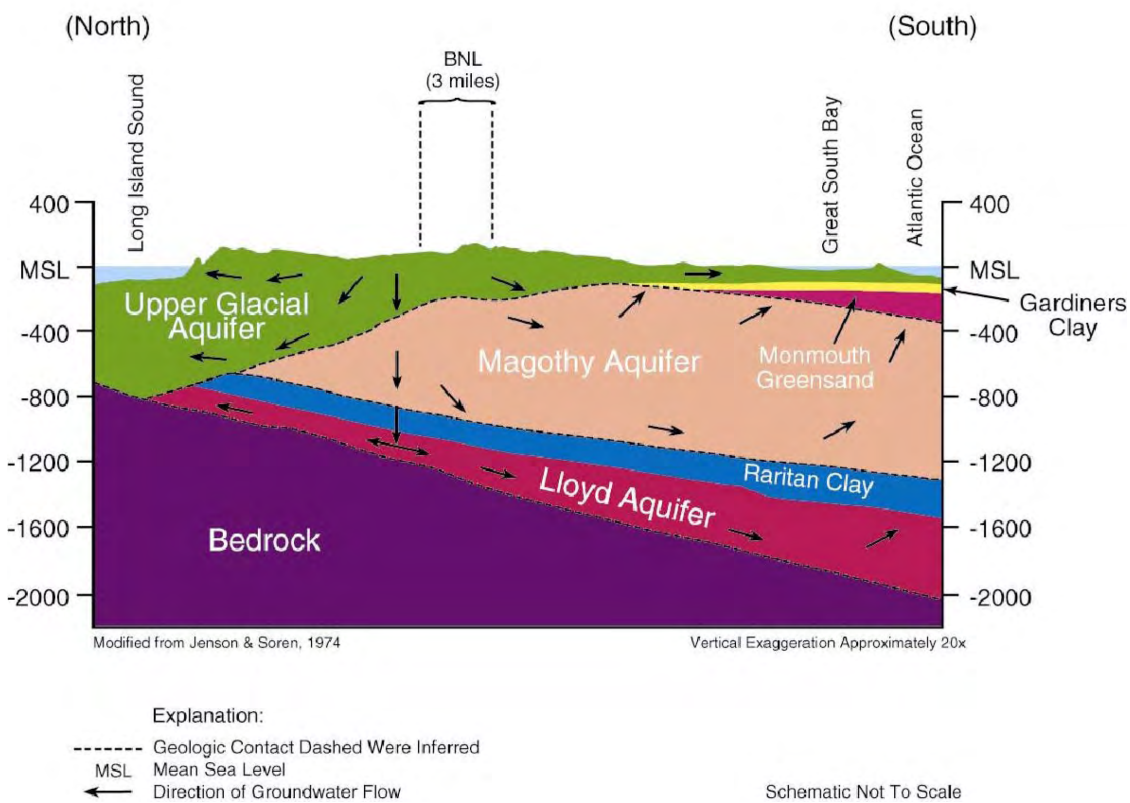
2.0 HYDROGEOLOGY

This section briefly describes the improvements to our understanding of the hydrogeologic environment at BNL and the surrounding area. It also summarizes the dynamics of the groundwater flow system in 2005 along with on-site pumping rates and rainfall recharge.

Detailed descriptions, including the lithology and the geometry of the aquifer underlying BNL and its surrounding areas, are found in the U.S. Geologic Survey (USGS) report by Scorca and others (1999), *Stratigraphy and Hydrologic Conditions at the Brookhaven National Laboratory and Vicinity, Suffolk County, New York, 1994–97,* and the USGS report by Wallace deLaguna (1963), *Geology of Brookhaven National Laboratory and Vicinity, Suffolk County New York.* The stratigraphy below BNL consists of approximately 1,300 feet of unconsolidated deposits overlying bedrock (**Figure 2-1**). Among these unconsolidated deposits, the current groundwater monitoring program focuses on groundwater quality within the Upper Pleistocene deposits, and the upper portions of the Matawan Group-Magothy Formation.

Figure 2-1. Generalized Geologic Cross Section in the Vicinity of Brookhaven National Laboratory.



The Pleistocene deposits are about 100–200 feet thick and are divided into two primary hydrogeologic units: undifferentiated sand and gravel outwash and moraine deposits, and the finer-grained, more poorly sorted stratigraphic Upton Unit. The Upton Unit makes up the lower portion of the Upper Glacial aquifer beneath several areas of the site. It generally consists of fine- to medium-white to greenish sand with interstitial clay. In addition to these two major hydrogeologic units, there are several other distinct hydrogeologic units within the Upper Glacial aquifer. They include localized, near-surface clay layers in the vicinity of the Peconic River (including the STP area), and reworked Magothy deposits that characterize the base of the aquifer in several areas. The Gardiners Clay is a regionally defined geologic unit that is discontinuous beneath BNL and areas to the south. Typically, it is characterized by variable amounts of green silty clay, sandy, and gravelly green clay, and clayey silt. Where it exists, the Gardiners

Clay acts as a confining or semi-confining unit that impedes the vertical flow and migration of contaminants between the Upper Glacial aquifer and the underlying Magothy aquifer.

The Magothy aquifer is composed of the continental deltaic deposits of the Cretaceous Age that unconformably underlie the Pleistocene deposits. The Magothy aquifer at BNL is approximately 800 feet thick, and because it is composed of fine sand interbedded with silt and clay, it is generally less permeable than the Upper Glacial aquifer. The Magothy aquifer is highly stratified. Of particular importance at BNL is that the upper portion of the Magothy contains extensive, locally continuous layers of grey-brown clay (referred to herein as the Magothy Brown Clay). Regionally, the Magothy Brown Clay is not interpreted as being continuous; however, beneath BNL and adjacent off-site areas, it acts as a confining unit (where it exists), impeding the vertical groundwater flow and movement of contaminants between the Upper Glacial and Magothy aquifers.

Regional patterns of groundwater flow near BNL are influenced by natural and artificial factors. **Figures 2-2 and 2-3** show the locations of pumping wells and recharge basins. Under natural conditions, recharge to the regional aquifer system is derived solely from precipitation. A regional groundwater divide exists immediately north of BNL near Route 25. It is oriented roughly east–west, and appears to coincide with the center line of a regional recharge area. Groundwater north of this divide flows northward, ultimately discharging to the Long Island Sound (**Figure 2-1**). Shallow groundwater in the BNL area generally flows to the south and east. During high water table conditions that groundwater can discharge into local surface water bodies such as the Peconic River and adjacent ponds. The BNL site is within a regional deep-water recharge area, where downward flow helps to replenish the deep sections of the Upper Glacial aquifer, the Magothy aquifer, and the Lloyd aquifer. South of BNL, groundwater flow becomes more horizontal and ultimately flows upward as it moves toward regional discharge areas such as Carmans River and Great South Bay. Superimposed on the natural regional field of groundwater flow are the artificial influences due to pumping and recharge operations.

2.1 Hydrogeologic Data

Various hydrogeologic data collection and summary activities were undertaken as part of the 2005 Groundwater Protection Program to evaluate groundwater flow patterns and conditions. This work is described in the following sections and includes the results of groundwater elevation monitoring, information on pumping and recharging activities on and off site, and precipitation data.

2.1.1 Groundwater Elevation Monitoring

Synoptic water levels are obtained quarterly from a network of on-site and off-site wells screened at various depths within the Upper Glacial aquifer and upper portions of the Magothy aquifer. These data are used to characterize the groundwater flow-field (direction and rate) and to evaluate seasonal and artificial variations in its flow patterns. Additional water level data from off-site wells are obtained from USGS.

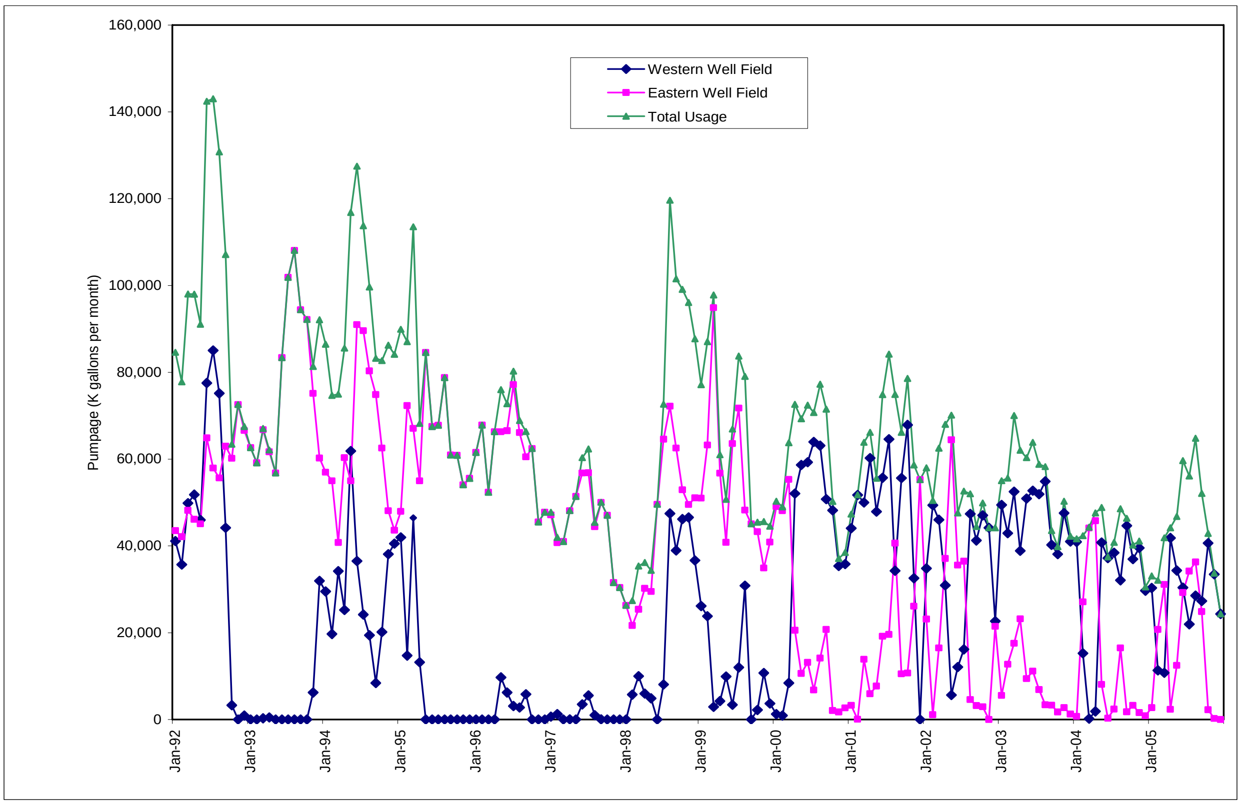
During 2005, water level data were collected during four synoptic events; from March 21st to 24th, June 11th to 15th, September 12th to 15th, and December 12th to 15th. These data were collected from 560 to 715 monitoring wells each period. Approximately 150 fewer wells were measured in March because an ice storm caused working conditions to become treacherous; the monitoring event was halted due to safety concerns. Water levels were measured with electronic water level indicators following BNL's Environmental Monitoring Standard Operating Procedure (EM-SOP-300). **Appendix A** (on the companion CD-ROM) has the depth-to-water (DTW) measurements and the calculated groundwater elevations for these quarterly synoptic measurements. Long-term and short-term hydrographs for select wells are discussed in **Section 2.2**.

2.1.2 Pumpage of On-Site Water Supply and Remediation Wells

BNL operates six water supply wells to provide potable and process cooling water and 40 active treatment wells. There are 12 treatment wells that are in standby mode. **Figures 2-2** and **2-3** show the locations of the water supply and remediation wells. The effects the groundwater withdrawals have on the aquifer system are discussed in **Section 2.2**.

Table 2-1 provides the monthly and total water usage for 2005 for the six on-site potable supply wells (4, 6, 7, 10, 11, and 12). It includes information on each well's screened interval and pumping capacity. These wells primarily withdraw groundwater from the middle section of the Upper Glacial aquifer. The variation in monthly pumpage primarily reflects changes in water demand, and maintenance schedules for the water supply system. The western potable well field includes wells 4, 6, and 7; the eastern field contains wells 10, 11, and 12. The BNL Water and Sanitary Planning Committee (formerly called the BNL Pump and Recharge Management Subcommittee) currently requires that the western well field be used as the primary source of water. Using the western well field minimizes the effects of supply well pumping on several segments of the groundwater contaminant plumes located in the center of the BNL site. **Figure 2-4** below summarizes monthly pumpage for the eastern and western well fields.

Figure 2-4.
Summary of BNL Supply Well Pumpage 1992 through 2005.



Overall, BNL's pumping of potable water has generally decreased since 1999. This reduction is mainly due to water conservation measures throughout the Laboratory. Process water usage at BNL has been reduced to negligible levels due to water conservation measures. As a result, Process wells 101, 103, and 105 have been abandoned, and most of the remaining process water is supplied through the potable water system.

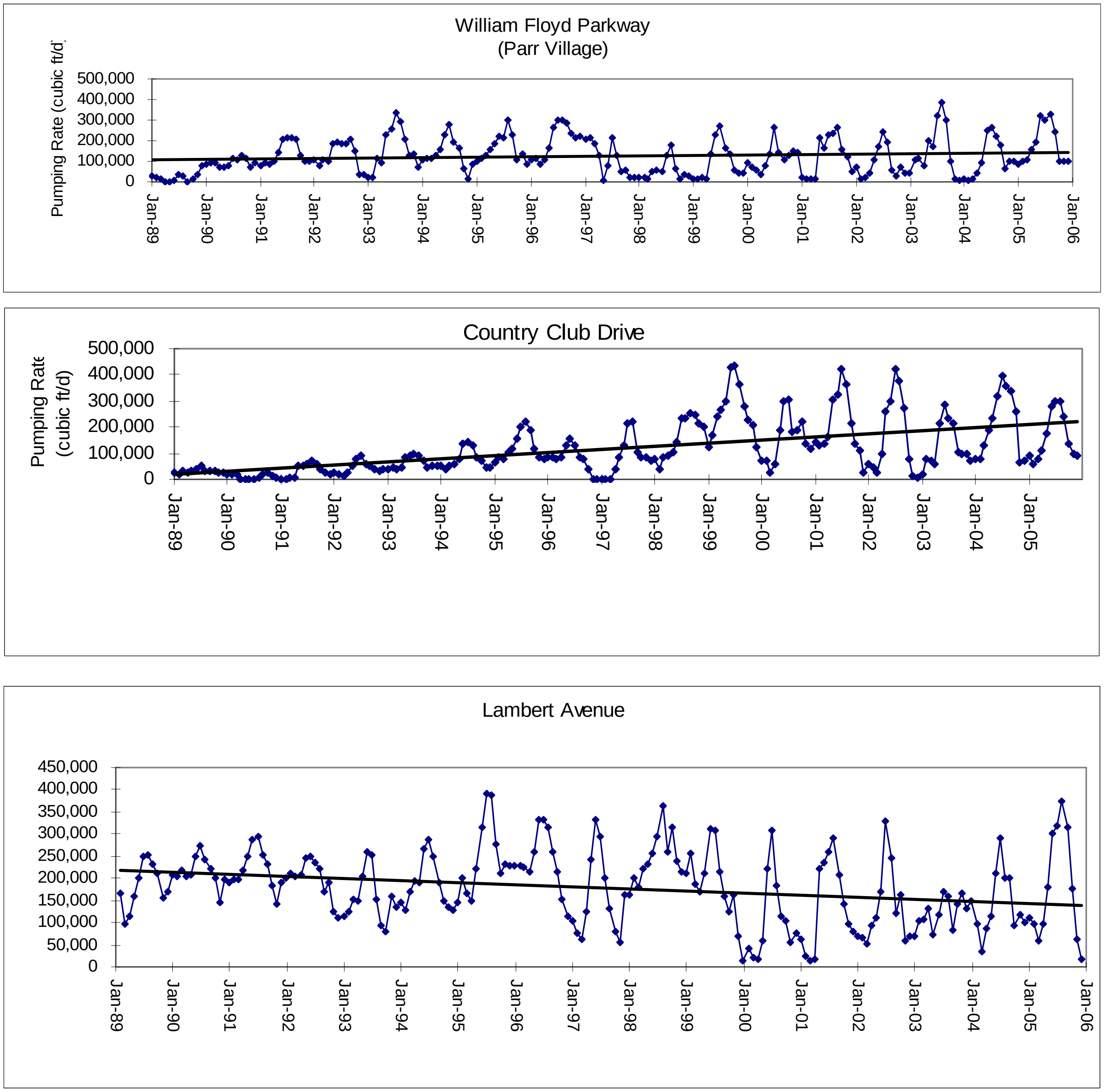
The desired annual pumpage from the western well field is approximately 75% of total pumpage. The western well field was the primary source of water for approximately 60% of the total water pumpage in 2005. More pumpage from the eastern well field was required in 2005 due to equipment problems with wells 4, 6, and 7, and the need for additional cooling water. Wells 11 and 12 provided significant pumpage during February-March and again during June-September 2005. Very little pumpage was obtained from well 10 since 2000 due to the impacts it has on the contaminant plumes in the central portion of the site. Well 10 remained in standby mode during most of 2005. **Table 2-2** summarizes the 2005 BNL process water usage. **Table 2-3** summarizes the 2005 monthly water pumpage for the groundwater remediation systems. Additional details on groundwater remediation system pumping are provided in **Section 3** of this report.

2.1.3 Off-Site Water Supply Wells

Several SCWA well fields are located near BNL. The two closest SCWA well fields are the William Floyd (Parr Village) Well Field and the Country Club Drive Well Field (see **Figures 2-2 and 2-3** for locations of the SCWA well fields). Other SCWA well fields (e.g., Lambert Avenue) are sited south of Sunrise Highway.

The William Floyd Well Field is west/southwest of BNL (**Figures 2-2 and 2-3**), and consists of three water supply wells that withdraw groundwater from the mid Upper Glacial aquifer and the upper portion of the Magothy aquifer. Country Club Drive Well Field is south/southeast of BNL, and consists of three water supply wells that withdraw groundwater from the mid section of the Upper Glacial aquifer. Pumpage information for 1989 through 2005 is provided as **Figure 2-5.** In 2005, the William Floyd (Parr Village) and Country Club Drive Well Fields produced 448 and 449 million gallons for the year, respectively. Lambert Avenue produced 481 million gallons for the year. Total pumpage increased from 2004 values at each of these three SCWA well fields in 2005.

Figure 2-5.
Suffolk County Water Authority Pumping Near BNL.



2.1.4 Summary of On-Site Recharge and Precipitation Data

This section summarizes artificial (i.e., on-site recharge basins) and natural recharge from precipitation. **Table 2-4** summarizes the monthly and total flow of water through the 10 on-site recharge basins during 2005. Their locations are shown on **Figures 2-2 and 2-3**. **Section 2.2** (Groundwater Flow) provides a discussion on the effects associated with recharge. Seven of the basins (HN, HO, HS, HT-W, HT-E, HX, and HZ) receive stormwater runoff and cooling water discharges. Flow into these basins is monitored monthly per the SPDES equivalency permit requirements. Basin HP is no longer in use and as such will not longer be discussed in this report. Basin HP received secondary cooling water discharge from the Medical Research Reactor (MRR) which is no longer in use. Generally, the amount of water recharging to the groundwater system via these basins reflects supply well pumpage. Annual water supply flow diagrams show the general relationships between recharge basins and the supply wells, and are published in Volume I of the annual Site Environmental Report.

The remaining three basins (Removal Action V [RA V], OU III, and Western South Boundary) were constructed to recharge water processed through the groundwater remediation systems. Until September 2001, treated groundwater from the OU III South Boundary Pump and Treat System was discharged solely to the OU III basin, adjacent to former recharge basin HP along Princeton Avenue. After September 2001, groundwater from that system and the OU III Middle Road Pump and Treat System was discharged equally to the OU III and RA V basins. Treated groundwater from the OU I South Boundary is discharged to the RA V basin. **Table 2-4** gives estimates of flow to these basins. The discharge to these basins for 2005 (23 and 27 million gallons per month, average, for the OU III and RA V basins, respectively) is significantly greater than that from other individual on-site basins.

Other important sources of artificial recharge, not included in **Table 2-4**, include a stormwater retention basin referred to as HW (on Weaver Drive), and the sand filter beds at the STP. Basin HW causes localized mounding of the water table. At the sand filter beds, approximately 10 to 15 percent of the treated effluent (approximately 15 million gallons annually) seeps directly to the underlying water table via leaks in the underlying tile-drain collection system. The remaining treated effluent (approximately 130 million gallons annually) is discharged from the STP to the Peconic River. Most of it recharges the water table before reaching the BNL site boundary, except during times of seasonally high water levels, such as the spring.

Precipitation provides the primary recharge to the groundwater system at BNL. In an average year, approximately 24 inches of rainfall recharges the Upper Glacial aquifer. Under long-term conditions in undeveloped areas of Long Island, about 50 percent of precipitation is lost through evapotranspiration and direct runoff to streams; the other 50 percent infiltrates the soil and recharges the groundwater system (Aronson and Seaburn 1974; Franke and McClymonds 1972). In 2005, it is estimated that the recharge at BNL was approximately 25 inches. **Table 2-5** summarizes monthly and annual precipitation results from 1949 to 2005 collected on site by the BNL Meteorology Group. Variations in the water table generally can be correlated with the amount of precipitation. As depicted in **Table 2-5**, total annual precipitation in 2005 was 50.1 inches, and is above the yearly average of 48.76 inches. The first nine months of 2005 featured below normal average monthly precipitation, continuing a below normal trend begun in 2004. This run of below average precipitation ended in October of 2005 when BNL recorded an all time record monthly total precipitation of 22.1 inches, exceeding the previous record of 11.98 inches in 1955. Monthly precipitation for 2005 ranged from 0.9 inches (August) to 22.1 inches (October).

2.2 Groundwater Flow

BNL routinely monitors horizontal and vertical groundwater flow directions and magnitudes within the Upper Glacial aquifer and uppermost Magothy aquifer by using water level data collected from a large network of on- and off-site monitoring wells. Short-term and long-term seasonal fluctuations of water levels are also evaluated using hydrographs for select wells, and trends in precipitation.

2.2.1 Water Table Contour Maps

Figure 2-2 shows groundwater elevation contour maps representing the configuration of the water table for December 2005. The contours were generated from the water level data collected during the December 2005 synoptic round from shallow glacial wells, assisted by a computer-aided contouring package (Quick SURF). Localized hydrogeologic influences on groundwater flow were considered, including on-site and off-site pumping wells, and on-site recharge basins (summarized in **Section 2.1**).

Groundwater flow in the shallow Upper Glacial aquifer in 2005 generally was characterized by a southeasterly component in the northern portion of the site, with a gradual transition to a more southerly direction at the southern boundary and beyond. Flow directions in the eastern portion of BNL are predominately to the east and southeast (**Figures 2-2 and 2-3**). This pattern is consistent with comparable historical data published by SCDHS, USGS, and BNL. The exception to this was in the central, developed portion of the site where changes in supply well pumping during the year had a significant influence on groundwater flow. During February-March and again from June-September the percentage of pumping from the eastern supply well field was greater than 50% of the total site pumpage due to increased sitewide cooling water demands and well equipment problems for the western well field. This is in contrast to the desired pumping distribution of 75% of total site pumpage from the western well field. The change resulted in an increased easterly component to groundwater flow in the central portion of the site which in turn shifted several contaminant plumes in the area, including the g-2 tritium plume, out of their monitoring well networks. The target supply well pumping distribution resumed in late September 2005 and normal flow conditions were again observed as shown in **Figure 2-2**.

The highest water table elevations on site were in the northwestern section, (nearest the groundwater divide), varying from a high of approximately 51 feet above mean sea level (msl) in December, to a low of approximately 49 feet above msl in September. The lowest elevations were along the southern boundary, with a high of approximately 34 feet above msl in June and a low of approximately 31 feet above msl in September. Localized hydrogeologic disturbances are evident on the groundwater contour maps. They result primarily from active on- and off-site pumping wells, and on-site recharge basins. Influences from the pumping wells can be seen as cones of depressions, most notably near potable supply well 7 and near the groundwater treatment wells along the southern boundary (**Figure 2-2**).

Influences from water recharge activities can be observed as localized mounding of the water table, particularly around recharge basin HO and the RA V basin (in the center of the site), the OU III basins, and the STP. The degree of mounding is generally consistent with the monthly flows to recharge basins summarized in Section 2.1. However, mounding also reflects the ability of the underlying deposits to transmit water, which varies across the site. For example, the volume of recharged water at the STP sand filter beds typically is not as great as that at recharge basin HO or the RA V basin. However, the presence of near-surface clay layers underlying portions of the STP's sand filter beds results in an extensive groundwater mound.

Other noteworthy features are the influence that surface water bodies have on groundwater flow directions. **Figure 2-2** shows groundwater flowing towards the Carmans River in areas south/southwest of BNL. This pattern is consistent with the fact that the Carmans River is a significant discharge boundary.

2.2.2 Deep Glacial Contour Maps

Figure 2-3 shows the potentiometric surface contour maps of the deep zone of the Upper Glacial aquifer for December 2005. The contours were generated in the same manner as the water table contours, but using water level data from wells screened only within the deep glacial zone.

The patterns for groundwater flow in the deep Upper Glacial for 2005 are similar to those in the shallow (or water table) zone. They are characterized by a southeasterly component in the northern portion of the site, with a gradual transition to a more southerly flow at the southern site boundary and beyond. In areas south/southwest of BNL, the deep glacial contour maps also show flow toward the Carmans River. The localized influences of pumping on the potentiometric surface configurations are evident as cones of depression. As with the water table configurations, variations in these localized hydrogeologic effects are attributed to the monthly variations in pumpage.

Although the localized influences of recharging on the potentiometric surface configurations are evident for the deep Upper Glacial aquifer, they are not as pronounced as those observed at the water table. Such hydrogeologic effects generally decrease with depth in the aquifer. Furthermore, mounding is not inferred beneath the STP sand filter beds because mounding is controlled by shallow, near-surface clay layers.

Finally, the surface water/groundwater interactions along the Peconic River are not thought to influence the deep glacial zone.

2.2.3 Well Hydrographs

Groundwater hydrographs are useful in estimating recharge rates and the location of the water table relative to contaminant sources. Long-term (typically 1950–2005) and short-term (1997–2005) well hydrographs were constructed from water level data that were obtained for select USGS and BNL wells, respectively. These hydrographs track fluctuations in water level over time. Precipitation data also were compared to natural fluctuations in water levels. **Appendix B** contains the well hydrographs together with a map depicting the locations of these wells.

Six long-term hydrographs were constructed from historical data on water level elevations obtained from wells installed and maintained by USGS and BNL. These wells provide reasonable areal coverage for historical trends in areas both on site and surrounding BNL (just south of the southern boundary). Changes in water level elevations indicate a long-term variability, with fluctuations from 8 to 14 feet. The maximum variation, 14 feet, reflects the fact that the period of record began in the early 1950s and subsequently encompassed the regional drought of the 1960s. The minimum variation of 8 feet is more indicative of the change in water level elevations since the late 1970s and early 1980s

Quarterly data on water levels collected during 2005 were used to construct nine short-term hydrographs from three well clusters (well cluster 75-39/-40/-41, 105-05/-07/-24, and 122-01/-04/-05). Generally, the highest groundwater elevations can be expected during March, based on long-term averages. In 2005 a second water table maxima was observed in the December quarterly measurement round. This was the result of the all time record rainfall received in October of 2005 (**Table 2-5)**.

2.3 New Geologic Data

The focus of the Environmental Restoration Program related to groundwater activities in 2005 was the operation and maintenance of groundwater remediation systems. Incidental new data were collected during the installation of temporary wells for the HFBR tritium plume. However, these data did not alter the BNL site conceptual model.

3.0 ENVIRONMENTAL RESTORATION GROUNDWATER MONITORING AND REMEDIATION

Chapter 3 gives an overview of groundwater monitoring and remediation efforts at BNL during calendar year 2005. The chapter is organized first by Operable Unit, and then by the specific groundwater remediation system and/or monitoring program. **Figure 1-2** shows the locations of monitoring wells throughout the site and by project. Monitoring well location maps specific to particular monitoring programs are included throughout Chapter 3.

Report and Data on CD

Appendices C and **D** contain the analytical results for each sample. Due to the large volume of data, these appendices are included on a CD ROM; this significantly reduces the size of the hardcopy of this report. The CD ROM has a table of contents with active links, such that, by selecting the specific project and analytical suite, the user will be directed to the associated table of results. Users can print a hardcopy of the results from the CD ROM. The groundwater results are arranged by specific monitoring project and then by analytical group (VOCs, SVOCs, metals, chemistry, pesticides/PCBs, and radionuclides). The data are organized further by well ID and the date of collection of the sample. Chemical/radionuclide concentrations, detection limits, and uncertainties are reported, along with a data verification, validation, and/or usability qualifier (if assigned), and/or a laboratory data qualifier. If a data verification/validation qualifier was not assigned, the laboratory data qualifier is presented. Results that exceed the corresponding groundwater standard or guidance criteria (see **Section 1.1.1** [Regulatory Drivers]) are in bold text. Inclusion of the complete results allows the reader to analyze them in detail. In addition, this entire report is included on the CD-ROM with active links to tables and figures.

About the Plume Maps

Maps are provided that depict the areal extent and magnitude of the contaminant plumes. In most cases, the volatile organic compound (VOC) plumes were simplified by using the total VOC (TVOC) values for drawing the contours, except for those plumes that consist almost exclusively of one chemical, such as the OU III Carbon Tetrachloride plume and the OU VI Ethylene Dibromide (EDB) plume. TVOC concentrations are a summation of all the individual VOCs analyzed by EPA Method 524.2.

The extent of plumes containing VOC contamination was contoured to represent concentrations that were greater than the typical NYS AWQS of 5 micrograms per liter (µg/L) for most compounds. Most radionuclide plumes were contoured to their appropriate maximum contaminant levels. The exception to this is the High Flux Beam Reactor (HFBR) Tritium Plume, which is contoured to 1,000 pico Curies per liter (pCi/L), or one twentieth of the 20,000 pCi/L drinking water standard. **Figure 3.0-1** shows the VOC and radionuclide plumes as well as the locations and groundwater capture zones for each of the treatment systems.

Following the capping of the landfill areas and the beginning of active groundwater remediation systems in 1997, there have been significant changes in the size and concentrations of several of the VOC plumes. These changes can be attributed to the following:

- The beneficial effects of active remediation systems
- Source control and removal actions
- The impacts of BNL pumping and recharge on the groundwater flow system
- Radioactive decay, biological degradation, and natural attenuation

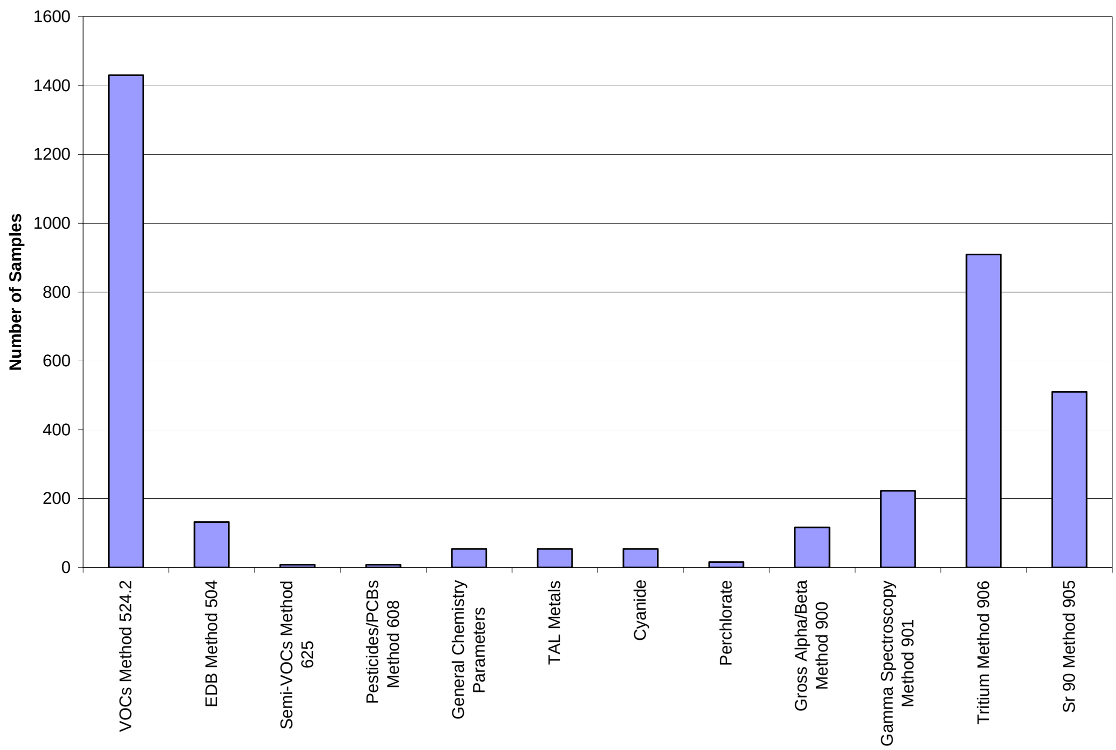
Additionally, BNL's ability to accurately depict these plumes has been enhanced over the years by:

- The addition of permanent monitoring wells to the existing well networks
- The installation of temporary wells during groundwater characterization efforts that helped to fill in data gaps

During 2005, the contaminant plumes were tracked by collecting 2,282 groundwater samples obtained from 739 on-site and off-site monitoring wells. **Figure 3.0-2** provides a summary of the number of analyses performed, arranged by analytical method. Unless otherwise noted, the extent of contamination for a given plume is depicted by primarily using 2005 data from permanent monitoring wells. In several cases, data from early 2006 were utilized. Contaminant plumes associated with HFBR Tritium, and Brookhaven Graphite Research Reactor/Waste Concentration Facility (BGRR/WCF) Sr-90 projects were further defined using temporary wells (i.e., direct push Geoprobes or vertical profiles).

A single representative round of monitoring data was chosen for each plume, typically from the last quarter of the year because it includes the most comprehensive sampling round for the year. This report also serves as the fourth quarter report for the remediation systems. Contaminant concentration trend plots for key monitoring wells in each plume are provided to identify significant changes. Data from monitoring wells sampled under BNL's Environmental Surveillance Monitoring Program are also evaluated.

Figure 3.0-2.
Summary of Laboratory Analyses Performed for the Environmental Management Program in 2005.



History and Status of Groundwater Remediation at BNL

Groundwater remediation systems have operated at BNL since 1997, beginning with the OU I South Boundary pump and treat system. The goal of groundwater remediation, as defined by the OU III Record of Decision, is, within 30 years or less, to prevent or minimize plume growth and not to exceed MCLs in the Upper Glacial aquifer. Based on additional information obtained during the Strontium-90 Pilot Study, the *OU III Explanation of Significant Differences* (BNL 2005b) identified changes to the cleanup goal timeframes for the Sr-90 plumes. For the BGRR/WCF and Chemical Holes Sr-90 plumes, MCLs must be reached within 65 years and 40 years, respectively. In addition, cleanup of the Magothy aquifer VOC contamination must meet MCLs within 70 years.

There are currently 12 groundwater remediation systems in operation, of which five began operation in 2004. Two systems are in standby mode (HFBR Tritium Pump and Recharge, and the Carbon Tetrachloride Pump and Treat). A petition to shut down the Building 96 Treatment System was approved by the regulators and the system was subsequently placed in standby mode in 2005. Due to increasing VOC concentrations, the northern-most extraction well was restarted in October 2005. Another system has met its cleanup goals and has been abandoned: the OU IV, Area of Concern (AOC) 5, Air Sparge/Soil Vapor Extraction System, referred to as the OU IV AS/SVE. **Figure 3.0-1** shows the locations and groundwater capture zones for each of the treatment systems. In addition to the groundwater treatment systems, two landfill areas (Current and Former) were capped, which minimizes the potential for groundwater contamination.

BNL's Plant Engineering personnel perform routine maintenance checks on the treatment systems daily, in addition to their routine and nonroutine maintenance. BNL's Environmental and Waste Management Services Division (EWMSD) collects the treatment system performance samples (influent, midpoint, effluent). Full details of the maintenance checks are recorded in the system's operation and maintenance daily inspection logs. The daily logs are available at the treatment facility, or in the project files.

In general, BNL uses two types of groundwater remediation systems to treat VOC contamination: pump and treat with air stripping or carbon treatment, or recirculation wells with air stripping or carbon treatment. Pump and treat remediation consists of pumping groundwater from the plume up to the surface and piping it to a treatment system, where the contaminants are removed by either air stripping or granular activated carbon. Treated water then is introduced back into the aquifer via recharge basins, injection wells, or dry wells.

Table 3.0-1 summarizes the operating remediation systems. Groundwater remediation at BNL is proceeding as predicted. A graph of actual versus model predicted VOC mass removal is shown in **Figure 3.0-3**.

The groundwater monitoring well networks for each program are organized into background, core, perimeter, and bypass wells. The wells are designated as follows:

- Background –water quality results will be used to determine upgradient water quality
- Plume Core – utilized to monitor the high concentration or core area of the plume
- Perimeter – used to define the outer edge of the plume both horizontally and vertically
- Bypass Detection – used to determine whether plume capture performance is being met

Table 3.0-1. Summary of Groundwater Remediation Systems at BNL.

Operable Unit System	Type	Target Contaminant	No. of Wells	Years of Operation	Recharge Method	Pounds VOCs Removed (Year/Cum)
Operable Unit I						
South Boundary	P&T, AS	VOC	2	9	Basin	10 314
Operable Unit III						
South Boundary	P&T, (AS)	VOC	7	8	Basin	133 2409
HFBR Pump and Recharge	Pump and Recirculate	Tritium	3	Standby: 8	Basin	NA 180
Industrial Park	Recirculation/ In-Well (AS/Carbon)	VOC	7	6	Recirculation Well	63 901
*Carbon Tet	P&T (Carbon)	VOC	3	Standby: 6	Basin	1 349
Building 96	Recirculation Well (AS/Carbon)	VOC	4	5	Recirculation Well	3 70
Middle Road	P&T (AS)	VOC	6	4	Basin	88 608
Western South Boundary	P&T (AS)	VOC	2	5	Basin	7 39
Chemical Holes	P&T, (IE)	Sr-90	1	3	Dry Well	0.57 1.75
North Street	P&T (Carbon)	VOC	2	2	Wells	72 187
North Street East	P&T (Carbon)	VOC	2	2	Wells	6 11
LIPA/Airport	P&T and Recirc. Wells (Carbon)	VOC	9	2	Wells and Recirculation Well	83 145
Industrial Park East	P&T (Carbon)	VOC	2	2	Wells	7 24
BGRR/WCF	P&T (IE)	Sr-90	5	1	Dry Wells	4.15
Operable Unit VI						
EDB	P&T (Carbon)	EDB	2	2	Wells	<1*** <1***

Notes:
AS = Air Stripping
AS/SVE = Air Sparging/Soil Vapor Extraction
EDB = ethylene dibromide
IE = Ion Exchange
LIPA = Long Island Power Authority
NA = Not Applicable
P&T = Pump and Treat
Recirculation = Double screened well with discharge of treated water back to the same well in a shallow recharge screen
In-Well = The air stripper in these wells is located in the well vault.

* This system was shut down August 1, 2004 and put in standby mode.
** Sr-90 removal is expressed in mCi.
*** ***EDB was only detected in the system influent once in 2005. Other low-level VOCs not attributable to BNL were detected; the results may be due to analytical lab contamination.

3.1 OPERABLE UNIT I

The two sources of groundwater contamination contained within the OU I project are the former Hazardous Waste Management Facility (HWMF) and the Current Landfill. The former HWMF was BNL's central RCRA Receiving Facility for processing, neutralizing, and storing hazardous and radioactive wastes for off-site disposal until 1997, when a new Waste Management Facility was constructed along East Fifth Avenue. Several hazardous materials spills were documented at the former HWMF. A soil remediation program was completed for this facility in September of 2005.

The plumes from the Current Landfill and former HWMF become commingled south of the former HWMF. The commingling was partially caused by the pumping and recharge effects of the Spray Aeration System, which operated from 1985 to 1990. This system was designed to treat VOC-contaminated groundwater originating from the former HWMF. The VOC plume is depicted in **Figure 3.1-1**. A segment of the plume extends off site, approximately 3,400 feet south of the site property boundary.

The on-site segment of the Current Landfill/former HWMF plume is being remediated by a groundwater pump and treat system consisting of two wells screened in the deep portion of the Upper Glacial aquifer at the site property boundary (OU I South Boundary Treatment System). The extracted groundwater is treated for VOCs by air stripping, and is recharged to the ground at the RA V basin, located northwest of the Current Landfill (**Figure 3.1-1**). A second system (North Street East System) was built to treat the off-site portion of the plume. The off-site groundwater remediation system began operations in June 2004 and was included under Operable Unit III Record of Decision (see **Section 3.2.15**).

Tritium is detected in several monitoring wells, but at concentrations below the 20,000 pCi/L DWS. Sr-90 is detected in on-site wells, one of which exceeded the 8 pCi/L DWS in 2005, as discussed in **Section 3.1.5.**

3.1.1 OU I South Boundary Pump and Treat System

This section summarizes the operational and monitoring well data for 2005 from the OU I South Boundary groundwater pump and treat system, and presents conclusions and recommendations for its future operation. This system began operating in December 1996.

Quarterly reports were prepared with the operational data from January 1, 2005 through September 30, 2005. Discharge Monitoring Reports for treated effluent water from the air-stripping tower were submitted to EPA and NYSDEC each month.

3.1.2 System Description

For a complete description of the OU I South Boundary Treatment System, see the *Operations and Maintenance Manual for the RA V Treatment Facility* (BNL 2005b).

3.1.3 Groundwater Monitoring

Well Network

The OU I South Boundary monitoring program uses a network of 57 monitoring wells (11 of which also are used for the Current Landfill and OU III North Street East monitoring programs, **Figure 1-2**). A discussion of monitoring well data specific to the Current Landfill source area is provided in **Appendix H**.

Sampling Frequency and Analysis

The wells are monitored as per the schedule provided in **Table 1-5**.

3.1.4 Monitoring Well VOC Results

Figure 3.1-1 shows the areal extent of VOC contamination from the Current Landfill/former HWMF area based on the full round of samples collected in the third and fourth quarters of 2005. The primary VOCs detected in the on-site segment of this plume include chloroethane and DCA, which originated from the Current Landfill. TCA, DCE, TCE, and chloroethane are prevalent in the off-site segment of the plumes (North Street East). The OU I South Boundary/North Street East plume (defined by TVOC concentrations greater than 5 µg/L) extends south from the Current Landfill (a distance of 4,100 feet) to the site boundary where it has been hydraulically cut off from the off-site segment of the plume by extraction wells EW-1 and EW-2. Its maximum width is about 1,200 feet at the southern site boundary. The plume segments with higher TVOC concentrations (greater than 50 µg/L) are approximately 300 feet wide. The areas of the plume displaying the highest TVOC concentrations (greater than 100 µg/L) were approximately 1,200 to 2,800 feet downgradient of the former HWMF. Contaminant concentrations near wells 98-59 have declined significantly, indicating that the trailing edge of the high concentration segment is continuing to migrate towards the site boundary.

The off-site portion of the plume is discussed in **Section 3.2.15 the North Street East Pump and Treat**.

Figure 3.1-2 shows the vertical distribution of VOCs. The transect line for cross-section A–A' is shown on **Figure 3.1-1**. DCA and chloroethane are primarily detected in the shallow zone of the Upper Glacial aquifer near the source areas, and in the deep Upper Glacial at the site boundary and off site. TCA, DCE, TCE, chloroethane, and chloroform are found in the mid to deep Upper Glacial aquifer off site, south of North Street.

The plume remains bounded by the current network of wells. **Figure 3.1-3** gives the historical trends in VOC concentrations for key plume core and bypass wells that monitor the plume. **Appendix C** has a complete set of 2005 analytical results for the 57 wells. Significant findings for 2005 include:

- There were no detections of VOCs above NYS AWQS in perimeter wells.
- Plume core well 098-59 (**Figure 3.1-3**) began to show a steadily decreasing trend in TVOC concentrations during 2002 after peaking at 371 µg/L in 1997, as a high-concentration slug of contaminants continues to migrate southward. The third-quarter 2005 result indicated that TVOC concentrations have dropped to 6 µg/L. This well is screened in the Upton Unit immediately above the Gardiners Clay.
- TVOC concentrations in plume core wells 115-14 and 115-31, both located adjacent to the extraction wells, continued to exhibit low concentrations, which ranged from 2 to 31 µg/L.
- TVOC concentrations in bypass wells 115-42 and 000-138 continued to decrease.
- The OU I South Boundary pump and treat system has created a break in the plume that is characterized by a region of low-level VOCs from south of the extraction wells to the vicinity of North Street (**Figure 3.1-1**).

3.1.5 Radionuclide Monitoring Results

The monitoring wells were analyzed for tritium and Sr-90 semiannually, and gamma spectroscopy annually. The complete results for these wells are provided in **Appendix C**.

In general, stable or decreasing tritium trends are observed for the wells in which tritium has been detected historically. Tritium concentration increases in well 108-12 (located along the south firebreak road) from nondetectable levels up to 3,520 pCi/L in September 2005, most likely represent the attenuated remnants of elevated tritium concentrations in the former HWMF (well 088-26) observed in 1997 and 1998. A plot of historical tritium results for select OU I South Boundary program wells is shown in **Figure 3.1-4**.

There are 10 wells (including six that are also part of the OU I South Boundary Monitoring Program) used to monitor Sr-90 contamination from the former HWMF **(Table 1-5)**. The extent of Sr-90 concentrations is shown in **Figure 3.1-5**. Sr-90 has historically been detected in three wells located within and downgradient of the former HWMF (088-26, 098-21, and 098-30) at concentrations above the 8 pCi/L DWS. Well 088-26 was the only one of the three to show Sr-90 concentrations above the DWS, with a maximum concentration of 12 pCi/L in September 2005. Sentinel monitoring wells were installed in 2002 downgradient of the leading edge of the plume. Sr-90 was detected in well 107-35 for the first time during the second half of 2004 at a maximum concentration of 2.6 pCi/L. Concentrations have remained in the 1 to 2 pCi/L range since that initial detection. Sr-90 concentration trends for key monitoring wells are provided in **Figure 3.1-6**.

3.1.6 System Operations

The extraction wells are currently sampled quarterly. The influent and effluent of the air-stripper tower are sampled once per month. All samples are analyzed for VOCs. In addition, the influent and effluent samples are analyzed for pH weekly, and iron and manganese monthly. **Table 3.1-1** provides the effluent limitations for meeting the requirements of the State Pollution Discharge Elimination System (SPDES) equivalency permit. Although it is not a permit requirement, the effluent is sampled for metals, pesticides, PCBs, Sr-90, and gross alpha/beta annually.

The following is a summary of the OU I operations for 2005.

January–September 2005

EW-2 was off from January to April due to a motor failure and electrical problems. Well maintenance, cleaning, and replacement of a pump occurred in April. Starting September 1, 2005 the system began pulse pumping operations as set forth in the 2004 Groundwater Status Report recommendations. The system operated on a one month on then one month off schedule.

October–December 2005

The system operated normally for the quarter with the system off in November for normal pulse pumping operations.

3.1.7 System Operational Data

Extraction Wells

During 2005, 196 million gallons of groundwater were pumped and treated by the OU I system, with an average flow rate of 378 gpm. **Table 2-3** contains the monthly pumping data for the two extraction wells. VOC and tritium concentrations in samples from EW-1 (115-27) and EW-2 (115-43) are provided in **Table F-1** in **Appendix F** (on the CD-ROM). TVOC levels in both wells continued to show a slight decreasing trend with time (**Figure 3.1-7**). Year-end tritium levels were below detection limits in both wells.

Table 3.1-1.
OU I South Boundary Pump and Treat System
2005 SPDES Equivalency Permit Levels

Parameters	Permit Level*	Max. Measured Value
pH	6.0 – 9.0 SU	6.15 – 7.9 SU
Benzene	0.8 µg/L	<0.50 µg/L
Chloroform	7.0 µg/L	<0.50 µg/L
Chloroethane	5.0 µg/L	<0.50 µg/L
1,2-Dichloroethane	5.0 µg/L	<0.50 µg/L
1,1-Dichloroethene	5.0 µg/L	<0.50 µg/L
1,1,1-Trichloroethane	5.0 µg/L	<0.50 µg/L
Carbon tetrachloride	5.0 µg/L	<0.50 µg/L
1,2-Dichloropropane	5.0 µg/L	<0.50 µg/L
Methylene Chloride	5.0 µg/L	<0.50 µg/L
Trichloroethylene	5.0 µg/L	<0.50 µg/L
Vinyl Chloride	2.0 µg/L	<0.50 µg/L
1,2-Xylene	5.0 µg/L	<0.50 µg/L
Sum of 1,3- & 1,4-Xylene	10.0 µg/L	<0.50 µg/L

Notes:
*Maximum allowed by requirements equivalent to a SPDES Permit.
SU = Standard Units
Required sampling frequency is monthly for VOCs and weekly for pH.

System Influent and Effluent

VOC and tritium concentrations in 2005 for the air-stripper influent and effluent are summarized in **Tables F-2** and **F-3** in **Appendix F**. Radiological (gross alpha/beta and gamma spectroscopy), pesticide, and metals data for the effluent are shown in **Table F-4**. The concentrations of TCA and DCA generally have decreased over the eight years of OU I South Boundary System operation.

The air-stripper system effectively removed all contaminants from the influent groundwater. All effluent data were below the analytical methods detection limit and below the regulatory limit specified in the equivalency permit conditions.

Cumulative Mass Removal

The mass of VOCs removed from the aquifer by the OU I treatment system was calculated. Average flow rates for each monthly monitoring period were used, in combination with the TVOC concentration in the air-stripper's influent, to calculate the pounds per month removed. The cumulative mass of VOCs removed by the treatment system vs. time was then plotted (**Figure 3.1-8**). During 2005, 9.14 pounds of VOCs were removed. Cumulatively, 321.6 pounds have been removed since 1997. The 1996 RA V Design modeling estimated that the system would remove 260 to 300 pounds by 2006–2011. Cumulative mass removal data for this system are summarized in **Table F-5**.

Air Discharge

Table 3.1-2 presents the VOC air emissions data for the year 2005 and compares the values to levels stipulated in NYSDEC Air Guide 1 regulations. Emission rates are calculated through mass balance for water treated during operations. The concentration of each constituent of the air-stripper's influent was averaged for the year. That value was converted from μg/L to pounds per gallon (lb/gal), which was multiplied by the average pumping rate (gal/hr) to compare with the regulatory value. All VOC air emissions were well below allowable levels.

Recharge Basin

There are nine sentinel monitoring wells in the immediate area surrounding the RA V recharge basin (**Figure 1-2**). These wells are used to monitor water quality and water levels to assess the impact of the recharge basin on the aquifer. **Appendix C** (on the CD-ROM) contains the data for these monitoring wells. All tritium detections were below 1,000 pCi/L during 2005. The highest detection of tritium was 690 pCi/L in well 076-177. Beginning November 1, 2001, the RA V recharge basin began receiving 650 gpm of treated groundwater from the OU III South Boundary and Middle Road treatment systems. The OU III South Boundary SPDES equivalency permit was modified to include the Middle Road treatment system and their outfalls at the OU III and RA V recharge basins.

Table 3.1-2
OU I South Boundary System
Air Stripper VOC Emissions Data

Parameter	Allowable ERP* (lb/hr)	Actual** ERP* (lb/hr)
Carbon tetrachloride	0.016	<0.0002
Chloroform	0.0086	0.0002
1,1-Dichloroethane	10**	0.00067
1,2-Dichloroethane	0.011	<0.0002
1,1-Dichloroethene	0.194	<0.0002
Chloroethane	10**	0.0004
1,1,1-Trichloroethane	10**	0.0001
Trichloroethene	0.119	0.0002

ERP = Emissions Rate Potential, stated in lb/hr.
* ERP is based on NYSDEC Air Guide 1 Regulations.
** Actual rate reported is the average for the year.
*** 6 NYCRR Part 212 restricts emissions of VOCs to a maximum of 10 lb/hr without controls.

3.1.8 System Evaluation

The pump and treat system continued to maintain hydraulic control of contaminants originating from the Current Landfill and former HWMF, and to prevent further contaminant migration across the site's southern boundary. No SPDES or Air equivalency permit limits have been exceeded, and no operating difficulties were experienced beyond normal maintenance. There have been no problems and no observed interference with other BNL operations, such as the recharge to Basin HO or the OU III South Boundary Pump and Treat system. Pulse pumping (one month on one month off) of the system was implemented beginning in September 2005 as per recommendations in the 2004 Annual report.

The OU I South Boundary Pump and Treat system performance can be evaluated based on the five major decisions identified by applying the DQO process.

1. Was the BNL Groundwater Contingency Plan activated?

No. There were no unusual or unexpected concentrations of contaminants observed in monitoring wells associated with the OU I South Boundary Pump and Treat System.

2. Has the plume been controlled?

Yes. An analysis of the plume perimeter and bypass wells reveals that there have been no significant increases in VOC concentrations during 2005; thus, the plume has not grown and continues to be controlled. **Figure 3.1-1** illustrates that the plume has been effectively cut off at the south boundary and there is now separation with the off-site segment of the plume.

The groundwater contour maps are used to evaluate the capture zones of the OU I South Boundary Pump and Treat System (**Figures 2-2 and 2-3**). The capture zone for the OU I South Boundary Pump and Treat System is indicated in **Figure 3.0-1**. The capture zone depicted includes the 50 µg/L isocontour that is the capture goal of this system.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate for a particular treatment system?

Yes. The hydraulic capture performance of the system is operating as previously modeled and the system continues to be effective in capturing and removing VOCs from the deep Upper Glacial aquifer.

In 2003, the beginning of a steady decline in TVOC concentrations in well 098-59 was observed. This decline continued in 2005 and it appears that at the present time the trailing edge of this high concentration segment has migrated south of this area. An additional monitoring well (recommended in the 2004 Groundwater Status Report) is scheduled for installation in June 2006 and will assist in tracking this high concentration segment as it migrates to the south boundary. 2005 Monitoring well TVOC concentrations are consistent with updated 2004 modeling predictions of a reduction in plume TVOC concentrations to a maximum of 100 µg/L in 2011. The predicted extent of TVOC contamination in 2011 is shown in **Figure 3.1.9**. The 2004 model updated concluded that the model was accurately predicting the plume. The planned monitoring well will aid in verifying that prediction. Based on monitoring well results and mass removal of contaminants the system is operating as planned.

4. Can the groundwater treatment system be shut down?

No, the system has not met all shutdown requirements (see below).

4a. Have asymptotic TVOC concentrations been reached in core wells?

Asymptotic conditions are demonstrated by analyzing the average trends in TVOC concentrations in the plume core wells. Asymptotic conditions have not yet been achieved. Aquifer cleanup continues to be demonstrated based on the continued decreasing slope to the trend of average TVOC concentrations in plume core wells, as shown in **Figure 3.1.10**. Changes in the makeup of the plume are shown in **Figure 3.1-11**, which compares the TVOC plume from 1997 to 2005.

4b. Is the mean TVOC concentration in core wells less than 50 µg/L?

Yes, the mean TVOC concentration is currently less than 50 µg/L and continues a decreasing trend (**Figure 3.1-10**).

4c. How many individual plume core wells are above 50 µg/L?

None of the ten plume core wells continues to have TVOC concentrations exceeding 50 µg/L. Well 098-59, located south of the former HWMF, declined to 6 µg/L during 2005.

4d. During pulsed operation of the system, is there significant concentration rebound in core wells?

The OU I South Boundary System is currently being pulsed on a monthly basis. The system pulsing began in September 2005 which is not sufficient time to observe any definitive trends in the data. The system will be operated continuously should concentrations in the extraction wells and upgradient core monitoring wells demonstrate a significant increase.

5. Have the groundwater cleanup goals been met? Specifically, have MCLs been achieved (expected by 2030)?

No. MCLs have not been achieved for individual VOCs in plume core wells. However, MCLs are expected to be achieved by 2030.

3.1.9 Recommendations

The following are recommendations for the OU I South Boundary Pump and Treat System and groundwater monitoring program:

- The routine operation and maintenance monitoring frequency implemented in the fourth quarter of 2004 should be continued. Plume core and perimeter wells are monitored on a semiannual frequency. Sentinel and bypass wells are sampled at a quarterly frequency.
- Continue pulsing of the treatment system wells to optimize system performance.
- Install a monitoring well upgradient of EW-1 and EW-2 duringJune 2006 as recommended in the 2004 Groundwater Status Report.

3.2 OPERABLE UNIT III

The OU III plumes, as depicted in **Figure 3.2-1,** are actually multiple commingled plumes originating from several sources defined in the OU III Remedial Investigation/Feasibility Study (RI/FS). Those sources include Building 96, Building 208, the Alternating Gradient Synchrotron (AGS), and the former carbon tetrachloride underground storage tank (UST). The eastern portions of the plume have sources in OU IV and the Former Landfill and Animal/Chemical Holes areas. **Figure 3.2-1** is a simplified representation of the plumes using TVOC concentrations. The eastern portion of **Figure 3.2-1** also includes the OU IV plume and the North Street (OU I/IV) plumes.

The primary chemical contaminants found in OU III groundwater are TCA, PCE, and carbon tetrachloride. These three chemicals are the primary VOCs detected in the OU III on-site monitoring wells. Off site, carbon tetrachloride and PCE are the main contaminants detected.

The OU III VOC plume extends from the AGS/WCF area in the northern part of the site, south to the vicinity of Flower Hill Drive off site (a distance of approximately 17,700 feet). The maximum width of its main body is about 5,800 feet, as defined by TVOC concentrations greater than 5 µg/L. The western lobe of the OU III plume is defined by discontinuous VOC contamination with concentrations less than 60 µg/L. This contamination results from multiple small source areas in the northern and central portions of the site, and its distribution has been complicated by earlier changes in the on-site groundwater flow system resulting from changes in pumping and recharge patterns. The basis for this representation of the lobe of the plume is the extensive vertical profile characterization conducted under the OU III Remedial Investigation RI, in addition to data points from several existing monitoring wells.

The two most prominent source areas are the Building 96 area, and the former Carbon Tetrachloride UST. On-site portions of the plume displaying the highest VOC concentrations during 2004 were south of Building 96 with TVOC concentrations up to 7,173 µg/L, continuing south to the Middle Road with TVOC concentrations of 1,692 µg/L, and the south boundary with TVOC concentrations up to 780 µg/L. TVOC levels range up to 527 µg/L (primarily carbon tetrachloride and TCA) in the off-site industrial park area.

The transect lines for cross-sections B–B' (**Figure 3.2-2**), C–C' (**Figure 3.2-3**) and other project-specific cross sections are shown on **Figure 3.2-1**. Cross sections B–B' and C–C' are oriented in a north–south direction beginning in both the central industrial and OU IV areas of the site, and continuing through the high concentrations segments of the plumes. Data obtained from existing monitoring wells and the Magothy Aquifer Characterization Project identified significant VOC contamination of the upper Magothy aquifer in the industrial park, south into North Shirley. A comparison of the OU III plumes in 1997 and 2004 is provided in **Figure 3.2-4**.

Sections 3.2.1 through **3.2.17** summarize and evaluate the groundwater monitoring and system operations data for the OU III operational groundwater treatment systems and the monitoring-only programs.

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3.2.1 Carbon Tetrachloride Pump and Treat System

This section summarizes the operational data from the OU III Carbon Tetrachloride Pump and Treat System and offers conclusions and recommendations for future operation and monitoring. This system began operating on October 6, 1999 and was formally shut down and placed in standby mode on August 1, 2004 after receiving regulatory approval of the petition for shutdown. This summary is prepared annually and discusses the operational data from January 1, 2005 through December 31, 2005.

As was recommended in the petition to shut down the carbon tetrachloride system, two new monitoring wells (095-300 and 095-301) were installed in the vicinity of extraction well EW-15 in 2004. Well 095-300 was installed to monitor the western edge of the plume in the vicinity of well EW-15, and well 095-301 was installed upgradient of well EW-15.

3.2.1.1 System Description

A complete description of the pump and treat system is contained in the *Carbon Tetrachloride Groundwater Removal Action Operations and Maintenance Manual* (BNL 2000d).

3.2.1.2 Groundwater Monitoring

Well Network

A network of 32 wells was designed to monitor the extent of the plume and the effectiveness of remediation.

Sampling Frequency and Analysis

The wells are sampled quarterly, and samples are analyzed for VOCs (see **Table 1-5**).

3.2.1.3 Monitoring Well Results

Carbon tetrachloride is the primary contaminant in this plume. The plume extends from the former UST southeast to the vicinity of the Weaver Drive recharge basin, a distance of approximately 1,300 feet (**Figure 3.2.1-1**). The width of the plume, as defined by the 50 µg/L isocontour, is approximately 120 feet. The complete 2005 analytical results from the monitoring of wells in the carbon tetrachloride program are provided in **Appendix C**. Significant findings for 2005 include:

- Plume core well 085-98, just south of the former UST, had carbon tetrachloride concentrations greater than 150,000 µg/L in 1999. A decreasing trend has been observed in this well, beginning in 1999 with the start of groundwater pumping. The concentration of carbon tetrachloride was 42 µg/L in November 2005 (**Figure 3.2.1-2**).
- Plume core well 085-17 is sited next to the BNL service station on Rochester Avenue and downgradient of the source area. It has continued to show declining carbon tetrachloride trends from a peak of more than 4,000 µg/L in 2000 to a concentration of 33 µg/L in October 2005 **(Figure 3.2.1-2)**.
- Plume core well 85-161 is approximately 120 feet downgradient of the source area. Concentrations in this well have remained low throughout 2004, with a concentration of 14 µg/L in October 2005.
- Plume core well 095-183 is approximately 450 feet downgradient of the source area. Carbon tetrachloride concentrations in this well have decreased from greater than 2,000 µg/L in 2000, to 17 µg/L in December 2005 **(Figure 3.2.1-2)**.
- Plume perimeter wells 095-300 and core well 095-301 were installed in 2004, as recommended in the *Petition to Shutdown the Carbon Tetrachloride System* (BNL 2004k). Well 095-300 was installed west of EW-15 to confirm the western edge of the carbon tetrachloride plume.

The analytical results for this well show a carbon tetrachloride concentration of 6.5 µg/L in October 2005, thus confirming the western edge of the plume. Well 095-301 was installed to monitor concentrations of the plume immediately upgradient of well EW-15. Concentrations of carbon tetrachloride were 180 µg/L in March 2005 but had dropped to 11 µg/L in this well in October 2005. In response to the concentrations observed in March, EW-15 went online April 5, 2005 and ran until May 17, 2005.

3.2.1.4 System Operations

Operating Parameters

In 2005, the extraction wells were sampled monthly. All samples are analyzed for VOCs. In addition, the pH of the influent and effluent samples was measured monthly during April and May when the system was operating. The parameters for sampling pH and VOCs adhere to the requirements of the SPDES equivalency permit. All effluent samples during this period of operation were below the permit levels (**Table 3.2.1-1**). The system operations are summarized below.

Table 3.2.1-1
Carbon Tetrachloride Pump & Treat System
2005 SPDES Equivalency Permit Levels

Parameters	Permit Limit *	Max. Measured Value
pH range	5.5 – 8.5 SU**	6.1 – 6.3 SU
bromodichloromethane	50.0 µg/L	<0.50 µg/L
carbon tetrachloride	5.0 µg/L	<0.50 µg/L
chloroform	7.0 µg/L	<0.50 µg/L
methylene chloride	5.0 µg/L	2.8 µg/L
tetrachloroethylene	5.0 µg/L	<0.50 µg/L
toluene	5.0 µg/L	<0.50 µg/L
trichloroethylene	5.0 µg/L	<0.50 µg/L
xylene (0-isomers)	5.0 µg/L	<0.50 µg/L
xylene (sum of M&P isomers)	10.0 µg/L	<0.50 µg/L

Notes:
SU = Standard Units
*Maximum allowed by requirements equivalent to a SPDES permit.
**pH value lowered by NYSDEC to 5.5 in September, 2000.

January – September 2005

Well EW-15 was turned on April 5 and ran until May 17, when the well was turned off. No other wells ran during January to July except for the monthly sampling events.

October – December 2005

The system was in standby mode during this period. Sampling for the SPDES equivalency permit was stopped and will be resumed if the system is restarted.

3.2.1.5 System Operational Data

System Influent and Effluent

Analytical results indicate that all parameters were below the regulatory limit specified in the SPDES equivalency permit during the period of operations in April and May.

The overall influent water quality to the carbon vessels continued to show a decrease in the concentrations of carbon tetrachloride. The influent carbon tetrachloride concentration at the beginning of system operations in October 1999 was 11,000 µg/L. The concentration was 35 µg/L at the end of May 2005, before shutting down well EW-15. This concentration was consistent with concentrations observed when the system was shut down. **Tables F-6** through **F-9** in **Appendix F** (on the CD-ROM) summarize carbon tetrachloride concentrations in the influent, effluent, and midpoint samples.

Cumulative Mass Removal

The mass of carbon tetrachloride removed from the aquifer was calculated using average flow rates for each monthly monitoring period and influent concentrations to the carbon treatment system. **Table 2-3** lists monthly pumpage rates for 2005. These rates were used in determining mass removal of carbon tetrachloride.

Table F-9 in **Appendix F** gives total pounds of carbon tetrachloride removed by the treatment system. **Figure 3.2.1-3** plots mass removal vs. time. Approximately 0.79 pounds of carbon tetrachloride were removed during 2005, with a cumulative total of 349.81 pounds since the system started in 1999.

3.2.1.6 System Evaluation

The system was placed in a standby mode in August 2004 after approval of the petition for shutdown. The system ran for approximately 1 month in 2005. The groundwater extraction wells will remain on a monthly sampling schedule to monitor for any significant rebound in concentrations of carbon tetrachloride. The OU IIII Carbon Tetrachloride Pump and Treat System performance can be evaluated based on the five major decisions identified by applying the DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no detections of either carbon tetrachloride or any other contaminants in wells associated with this monitoring network during 2005 that triggered the BNL Groundwater Contingency Plan.

2. Were the cleanup goals met?

Yes. The groundwater cleanup goals for the system have been met. The system was shut down in August 2004. EW-15 was turned on from April 5, 2005 to May 17, 2005 due to elevated carbon tetrachloride concentrations detected in newly installed monitoring well 095-301.

3. Has the plume been controlled?

Yes. The plume has been controlled.

4. Is the system operating as planned?

The system is currently shut down and being maintained in standby mode. Shutdown of the system at these concentrations is consistent with meeting the OU III ROD cleanup objectives by 2030.

5. Is an engineering evaluation needed to modify the Middle Road treatment system to ensure the capture and remediation of the carbon tetrachloride plume?

Based on data from bypass and Middle Road tracking wells, no engineering study is required at this time.

3.2.1.7 Recommendations

The following are recommendations for the OU III Carbon Tetrachloride Groundwater Remediation System and monitoring program:

- Change the sampling of the extraction wells from a monthly to quarterly basis.
- The monitoring well network is adequate and no modifications are necessary at this time with the exception of increasing the sampling frequency for well 095-90 to quarterly. This is due to the expected arrival of the leading edge of the plume in this area in the next year.
- If significant concentrations of carbon tetrachloride are detected, the system will be turned on.
- The increased VOC concentrations (TCA, DCE) in well 095-93 observed over the past several years will be evaluated including additional groundwater characterization in this area.

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3.2.2 Building 96 Air Stripping System

This section summarizes the 2005 operational data from the OU III Building 96 Source Control System, which consists of recirculation wells with air stripping and vapor phase carbon treatment, and presents conclusions and recommendations for future operation. The system began operation in February 2001. Three of the four recirculation wells (wells RTW-2, RTW-3, and RTW-4) were placed in standby mode in July 2004 and the fourth recirculation well (RTW-1) was placed in standby mode on June 1, 2005 and remained in standby until it was restarted October 17, 2005 due to a rebound in VOC concentrations.

3.2.2.1 System Description

The Building 96 groundwater treatment system consists of four recirculation treatment wells (RTW-1 through RTW-4). Contaminated groundwater is drawn from the aquifer via a submersible well pump in a lower well screen, 48 to 58 feet below land surface (bls), near the base of the contaminant plume. The groundwater then is pumped into a stripping tray adjacent to the well, and after treatment is recharged back to the shallow portion of the plume, 25 to 35 feet bls, through the upper screen. A complete description of the system is included in the *Building 96 Groundwater Source Control Treatment System Operations and Maintenance Manual* (BNL 2002f).

3.2.2.2 Groundwater Monitoring

The monitoring network of 33 wells is used to monitor the VOC plume and the effectiveness of the groundwater remediation system (**Figure 1-2**). The wells are sampled and analyzed for VOCs in accordance with **Table 1-5**.

3.2.2.3 Monitoring Well Results

Complete VOC results are provided in **Appendix C** (on the CD-ROM). The fourth-quarter 2005 plume is shown on **Figure 3.2.2-1**. The highest TVOC concentration seen in 2005 was 7,173 µg/L, from well 085-353 (MW-5), during the second-quarter sampling round. Historically, the highest concentration seen in this area was 18,002 µg/L TVOCs, in well 095-84 in October 1998. Monitoring wells downgradient of extraction well RTW-1 showed TVOC concentrations ranging from 1.64 µg/L to 343 µg/L. Monitoring well 095-295, located on the west side of the plume area, had increased to a concentration of 446 µg/L TVOC during the fourth-quarter sampling but decreased to 5.23 µg/L during the first quarter of 2006. The contamination seen on the west side of the plume area would not be treated by RTW-2, -3, or -4 but is expected to be captured by the OU III Middle Road System.

3.2.2.4 System Operations

Operating Parameters

Three of the four downgradient extraction wells (RTW-2, -3, and -4) were placed in standby mode in July 2004. Monthly influent samples from these three extraction wells were collected and analyzed for VOC until July 2005, when the sampling frequency was changed to quarterly sampling due to extremely low levels of VOCs (**Table F-10** in **Appendix F**). For the only operating extraction well, RTW-1, influent and effluent samples were collected monthly from January 2005 through July 2005 and analyzed for VOCs. In July 2005, RTW-1 was placed in standby mode. When RTW-1 was in standby mode for the months of August and September, only influent samples were collected. On October 17, 2005, recirculation well RTW-1 was restarted due to a rebound in VOC concentrations in the vicinity of RTW-1, and the monthly collection of influent and effluent samples was resumed.

Influent, midpoint, and effluent air samples from the carbon vessels were sampled quarterly and analyzed for VOCs by EPA method TO-14A. These samples monitor the efficiency of the granular activated carbon (GAC) units and are used to determine if a carbon changeout is required. Air sampling results are included in **Table F-11** in **Appendix F**. The system operations for 2005 are summarized below.

January –May 2005

Recirculation well RTW-1operated normally for the period from January through May. Monthly influent and effluent samples were collected from RTW-1 and analyzed for VOCs.

June –December 2005

Extraction well RTW-1 was placed in standby mode on June 1, 2005 and remained in standby until it was restarted October 17, 2005 due to a rebound in VOC concentrations. During the period when RTW-1 was in standby mode, only monthly influent samples were collected; when the system was restarted in October 2005, collection and analysis of monthly influent and effluent samples resumed. The treatment system, RTW-1, operated normally for the remainder of the year.

3.2.2.5 System Operational Data

Recirculation Well Influent and Effluent

Three of the four downgradient extraction wells (RTW-2, RTW-3, and RTW-4) were placed in standby mode in July 2004, but even though these wells were off, influent samples were still collected and RTW-4 monthly from January 2005 through July 2005. After July 2005, sampling of wells RTW-2, RTW-3, was changed from monthly to quarterly, due to extremely low VOC concentrations. **Table F-10** lists the influent VOC concentrations for recirculation wells RTW-2, -3, and -4. **Table F-10** also lists the influent and effluent VOC concentrations for the one remaining operating extraction well, RTW-1. The highest influent TVOC concentration, 72.1 μg/L, was from January 2005. Effluent VOC concentrations for RTW-1 were less than the DWS or were nondetectable.

Cumulative Mass Removal

The mass of VOCs removed from the aquifer for extraction well RTW-1 was determined. The gallons of water pumped during each month were used, in combination with the influent TVOC concentrations, to calculate the pounds removed. The pumping and mass removal data are summarized in **Table F-12** in **Appendix F**. During 2005, the treatment system removed approximately three pounds of VOCs during its limited operation. Since February 2001, the system has removed approximately 70 pounds of VOCs.

Air Treatment System

Air samples were collected quarterly from the GAC vessels before treatment (influent), between the two vessels (midpoint), and after the second vessel (effluent). The findings are used to monitor the efficiency of the GAC units and to determine if a carbon changeout is required (**Table F-11**). All compounds detected in the carbon effluent during the operating year were below the New York State allowable emission rates (lbs/hr) (**Table 3.2.2-1**).

3.2.2.6 System Evaluation

RTW-1 operated from January through June, was in standby mode for July, August, and September, then restarted and operated October through December. Three pounds of VOCs were removed during 2005. Discharge concentrations to the aquifer have been less than the drinking water standard. Approximately 8.5 million gallons of groundwater were treated during the year.

A review of the Building 96 treatment well influent and monitoring well data indicated that the remedial effectiveness of RTW-1 had reached a plateau without significant impact on the high concentrations of a continuing source of VOCs located in the silty soil zone of the aquifer upgradient of RTW-1. Therefore, in an attempt to reduce the high concentrations of VOC, primarily PCE, in the silty zone area upgradient of RTW-1, the injection of $KMnO_4$ was proposed (*Building 96 Site Source Reduction Chemical Oxidation Scope of Work,* BNL, November 2004d).To date, three rounds of

$KMnO_4$ injections have been conducted, in the silty zone area upgradient of extraction well RTW-1. This area has seen elevated VOC concentrations, primarily due to the presence of PCE. The first round of $KMnO_4$ injections was conducted from December 7, 2004 through January 13, 2005 and consisted of 1,000 gallons of a 1.2% solution of $KMnO_4$ being injected at 83 temporary well locations from 20 feet to 40 feet bls. The second round of $KMnO_4$ injections was conducted from April 19, 2005 through April 26, 2005. This round consisted of 600 gallons of a 2.0% solution of $KMnO_4$ being injected at 29 temporary well locations from 20 feet to 40 feet bls. Details for the first and second rounds of $KMnO_4$ injections are presented in the *OU III Building 96 Groundwater Treatment System Shutdown Petition (AOC 26B)* (BNL 2005c).

In accordance with the shutdown petition, repeat injections of $KMnO_4$ were recommended to be conducted on an as-needed basis to ensure that VOC concentrations were less than 380 μg/L to meet the OU III ROD cleanup objectives. Due to continued elevated levels of VOC concentrations (primarily PCE) in the Building 96 area upgradient of RTW-1, a third round of $KMnO_4$ injections was conducted January 1 through 9, 2006. The third round consisted of 330 gallons of a 2.0% solution of $KMnO_4$ being injected at 22 locations from 20 feet to 30 feet bls. The locations for the three rounds of $KMnO_4$ injections are shown on **Figure 3.2.2-2.** Also, a cross section that includes this area is shown on **Figure 3.2.2-3.**

After three rounds of $KMnO_4$ injections, elevated VOC concentrations (primarily PCE) are still present in the northern part of the silty zone area upgradient of RTW-1 near wells 085-353 (MW-5) and 085-347 (MW-1A). The highest TVOC concentrations in this area in 2005 were 7,173 μg/L and 2,649 μg/L in wells 085-353 (MW-5) and 085-347 (MW-1A), respectively. The monitoring results after three rounds of $KMnO_4$ injections have shown that this remediation has been only partially effective in reducing PCE concentrations in the Building 96 source area.

Table 3.2.2-1.
OU III Building 96
VOC Emission Rates, 2005 Average

Parameter	Allowable ERP*	Actual** ER
dichlorodifluoromethane	0.0000187	0.00000264
acetone	0.000674	ND
methylene chloride	0.000749	0.00000110
2-butanone	0.000187	ND
benzene	0.000112	0.00000722
tetrachloroethene	0.000165	ND
m,p-xylene	0.0000116	ND
isopropylbenzene	0.000243	ND
n-propylbenzene	0.0000599	ND
1,3,5-trimethylbenzene	0.000375	0.00000404
1,2,4-trimethylbenzene	0.000225	0.0000125
4-isopropyltoluene	0.00000749	ND
naphthalene	0.0000225	ND
carbon disulfide	0.0000487	ND
styrene	0.00000637	ND
trans-1,3-dichloropropane	0.0000157	ND

ER = Emissions Rate
ERP = Emissions Rate Potential, stated in lb/hr.
* ERP is based on NYSDEC Air Guide 1 Regulations.
** Actual rate reported is the average for the year.
ND = Analyte not detected

In the area upgradient of extraction well RTW-1, contamination is seen at two distinct depths that are separated by a low permeability zone (silty zone). A shallower area of contamination is located above and in this silty zone, approximately 20 to 27 feet bls. Also, a deeper zone of contamination is below the silty zone at approximately 30 to 55 feet bls. The focus of the $KMnO_4$ injections were the areas above, in, and below the silty zone. The $KMnO_4$ was injected at depths that encompassed both the shallow and the deeper areas of contamination. A review of the monitoring well data and the cross section (**Figure 3.2.2-2** and **Figure 3.2.2-3)** indicates that the $KMnO_4$ injections resulted in some success at remediating the PCE concentrations in the deeper zone (30 to 55 feet bls). Based on monitoring data, the $KMnO_4$ injections have not been effective to date in reducing the PCE concentrations in the shallow silty zone. A comparison of the plume from 2000 to 2005 is shown in **Figure 3.2.2-4.**

The OU III Building 96 source control system performance can be evaluated based on the two major decisions identified by applying the DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no unusual detections of PCE, TCA, or any other contaminants in wells associated with the monitoring network during 2005 that would have triggered the BNL Groundwater Contingency Plan. The highest VOC concentrations are seen in the silty zone area upgradient of extraction well RTW-1. The highest TVOC concentration seen in 2005 was 7,173 µg/L, from well 085-353 (MW-5) during the second-quarter sampling round.

2. Have the source control objectives been met?

No. Based on the goals established in the *Building 96 Groundwater Source Control Operations and Maintenance Manual* (BNL 2002e), the source control goals for this system have been not been met. Based upon monitoring data the $KMnO_4$ injections have not been effective to date in reducing the PCE concentrations in the shallow silty zone.

3.2.2.7 Recommendations

The following are recommendations for the OU III Building 96 groundwater remediation system and monitoring program:

- Recirculation well RTW-1 is downgradient of the silty zone area, and pumps from 48 to 58 feet bls, below the silty zone. This well recharges its effluent to the shallower zone above the silty zone, 25 to 35 feet bls. It can be seen that the silty zone layer is between the lower extraction well screens and the upper discharge well screens for RTW-1(**Figure 3.2.2-3)**. From a review of the monitoring well data, influent data, and the cross section for the Building 96 area, the continued operation of extraction well RTW-1 is no longer providing capture of the plume. Therefore, it is recommended that extraction well RTW-1 be placed in standby mode and sampled quarterly.
- Downgradient monitoring will continue and, if needed, downgradient recirculation wells RTW-2,-3, and -4 can be restarted if elevated VOC concentrations are seen. These wells are 230 to 250 feet downgradient of RTW-1 and would be able to intercept and treat any contamination migrating downgradient past it.
- The influent for recirculation wells RTW-2, RTW-3, and RTW-4 will be sampled quarterly.
- Monitoring wells sampling frequencies will be changed from monthly to quarterly, effective the third quarter of 2006. No $KMnO_4$ injections are planned for 2006, and based on data observations over the past several years, a monthly frequency is no longer necessary for these wells.
- Monitoring will continue in 2006 and the results will continue to be evaluated. If VOC concentrations don’t show a decline in the source area wells, alternative methods for remediating the contamination in the silty zone upgradient of extraction well RTW-1 will be evaluated including soil excavation and biodegradation enhancers such as molasses. The potential for creating breakdown products such as vinyl chloride will be addressed as part of the evaluation.

3.2.3 Middle Road Pump and Treat System

The Middle Road Groundwater Pump and Treat System began operating on October 23, 2001. This section summarizes the operational data from the Middle Road system for 2005, and presents conclusions and recommendations for future operation. The analytical data from the monitoring wells also are evaluated in detail.

3.2.3.1 System Description

The Middle Road system was designed with six extraction wells and air-stripping technology to remove VOCs from the groundwater. On September 30, 2003, extraction wells RW-4 and RW-5 were placed in standby mode due to low concentrations of VOCs. The system is currently operating at a pumping rate of approximately 400 gpm. A complete description of the system is included in the *Operation and Maintenance Manual for the OU III Middle Road and South Boundary Groundwater Treatment Systems, Revision 1* (BNL, July 2003f).

3.2.3.2 Groundwater Monitoring

The Middle Road Monitoring Program consists of a network of 23 monitoring wells located between the Princeton Avenue firebreak road and the OU III South Boundary Pump and Treat System (**Figure 1-2**).

The 23 Middle Road wells are sampled and analyzed for VOCs. Nine of the wells are sampled quarterly, and the others are sampled semiannually. Several wells are also utilized in the OU III HFBR Tritium Monitoring Program (**Table 1-5**).

3.2.3.3 Monitoring Well Results

The complete VOC results are shown in **Appendix C**. The highest plume concentrations are found between extraction wells RW-1 and RW-3, based on influent data for these wells and available monitoring well data (**Figure 3.2-1**). TVOC concentrations in monitoring wells east of RW-3 are below 100 µg/L. VOC concentrations have generally continued to decline in 2005. Results for key monitoring wells are as follows.

- The highest TVOC concentration detected was in bypass detection well 113-17, at 1,692 µg/L. The VOCs in this bypass well were present prior to the operation of the pump and treat system, and are expected to be captured by the OU III South Boundary system. Additional characterization is planned in 2006 to determine the depth and location of these higher concentrations, located between the Middle Road and South Boundary systems.
- Plume core well 105-23 is approximately 2,000 feet upgradient of RW-1, near Princeton Avenue. TVOC concentrations have decreased from 1,794 µg/L during 2001, to 85 µg/L in the fourth quarter of 2005 (**Figure 3.2.3-1)**.
- TVOC concentrations in plume core wells to the east of well 105-23, along Princeton Avenue, were generally below 100 µg/L in 2005. TVOC concentrations decreased in well 105-44, from 423 µg/L in 2001 to less than 10 µg/L in the fourth quarter of 2005 (**Figure 3.2.3-1)**.

Figure 3.2.3-2 shows the vertical distribution of contamination running along an east–west line through the extraction wells; the location of this cross section (E–E') is given in **Figure 3.2-1**. VOC contamination in the western portion of the remediation area (RW-1 through RW-3) extends into the Upper Magothy aquifer, as does the screen on well RW-3.

3.2.3.4 System Operations

The effluent sampling parameters for pH and VOCs follow the requirements for monthly sampling, as per the SPDES equivalency permit. In addition, system influent samples are analyzed for tritium during each system-sampling event. Tritium remains below detection limits in all samples. All effluent concentrations from the treatment system during this period of operation were below equivalency permit levels (**Table 3.2.3-1**).

Approximately 157 million gallons of water were pumped and treated in 2005 by the OU III Middle Road System. The following paragraphs summarize the Middle Road System operations for 2005.

January–September 2005

Recovery wells RW-1 and RW-2 were offline from March–June, due to electrical repairs and then a pump motor failure. The system was shut down for 3 days to remove sand buildup in the inlet screens and the tower spray nozzles.

October 2005

The system pumped and treated approximately 11 million gallons of water in October.

November 2005

The system pumped and treated approximately 16 million gallons of water in November.

December 2005

Approximately 15 million gallons of water were pumped and treated.

Table 3.2.3-1.
Middle Road Air Stripping Tower
2005 SPDES Equivalency Permit Levels

Parameters	Permit Limit *	Max. Observed Value
pH range (SU)	6.5–8.5	6.4 – 7.6
carbon tetrachloride	5 µg/L	ND
chloroform	7 µg/L	ND
dichlorodifluoromethane	5 µg/L	ND
1,1-dichloroethane	5 µg/L	ND
1,1-dichloroethylene	5 µg/L	ND
methyl chloride	5 µg/L	ND
tetrachloroethylene	5 µg/L	2.3 µg/L
toluene	5 µg/L	ND
1,1,1-trichloroethane	5 µg/L	ND
1,1,2 trichloroethane	5 µg/L	ND
trichloroethylene	10 µg/L	ND

Notes:

*Maximum allowed by requirements equivalent to a SPDES permit.
ND = Not detected above method detection limit of 0.50 µg/L.
SU = Standard Units
Required sampling frequency is monthly for VOCs and pH.

3.2.3.5 System Operational Data

System Influent and Effluent

All parameters (except pH) in the SPDES equivalency permit limits were within the specified ranges during 2005. pH was slightly lower than the permit limits during one sampling event in 2005, most likely due to natural fluctuations. All effluent data were either below the method detection limit, or below the regulatory limit specified in the equivalency permit. pH was slightly below permit limits during one sampling event due to natural fluctuations.

Results from samples collected from the extraction wells are found on **Table F-13 (Appendix F).** The influent's overall water quality showed a slight decrease in VOC concentrations over the reporting period. The average TVOC concentration in the influent during 2005 was 64 µg/L (see **Table F-14**). The system influent was also sampled for tritium, which was not detected above the reporting limit in any sample during 2005. The results from sampling the influent and effluent are summarized in **Tables F-14** and **F-15**, respectively.

Cumulative Mass Removal

Mass balance was calculated for the period of operation to determine the mass removed from the aquifer by the pumping wells. Average flow rates for each monthly monitoring period were used, in combination with the TVOC concentration in the air-stripper influent, to determine the pounds removed. Flow averaged 287 gpm during 2005 (**Table 2-3**, and **Table F-16**), and approximately 87 pounds of VOCs were removed. Approximately 608 pounds of VOCs have been removed since the system began startup testing on October 23, 2001. The cumulative total of TVOCs removed vs. time is plotted in **Figure 3.2.3-3**.

Air Discharge

Table 3.2.3-2 shows the air emissions data from the system for the OU III Middle Road tower during 2005, and compares the values to levels stipulated in NYSDEC Air Guide 1 regulations. Emission rates are obtained through mass-balance calculations for all water treated during that time (**Table F-13**). The concentration of each constituent was averaged for 2005, and those values were used in determining the emissions rate. All air emissions were below permitted limits.

Table 3.2.3-2.
Middle Road Air Stripper
VOC Emission Rates, 2005 Average

Parameter	Allowable ERP* (lb/hr)	Actual** (lb/hr)
carbon tetrachloride	0.022	0.0005
chloroform	0.0031	0.0001
1,1-dichloroethane	10***	0.000003
1,2-dichloroethane	0.008	0.000011
1,1-dichloroethylene	0.034	0.0003
cis-1,2-dichloroethylene	10***	0.0001
trans-1,2-dichloroethene	10***	0
tetrachloroethylene	0.387	0.0112
1,1,1-trichloroethane	10***	0.0013
trichloroethylene	0.143	0.0003

Notes:
ERP = Emission Rate Potential. Reported in lb/hr.
*ERP based on NYSDEC Air Guide 1 Regulations.
** Rate reported is the average rate for the year.
*** 6 NYCRR Part 212 restricts emissions of VOCs to a maximum of 10 lb/hr without controls.

Extraction Wells

Extraction wells RW-4 and RW-5 were shut down on September 30, 2003 and placed on standby due to low concentrations of VOCs. The extraction wells, including wells RW-4 and RW-5, are sampled quarterly.

3.2.3.6 System Evaluation

The system has been operating since October 24, 2001. Groundwater-level mapping indicates that hydraulic control has been achieved.

The OU III Middle Road Pump and Treat System performance can be evaluated based on the five major decisions identified for this system from the groundwater DQO process.

1. Was the BNL Contingency Plan triggered?

No. There were no unusual or unexpected VOC concentrations observed in the monitoring wells and extraction wells associated with the OU III Middle Road Pump and Treat System during 2005.

2.Has the plume been controlled?

Yes. VOC concentrations in plume perimeter wells remained stable at low concentrations during 2005, indicating that the plume is being controlled. High VOC concentrations in bypass wells were present before the system was operational and are not within the capture zone of the extraction wells. It will take several additional years before the contaminants migrate to the South Boundary system. Quarterly groundwater elevation data were obtained from many of the OU III Middle Road monitoring program wells, in addition to wells located throughout the BNL on-site and off-site monitoring areas. Groundwater contour maps are generated using these data (**Figures 2-2** and **2-3**).

The capture zone for the OU III Middle Road system is depicted in **Figure 3.0-1**. The capture zone includes the 50 µg/L isocontour, which is the capture goal of this system.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate for this treatment system?

Yes. The system is operating as planned based on the mass removal of VOCs. Monitoring wells continue to show decreasing concentration trends during 2005.

4. Can the groundwater treatment system be shut down?

No, the system has not met all shutdown requirements (see 4a through 4d).

4a. Have asymptotic VOC concentrations been reached in core wells?

No. Groundwater remediation for this system is still in the early stages. Monitoring and extraction wells have shown generally decreasing concentration trends since 2002 and these trends have continued.

4b. Is the mean TVOC concentration in core wells less than 50 µg/L (expected by 2025)?

No. Groundwater remediation for this system is still in the early stages.

4c. How many individual plume core wells are above 50 µg/L?

Three of the 14 plume core wells contain TVOC concentrations greater than 50 µg/L.

4d. During pulsed operation of the system, is there significant concentration rebound in the core wells?

The OU III Middle Road System has not been pulsed, to date.

5. Have the groundwater cleanup goals been met? Have MCLs been achieved (expected by 2030)?

No. MCLs have not been achieved for individual VOCs in plume core wells. However, MCLs are expected to be achieved by 2030.

3.2.3.7 Recommendations

The following recommendations are made for the OU III Middle Road Pump and Treat System and groundwater monitoring program:

- Maintain the routine operation and maintenance monitoring frequency that began in 2003.
- Continue extraction wells RW-4 and RW-5 in standby mode during 2006. Restart the wells if extraction or monitoring well data indicate that TVOC concentrations exceed the 50 µg/L capture goal.
- Shut down well RW-6 due to low VOC concentrations (below MCLs in 2005). Continue quarterly sampling of the well. Restart the well if TVOC concentrations in the vicinity of this well exceed the 50 µg/L capture goal.
- Install one or two temporary wells near HFBR tritium extraction wells EW-9, EW-10, and EW-11 (**Figure 3.2.3-1**) to characterize the high-concentration portion of the plume. Based on the results from the temporary wells, consider installing a monitoring well.

3.2.4 South Boundary Pump and Treat System

This section summarizes the operational data from the OU III South Boundary groundwater pump and treat system for 2005, and gives conclusions and recommendations for future operation. Also included within this section is an evaluation of the system and extraction well monitoring and sampling data.

3.2.4.1 System Description

This system began operation on June 17, 1997, utilizing air-stripping technology for treatment of extracted groundwater from seven extraction wells. The system is currently operating at a pumping rate of approximately 600 gpm, utilizing six extraction wells. Extraction well EW-12 was placed on standby during October 2003, due to low VOC concentrations. A complete description of the system is included in the *Operation and Maintenance Manual for the OU III Middle Road and South Boundary Groundwater Treatment Systems, Revision 1* (BNL 2003f).

3.2.4.2 Groundwater Monitoring

The monitoring well network consists of 38 wells and was designed to monitor the VOC plume(s) in this area of the southern site boundary, as well as the efficacy of the groundwater remediation system (**Figure 3.2.4-1**). The South Boundary wells are sampled and analyzed for VOCs at frequencies detailed in **Table 1-5**.

3.2.4.3 Monitoring Well Results

The south boundary segment of the OU III VOC plume continued to be bounded by the existing monitoring well network. VOC concentrations in the plume perimeter wells were less than 5 µg/L (**Figure 3.2.4-1**). VOCs were detected in the deep Upper Glacial aquifer in the vicinity of the site boundary, as depicted in **Figures 3.2-2** and **3.2.4-1. Appendix C** (on CD-ROM) has the complete groundwater monitoring results for 2005.

The plume core wells continued to show the same trend of decreasing VOC concentrations that were observed following the startup of the pump and treat system in 1997, with several exceptions. The bulk of the VOC contamination in this area is currently located between EW-3 and EW-5, as can be seen in **Figure 3.2.4-2,** which is a cross section (F–F') drawn along the south boundary and incorporating the extraction wells. The VOC concentration trends for specific key plume core wells are shown in **Figure 3.2.3-1.** Results for key monitoring wells are as follows:

- Plume core well 114-07 is immediately upgradient of EW-12. Increasing VOC concentrations in this well during 1998 prompted the addition of EW-12, which began pumping in December 1999. TVOC concentrations in 2005 remained below the NYS AWQS, with no VOCs exceeding NYS AWQS since 2001. EW-12 was placed on standby in October 2003.
- Plume core well 122-22 is immediately east of EW-8. A sharp drop in TVOC concentrations was observed during 1997 and 1998 from its pre startup concentration of 1,617 µg/L. VOC concentrations have remained very low, with no VOC exceedances of NYS AWQS since 2002.
- Plume core well 122-19 is directly downgradient of EW-8. TVOC concentrations were as high as 367 µg/L in 1997; VOCs have not been detected above standards since 2002.
- Plume core well 122-04 is located between EW-7 and EW-8. TVOC concentrations have remained below the NYS AWQS during 2005.
- Plume core well 121-23 is immediately downgradient of EW-5. During 2005, the TVOC concentrations ranged between 215 and 241 µg/L. The spikes in TVOC concentrations are the result of either higher concentration slugs of VOCs arriving at the site boundary, or contamination

being pulled back from the downgradient capture zone. The primary contaminant observed is PCE. This is consistent with the contaminant distribution in EW-4 and EW-5.

- Plume core well 121-13 is immediately upgradient of, and between, EW-4 and EW-5. TVOC concentrations in this well have fluctuated somewhat since 1997, peaking at 1,098 µg/L in 1999. The PCE concentration in this well ranged from 780 µg/L in June to 96 µg/L in November, which was the highest TVOC concentration for this area in 2005. PCE is the primary compound in wells 121-13, 121-23, EW-4, and EW-5. This contamination is being captured by the treatment system.
- Plume core well 121-11 is upgradient of EW-3. TVOC concentrations ranged from 40µg/L in June 2005 to approximately 33 µg/L in November 2005.
- Bypass detection well 122-35, south of EW-8, continued to show little to no detectable levels of VOCs. VOC concentrations in well 122-34, clustered with 122-35, were below NYS AWQS in 2003 through 2005.
- Plume core well 122-05 is a Magothy monitoring well west of EW-8. TVOC concentrations have decreased slightly from recent levels of about 50 µg/L, to 36 µg/L in November 2005.
- Magothy wells 121-40, 121-44, and 122-41 showed no detectable levels of VOCs during 2005.

3.2.4.4 System Operations

The individual extraction wells are sampled quarterly and all samples are analyzed for VOCs. The effluent sampling parameters of pH and VOCs are done monthly, in accordance with SPDES permit equivalency requirements (**Table 3.2.4-1**). In addition, samples are analyzed for tritium with each system-sampling event. In all samples, tritium continues to remain below reporting limits. All effluent VOC concentrations from the treatment system during this period of operation were below permit equivalency requirements. pH was slightly below the lower permit limit during one sampling event, due to natural fluctuations.

Table 3.2.4-1.
OU III South Boundary Air Stripping Tower
2005 SPDES Equivalency Permit Levels

Parameters	Permit Limit*	Max. Observed Value
pH range(SU)	6.5 – 8.5	6.3–7.6
carbon tetrachloride	5 µg/L	ND µg/L
chloroform	7 µg/L	ND
dichlorodifluoromethane	5 µg/L	ND
1,1-dichloroethane	5 µg/L	ND
1,1-dichloroethylene	5 µg/L	ND
methyl chloride	5 µg/L	ND
tetrachloroethylene	5 µg/L	ND
toluene	5 µg/L	ND
1,1,1-trichloroethane	5 µg/L	ND
1,1,2 trichloroethane	5 µg/L	ND
trichloroethylene	10 µg/L	ND

*Maximum allowed by requirements equivalent to a SPDES permit.
ND = Not detected above method detection limit of 0.50 µg/L.
Required sampling frequency is monthly for VOCs and pH.

OU III South Boundary System Operations

The following summarizes system operations for 2005. Approximately 248 million gallons of water were pumped and treated in 2005 by the OU III South Boundary System.

January–September 2004

Approximately 182 million gallons of water were pumped and treated. There were communications and electrical problems during this period.

October 2005

The system pumped and treated approximately 14 million gallons of water in October. There were communications and electrical problems during the month.

November 2005

The system pumped and treated approximately 26 million gallons of water.

December 2005

Approximately 24 million gallons of water were pumped and treated in December.

3.2.4.5 System Operational Data

System Influent and Effluent

Figure 3.2.4-3 plots the concentrations of TVOCs in the extraction wells versus time. The overall influent water quality and the individual extraction wells show a general leveling off of concentrations. The system was also sampled monthly for tritium, which was not detected above the reporting limit in any sample during 2005. System influent and effluent sampling results are summarized in **Tables F-18** and **F-19**, respectively.

Cumulative Mass Removal

Average flow rates for each monthly monitoring period were used, in combination with the TVOC concentration in the air-stripper influent, to calculate the mass removed (see **Table F-20**). The cumulative total of TVOCs removed by the treatment system versus time is plotted in **Figure 3.2.4-4**. The 2005 total was approximately 133 pounds. Cumulatively, the system has removed approximately 2,409 pounds since it was started on June 17, 1997.

Table 3.2.4-2.
South Boundary Air Stripper
VOC Emission Rates, 2005 Average

Parameter	Allowable ERP*	Actual** ER
carbon tetrachloride	0.022	0.0016
chloroform	0.0031	0.0003
1,1-dichloroethane	10***	<0.0002
1,2-dichloroethane	0.008	0.0002
1,1-dichloroethylene	0.034	0.0005
cis-1,2-dichloroethylene	10***	0.0002
trans-1,2-dichloroethylene	10***	0
tetrachloroethylene	0.387	0.0107
1,1,1-trichloroethane	10***	0.0016
trichloroethylene	0.143	0.0003

ERP = Emissions Rate Potential, stated in lb/hr.
* ERP is based on NYSDEC Air Guide 1 Regulations.
** Actual rate reported is the average for the year.
*** 6 NYCRR Part 212 restricts emissions of VOCs to a maximum of 10 lb/hr without controls.

Air Discharge

Table 3.2.4-2 shows the air emissions data from the OU III South Boundary Tower for the operational period, and compares the values to levels stipulated in NYSDEC Air Guide 1 regulations. Emission rates are obtained through mass-balance calculations for all water treated during that time (**Table F-18**). The concentration of each constituent was averaged for the year, and that value was used in the calculation. All air emissions were below allowable levels.

Extraction Wells

In general, the extraction wells continued to show slowly decreasing VOC concentrations during 2005 (**Figure 3.2.4-3**). **Table F-17** in **Appendix F** summarizes the data for the extraction wells.

3.2.4.6 System Evaluation

The pump and treat system continues to maintain hydraulic control and continues to prevent further migration across the southern site boundary. Plume core and bypass wells continued to show stable or decreasing VOC concentrations. The system operated at an average of 472 gpm during 2005. There was some minor downtime due to electrical problems and scheduled maintenance. No permit equivalency standards were exceeded and no operating difficulties were experienced beyond normal maintenance, except for pH. There have been no air emission exceedances.

The OU III South Boundary Pump and Treat system performance can be evaluated based on the five major decisions identified for this system resulting from the groundwater DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no unusual or unexpected VOC concentrations observed in the monitoring wells associated with the OU III South Boundary Pump and Treat System during 2005.

2. Has the plume been controlled?

Yes. An analysis of the plume perimeter and bypass wells reveals that there have been no significant VOC concentration increases in these wells during 2005.

The capture zone for the OU III South Boundary Pump and Treat System is depicted in **Figure 3.0-1**. The capture zone depicted includes the 50 µg/L isocontour, which is the capture goal of this system.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate for a particular treatment system?

Yes. The OU III South Boundary System continues to be effective in removing VOCs from the deep portions of the Upper Glacial aquifer. Actual mass removal is tracking very closely to the projections using the groundwater model (**Figure 3.2.4-4**). **Figure 3.2-4** compares the OU III plume from 1997 to 2005. The overall reduction in the high-concentration areas of the plume near the south boundary is evident.

The OU III South Boundary system is planned to operate for 10 to 15 years; at the end of 2005, it had operated for approximately 8.5 years. The system is removing contamination at the expected rate and hydraulic control of the plume was demonstrated; hence, it is operating as planned. The duration of operation for the OU III South Boundary system is dependent on the partition coefficient of the contamination, the rate of desorption (i.e., linear or nonlinear), and the effectiveness of the Middle Road Groundwater Treatment System. The Middle Road system started operation approximately 4.5 years after the OU III South Boundary system. The contaminant travel time from Middle Road to the OU III South Boundary system is about 5 to 10 years. Therefore, the high concentrations observed in the vicinity of well 113-17 will likely determine the operating period of this system (**Figure 3.2-1 and 3.2-2**). The duration of operation could be closer to 15 years than 10 years.

The trend in the mean of the TVOC concentrations in the core groundwater monitoring wells is declining. However, there is significant variability in the mean from quarter to quarter. This is indicative of the expected capture of pulses (or slugs) of higher concentration contamination. The target contamination in this area is the result of periodic historical releases, rather than continuous sources of contamination.

4. Can the groundwater treatment system be shut down?

No, the system has not met all shutdown requirements (see below).

4a. Have asymptotic TVOC concentrations been reached in core wells?

No. The average TVOC concentrations of the OU III South Boundary wells continued a decreasing trend in 2005 (**Figure 3.2.4-5**).

4b. Is the TVOC concentration in core wells less than 50 µg/L?

No. Two core wells, 121-13 and 121-23, have TVOC concentrations above 50 µg/L.

4d. During pulsed operation of the system, is there significant concentration rebound in the core wells?

The OU III South Boundary System has not been pulsed, to date.

5. Have the groundwater cleanup goals been met? Specifically, have MCLs been achieved (expected by 2030)?

No. MCLs have not been achieved for individual VOCs in plume core wells. Based on modeling results, MCLs are expected to be achieved by 2030, as required by the OU III ROD.

3.2.4.7 Recommendations

The following are recommendations for the OU III South Boundary Pump and Treat System and groundwater monitoring program:

- A routine operations and maintenance monitoring frequency was implemented in the fourth quarter of 2003. This frequency should be maintained during the O & M phase.
- Change monitoring of the OU III South Boundary Magothy wells (121-40, 121-44, 122-41, and 122-05) to a semiannual frequency in 2006.
- Extraction well EW-12 was placed in standby mode in 2003. This well will continue in standby mode during 2006. The well will restarted if extraction or monitoring well data indicate TVOC concentrations exceed the 50 µg/L capture zone.
- Shut down extraction well EW-8, due to low VOC concentrations in this well. The highest concentration observed in this well in 2005 was 6.4 µg/L of tetrachloroethylene. Continue quarterly sampling of this well. The well will restarted if extraction or monitoring well data indicate TVOC concentrations exceed the 50 µg/L capture zone.
- Install temporary and permanent wells in the Magothy aquifer downgradient of the Middle Road treatment system to enhance the monitoring well network. This will help determine the extent of VOCs in the Magothy aquifer between the Middle Road and South Boundary plume monitoring networks, as well as provide additional hydrogeologic data.

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3.2.5 Western South Boundary Pump and Treat System

The Western South Boundary Pump and Treat System was designed to capture the VOCs in the Upper Glacial aquifer along the western portion of the BNL south property boundary. This system captures the highest VOCs observed at the western south boundary and remediates a portion of the OU III VOC plume to reduce additional off-site migration of the contamination and potential impacts of the VOC plume to the Carmans River. The system began operating in September 2002.

3.2.5.1 System Description

A complete description of the Western South Boundary Treatment System is contained in the *Operations and Maintenance Manual for the Western South Boundary Treatment System* (BNL 2002e).

3.2.5.2 Groundwater Monitoring

A network of 17 wells is used to monitor this portion of the OU III plume. Their locations are shown in **Figure 1-2**. The wells are sampled at the O&M phase frequency; see **Table 1-5** for details.

3.2.5.3 Monitoring Well Results

The primary VOCs associated with this portion of the OU III plume are dichlorodifluoromethane (freon), TCA, TCE, and chloroform. VOC contamination in the monitoring wells is located in the mid to deep Upper Glacial aquifer. Groundwater monitoring for this system was initiated in 2002. **Figure 3.2-1** presents fourth-quarter 2005 monitoring well concentrations. A summary of key monitoring well data for 2005 follows:

- Maximum TVOC concentrations during 2005 were found in perimeter well 130-03, located west of extraction well WSB-1, at 48 μg/L during the second quarter, with dichlorodifluoromethane as the highest VOC, at 26 μg/L. This is slightly lower than 2004, when the maximum TVOC concentration was 58 μg/L and dichlorodifluoromethane was 38 μg/L. Dichlorodifluoromethane, which was first detected in this well in mid 2001, has been increasing slightly each year, except for 2005. The capture zones of the Western South Boundary extraction wells were not intended to include this area.
- Plume core wells 121-42, 126-11, 126-13, 126-14, 127-04, and 127-06 have been steadily decreasing in concentrations since the treatment system was started in 2002. TVOC concentrations in core well 126-15, located midway between the two extraction wells, have remained consistently low, at less than 5 μg/L.
- TVOC concentrations in plume bypass wells 126-16, 127-07, and 130-08 have remained steady, between 20 μg/L to 43 μg/L, since the system started. If any of these wells starts showing increasing trends, the need to take further action will be evaluated.
- Plume perimeter wells 119-03 and 125-01 monitor the groundwater quality in the vicinity of the OU III Western South Boundary recharge basin. There were no detections of VOCs exceeding NYS AWQS for these wells in 2005.

3.2.5.4 System Operations

During 2005, the extraction wells were sampled monthly; however, they were not sampled in December, as discussed below. The influent and effluent of the air-stripper tower were sampled twice per month, except when the system was placed in standby mode for pulse pumping from early September through October, and all of December. All samples were analyzed for VOCs. In addition, the effluent sample was analyzed for pH and tritium twice a month. **Table 3.2.5-1** provides the effluent limitations for meeting the requirements of the SPDES equivalency permit. All effluent discharges met the SPDES equivalency permit requirements. The system operations are summarized as follows:

January–September 2005
The treatment system operated normally from January to May. However, there was one effluent pH reading in March of 6.3 SU; the permitted low is 6.5. The pH remained within the permitted range the remainder of the year. In June the system was shut down for six days so the recharge basin could be drained and scraped of scaling.

From June to August the system operated normally. In September, the system operated for the first week and then was shut down and placed in standby as part of the pulse pumping schedule set forth in the *2004 Groundwater Status Report* recommendations. The system is now on a schedule of one month on and two months off. During pulse pumping, if the system is off the extraction wells are still sampled; however, the influent and effluent are not.

October–December 2005
The system was off in October and December as part of the pulse pumping schedule. Normal system operations were conducted in November and the system operated without interruption. In December a problem with the tower float switch was discovered while trying to sample the extraction wells. Due to this technical problem no extraction well samples were collected in December.

Table 3.2.5-1.
Western South Boundary Pump & Treat System
2005 SPDES Equivalency Permit Levels

Parameter	Permit Level (µg/L)*	Max. Measured Value (µg/L)
pH range	6.5–8.5 SU	6.3–7.7 SU
carbon tetrachloride	5	<0.5
chloroform	7	<0.5
dichlorodifluoromethane	5	<0.5
1,1-dichloroethane	5	<0.5
1,1-dichloroethylene	5	<0.5
methyl chloride	5	<0.5
tetrachloroethylene	5	<0.5
toluene	5	<0.5
1,1,1-trichloroethane	5	<0.5
1,1,2-trichloroethane	5	<0.5
trichloroethylene	10	<0.5

Maximum allowed by regulations equivalent to SPDES permit.
Required effluent sampling frequency is 2x/month for VOCs and monthly for pH.

3.2.5.5 System Operational Data

Extraction Wells
During 2005, approximately 120 million gallons of groundwater were pumped and treated by the OU III Western South Boundary System, with an average flow rate of approximately 200 gpm. **Table 2-3** gives monthly pumping data for the two extraction wells. VOC and tritium concentrations for extraction wells WSB-1 (126-12) and WSB-2 (127-05) are provided in **Table F-21** in **Appendix F** (on the CD-ROM). VOC levels in both wells continued to show a slight decreasing trend with time, while a slight rebound in VOC concentrations is noted during the pulse pumping month of October in extraction well WSB-2. TVOC extraction well concentrations typically averaged between 8 to 11 µg/L for 2005, and the October value was 20 µg/L. (**Figure 3.2.5-1)**.

System Influent and Effluent
All influent TVOC concentrations were less than 10 µg/L, and individual VOC concentrations were less than the NYS AWQS. These levels are consistent with the 2004 influent concentrations. The influent consists primarily of dichlorodifluoromethane, TCA, TCE, and chloroform (**Tables F-22** and **F-23**, **Appendix F**).

The air-stripper system effectively removed all elevated contaminants from the influent groundwater. All effluent data were below the analytical method's detection limit and below the regulatory limit specified in the equivalency permit conditions.

Cumulative Mass Removal

The mass of VOCs removed from the aquifer by the treatment system was calculated. Average flow rates for each monthly monitoring period were used, in combination with the TVOC concentration in the air-stripper's influent, to calculate the pounds removed per month (**Table F-24, Appendix F**). The cumulative mass of VOCs removed by the treatment system is provided in **Figure 3.2.5-2**. During 2005, 7 pounds of TVOCs were removed; a total of 39 pounds have been removed since the startup of the system in 2002.

Air Discharge

Table 3.2.5-2 presents the VOC air emission data for the year 2005 and compares the values to levels stipulated in NYSDEC Air Guide 1 regulations. Emission rates are calculated through mass balance for all water treated during operation. The concentration of each constituent of the air-stripper's influent was averaged for the year. That value was converted from μg/L to lb/gal, which was multiplied by the average pumping rate (gal/hr) to compare with the regulatory value. All VOC air emissions were well below allowable levels.

Table 3.2.5-2.
Western South Boundary
Air Stripper VOC Emissions Data

Parameter	Allowable ERP* (lb/hr)	Actual ERP (lb/hr)
carbon tetrachloride	0.016	<0.0002
chloroform	0.0086	0.0002
1,1-dichloroethane	10**	<0.0002
1,2-dichloroethane	0.011	<0.0002
1,1-dichloroethene	0.194	0.0001
chloroethane	10**	<0.0002
1,1,1-trichloroethane	10**	0.0002
trichloroethene	0.119	0.0001

ERP = Emissions Rate Potential, stated in lb/hr.
* Based on NYSDEC Air Guide 1 Regulations.
** 6 NYCRR Part 212 restricts emissions of VOCs to a maximum of 10 lb/hr without controls.

3.2.5.6 System Evaluation

The system has been fully operational since September 2002, except for the pulse pumping initiated in late 2005. The Western South Boundary Pump and Treat System performance can be evaluated based on the five major decisions identified for this system from the groundwater DQO process.

1. Was the BNL Contingency Plan triggered?

No. There were no unusual or unexpected VOC concentrations observed in the monitoring wells associated with the Western South Boundary Treatment System during 2005.

2. Has the plume been controlled?

Yes. VOC concentrations in most of the plume perimeter wells remained stable at or less than the drinking water standard during 2005, indicating that the plume is being controlled. However, perimeter well 130-03 has been slowly increasing over the last few years. As noted above, low VOC concentrations in the bypass wells were present before the system was operational and not within the capture zone of the extraction wells. The capture zone for the treatment system is depicted in **Figure 3.0-1**.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate?

Yes. The system is operating as planned based on the mass removal of VOCs. Plume core monitoring wells began showing decreasing concentration trends since 2002.

4. Can the groundwater treatment system be shut down?

No, the system has not met all shutdown requirements; however, as per the 2004 recommendations, the extraction wells began pulse-pumping in late 2005 (see 4a through 4b).

4a. Have asymptotic VOC concentrations been reached in core wells?

No. As noted in Section 3.2.5.3 above, all core monitoring wells have been steadily decreasing since the system became operational in mid 2002. The extraction wells have shown generally decreasing concentration trends since 2002. However, there was a doubling of TVOC concentrations in extraction well WSB-2, to 20 μg/L, in October 2005.

4b. Is the mean TVOC concentration in core wells less than 20 μg/L?

No. Five out of seven core wells have been below 20 μg/L TVOCs for the past 18 months.

4c. How many individual plume core wells are above 20 μg/L TVOCs?

TVOC concentrations in two of seven core wells were above 20 μg/L. Well 121-42, just upgradient of extraction well WSB-2, had a high TVOC concentration of 20.4 μg/L in 2005. Well 126-14, just upgradient of extraction well WSB-1, showed TVOCs up to 26 μg/L for the year.

4d. During pulsed operation of the system, is there significant concentration rebound in core wells?

No. It is too early to observe an impact in the monitoring wells since the extraction wells were first shut down for pulse pumping in September and October 2005. TVOC concentrations in the extraction wells typically averaged between 8 to 11 μg/L for 2005; however, the October value increased to 20 μg/L prior to restart in November.

5. Have the groundwater cleanup goals been met? Are MCLs expected to be been achieved by 2030?

No. MCLs have not been achieved for individual VOCs in all plume core wells. However, MCLs are expected to be achieved by 2030.

3.2.5.7 Recommendations

The following are recommendations for the OU III Western South Boundary Treatment System and groundwater monitoring program:

- Due to the low influent concentrations and because five out of seven plume core wells have reached the cleanup objective of 20 μg/L TVOCs, it is recommended that pulse pumping the extraction wells continue. The wells will be shut down for two months, then turned back on for one month. This process will continue to evaluate any changes to the VOC concentrations in the influent and the monitoring wells.
- The extraction wells sampling frequency will change from monthly to quarterly.

3.2.6 Industrial Park In-Well Air Stripping System

This section summarizes the operational data from the OU III Industrial Park In-Well Air Stripping System for 2005 and presents conclusions and recommendations for its future operation. The system began operation on September 27, 1999. The OU III Industrial Park system was designed to contain and remediate the portion of OU III plume existing between BNL's southern boundary and the southern boundary of the Parr Industrial Park. **Figure 3.2-1** illustrates the extent of the OU III contaminant plume in the vicinity of the Industrial Park.

3.2.6.1 System Description

The OU III Industrial Park system consists of a line of seven in-well air stripping treatment wells. Each treatment well is constructed with two well screens separated by an inflatable packer. Contaminated groundwater is withdrawn from the aquifer via submersible pump through a lower screen (extraction screen) set at the base of the treatment well. The groundwater is pumped to a stripping tray located in a belowground vault over the wellhead. After passing through the stripping tray, treated groundwater flows back down the well and is recharged to a shallower portion of the aquifer through an upper screen (recharge screen). Some of the treated groundwater that is recharged through the upper screen recirculates through the cell and is drawn back into the extraction screen for further treatment, while the balance flows in the direction of regional groundwater flow.

A closed-loop air system through a single blower keeps the vault under a partial vacuum. This vacuum draws air from below the stripping tray as contaminated groundwater is discharged on top. VOCs are transferred from the liquid phase to the vapor phase as contaminated groundwater passes through the stripping tray. The contaminated air stream is carried from the vault to a treatment and control building, where it is passed through two granular activated carbon (GAC) units in series to remove the VOCs. Treated air is then recirculated back to the wellhead. The carbon units, system blower, and system control panel are all housed in a one-story masonry treatment building. A complete description of the system is included in the *Operation and Maintenance Manual for the OU III Off-Site Removal Action* (BNL 2000e).

3.2.6.2 Groundwater Monitoring

Well Network

The monitoring well network consists of 40 wells and is designed to monitor the VOC plumes in the vicinity of the industrial park south of the site, and also the effectiveness of the in-well air stripping groundwater treatment system on this part of the high-concentration OU III VOC plumes. The wells are located throughout the industrial park, and on Carleton Drive, shown in **Figure 3.2.1.** Screen depths vary, to capture water levels at multiple levels and to obtain water quality data as follows: 1) above the treatment well effluent depth, 2) at the effluent depth, and 3) at the treatment well influent depth.

Sampling Frequency and Analysis

In general, plume core and perimeter wells are sampled either annually or semiannually and analyzed for VOCs. Bypass detection and Magothy wells are sampled quarterly and analyzed for VOCs (**Table 1-5**).

3.2.6.3 Monitoring Well Results

The complete results are included in **Appendix C** (on the CD-ROM). VOC concentrations in the plume perimeter wells that monitor the width of the plume (000-245 and 000-272) remained below NYS AWQS during 2005. Based on these data, the plume is effectively bounded by the current well network. **Figure 3.2.4-1** shows the plume distribution based on fourth-quarter 2005 data. The vertical extent of contamination is shown in **Figure 3.2.6-1**. The location of this cross section (G–G') is illustrated in **Figure 3.2-1**.

The highest TVOC concentrations in the industrial park area observed in 2005 were between remediation wells UVB-4 and UVB-5: 452 µg/L in well 000-262, in November 2005. This is down from the 2004 maximum concentration of 527 µg/L in well 000-268, which is located between UVB-6 and UVB-7 in the eastern portion of the industrial park system. VOC concentrations showed a slight increase in the industrial park monitoring wells during 2005. Results for key monitoring wells are as follows.

- Plume core wells 000-253 (just east of UVB-1) and 000-256 (between UVB-1 and UVB-2), which had both shown concentrations in 2001 well over 1000 µg/L, have continued to show concentrations at or just slightly above drinking water standards.
- 000-259 (between UVB-2 and UVB-3) showed increases in concentrations during 2005, with a concentration of 438 µg/L detected in November 2005. This is consistent with data observed in extraction wells UVB-2 and -3.
- A steady decline in VOC concentrations was observed in plume core well 000-112 (immediately upgradient of UVB-1 and UVB-2) from 1999 through early 2002, except during the latter portion of 2002. TVOC concentrations were at 12 µg/L in November 2005 (**Figure 3.2.6-2**).
- Plume core well 000-262 (between UVB-4 and UVB-5) began showing decreasing TVOC concentrations in 2002; these were at 224 µg/L in the fourth quarter of 2004 (**Figure 3.2.6-2**). TVOC concentrations in this well peaked at 2,175 µg/L in 2001 and were at 438 µg/L in November 2005. This is an increase from 2004 but consistent with data observed in adjacent UVB wells 4 and 5.
- The VOC concentration in well 000-268 (between UVB-6 and UVB-7) was 282 µg/L in November 2005 (**Figure 3.2.6-2**). The data are consistent with data observed in UVB wells 6 and 7.
- VOC concentrations in bypass monitoring wells located near Carleton Drive were stable or decreasing during 2005. Wells 000-431 and 000-432 serve as bypass monitoring points downgradient of UVB-2. Well 000-432 has shown TVOC concentrations between 5 µg/L and 15 µg/L since sampling began in 2003. TVOC concentrations in 000-431 varied from 5 µg/L to 10 µg/L during 2005. The low VOC concentrations in these wells indicate that the system is effective in hydraulically controlling the plume.
- The remaining bypass wells for the OU III Industrial Park System are wells 000-273, 000-274, 000-275, 000-276, 000-277, and 000-278. TVOC concentrations in these wells are all below the capture goal of 50 µg/L, indicating that the system is effective in capturing the plume. The highest concentration observed was 26 µg/L (March 2005), in well 000-274.
- VOC concentrations for individual constituents remained below NYS AWQS (5 µg/L) in each of the shallow wells screened to monitor the adjacent UVB effluent wells.

3.2.6.4 System Operations

In 2005, approximately 116 million gallons of groundwater were pumped and treated.

Operating Parameters

Water samples are obtained monthly from each of the seven wells before air stripping in each UVB tray and after treatment. All samples are analyzed for VOCs. These samples determine the wells' removal efficiency and performance. Based on these results, operational adjustments are made to optimize the system's performance.

System Operations

The following summarizes the system operations for 2005.

January – September 2005

Well UVB-2 was offline January 1 through January 9 with electrical problems. Well UVB-1 was offline from January 12 to January 31 with a faulty pump. Well UVB-1 was off the entire month of February waiting for the pump to be replaced. The entire system was off from February 24 to March 7 for repairs to the blower and condenser units. Well UVB-1 was repaired and started on March 7. Well UVB-2 was off from March 18 to March 31 with electrical problems.

Well UVB-1 was offline from April 14 to April 30 with a faulty pump. Well UVB-2 was offline the entire month of April with electrical problems. Well UVB-3 was offline from April 1 to April 7 with electrical problems. Wells UVB-1 and UVB-7 were offline the entire month of May waiting to be developed. UVB-2 was offline the entire month with electrical problems. Well UVB-3 was offline from May 22 to May 31 with electrical problems The entire system was offline from May 16 to May 17 for maintenance to the blower and condenser units. Wells UVB-1, UVB-2, and UVB-7 were offline the entire month of June waiting for repair. Well UVB-4 was offlinemost of June with electrical problems.

July – September 2005

Wells UVB-1 and UVB-5 were offline the entire month of July with electrical problems. Wells UVB-2 and UVB-4 were offline most of the month of July waiting to be repaired. Routine maintenance was preformed on the blower July 12. Wells UVB-1 and UVB-5 remained offline the entire month of August with electrical problems. Wells UVB-4 and UVB-3 ran sporadically for the month of August. Wells UVB-1, UVB-3, UVB-4, and UVB-5 were offline the entire month of September for repair.

October – December 2005

Well UVB-1 was put in standby per recommendations in the 2004 annual report in October 2005. The system was offline October 4 to October 10 and again from November 9 to November 16 with electrical problems. Well UVB-1 was repaired and temporarily restarted on November 11 for testing. UVB-3 was offline from November 21 to November 29 with a faulty float. UVB-2 was offline most of November waiting for repairs.

3.2.6.5 System Operational Data

Recirculation Well Influent and Effluent

During 2005, influent TVOC concentrations in all treatment system wells remained stable (**Figure 3.2.6-3**). The corresponding effluent well concentrations (**Figure 3.2.6-4**) showed decreasing or stable TVOC concentrations for the year. The concentrations in UVB-1 have decreased significantly since startup in 1999. There was significant downtime in 2005 due to electrical problems and fouling of the recharge screens.

During the fourth quarter 2005, the average removal efficiency for VOCs was 90 percent. Overall for 2005, the average removal efficiency was 89 percent (**Table F-25**, **Appendix F**).

Cumulative Mass Removal

Calculations were performed to determine the VOC mass removed from the aquifer by the remediation wells during the year. The average estimated flow rates for each monthly monitoring period were used, in combination with the influent and effluent TVOC concentrations, to calculate the pounds per month removed. **Table F-26** summarizes these data and they are included in **Appendix F**. Flow averaged approximately 32 gpm for the wells during 2005. **Figure 3.2.6-5** plots the total pounds of TVOCs removed by the treatment system vs. time. During 2005, 63 pounds were removed from the aquifer, with a total of 90 pounds removed to date. Pumpage was low this year due to significant downtime of the system.

Air Treatment System

Air samples were collected quarterly from the GAC vessels prior to treatment, between the two vessels, and after the second vessel (effluent). The samples were used to determine when a GAC changeout is needed. In addition, airflow rates were recorded to optimize the efficiency of individual recirculation wells.

Airflow rates are measured for each in-well air-stripping unit inside the treatment building. These rates averaged 554 cfm for the seven wells during 2005 (**Table F-27, Appendix F**).

3.2.6.6 System Evaluation

The OU III Industrial Park In-Well Air Stripping system performance can be evaluated based on the five major decisions identified for this system resulting from the groundwater DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no unusual or unexpected VOC concentrations observed in the monitoring wells associated with the OU III Industrial Park System during 2005.

2. Has the plume been controlled?

Yes. An analysis of the plume perimeter and bypass well data reveals that there have been no significant VOC concentration increases in these wells during 2005. Therefore, we conclude that there has been no plume growth and the plume continues to be controlled.

The capture zone for the OU III Industrial Park System is depicted in **Figure 3.0-1**. The capture zone depicted includes the TVOC 50 µg/L isocontour, which is the capture goal of this system.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate for this treatment system?

Yes. The treatment system is effectively removing contamination. The current estimate for treatment system operations is 12 years, which is significantly longer than the design estimate (7 to 9 years). The OU III Industrial Park System continues to effectively remove VOCs from the deep Upper Glacial aquifer. Actual mass removal is approximately 10 percent above projections using the groundwater model (**Figure 3.2.6-5**). **Figure 3.2-4** compares the OU III plume from 1997 to 2005. The overall reduction in the high-concentration areas of the plume near the south boundary is evident. This is an indication that concentrations of VOCs approaching the Industrial Park System will decrease over time.

The OU III Industrial Park System is currently planned to operate for 12 years; at the end of 2005, it had operated for 6 years. The trend in the mean of the TVOC concentrations in the core groundwater monitoring wells is a declining one (**Figure 3.2.6-6**). The system is removing contamination at the expected rate and hydraulic control of the plume is demonstrated; hence, it is operating as planned.

4. Can the groundwater treatment system be shut down?

No, the system has not met all shutdown requirements (see below).

4a. Have asymptotic TVOC concentrations been reached in core wells?

No. During 2005, concentrations showed an overall slightly increasing trend.

4b. Is the mean TVOC concentration in core wells less than 50 µg/L (expected by 2025)?

No, the mean TVOC concentration in the plume core wells was 157 µg/L in the fourth-quarter 2005.

4c. How many individual plume core wells are above 50 µg/L?

Five (000-249, 000-259, 000-262, 000-268, and 000-271) of the nine plume core wells have TVOC concentrations exceeding 50 µg/L, as of the fourth quarter 2005.

4d. During pulsed operation of the system, is there significant concentration rebound in the core wells?

The OU III Industrial Park System has not been pulsed to date.

5. Have the groundwater cleanup goals been met? Have MCLs been achieved (expected by 2030)?

No. MCLs have not been achieved for individual VOCs in plume core wells. Based on model results, MCLs are expected to be achieved by 2030, as required by the OU III ROD.

3.2.6.7 Recommendations

The following are recommendations for the Industrial Park In-Well Air Stripping System and groundwater monitoring program:

- The current routine operations and maintenance monitoring frequency should be maintained during 2006.
- The system should continue operations at 60 gpm per well except for well UVB-1, which is to remain in a standby mode. Monthly sampling will continue and if higher concentrations are observed, well UVB-1 will be restarted.
- Increase the operational time of the system in 2006, as 2005 had extended periods of downtime due to electrical and well fouling problems.

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3.2.7 Industrial Park East Pump and Treat System

This section summarizes the 2005 operational and monitoring well data for the OU III Industrial Park East (IPE) groundwater pump and treat system, and presents conclusions and recommendations for its future operation. The system began full operation in June 2004 to provide capture and control for a downgradient portion of the OU III VOC plume, which has migrated beyond the BNL site boundary.

3.2.7.1 System Description

The treatment facility (Building OS-2) is located at the Industrial Park immediately east of Building OS-1, the Industrial Park Groundwater Treatment System. This system includes two extraction wells and one recharge well. Extraction well EW I-1 is screened in the Upper Glacial aquifer, near the high-concentration core of the plume, and EW I-2 is screened in the upper portion of the Magothy aquifer (see **Figure 3.2.4-1**). Extraction well EW I-1 is designed to operate at a maximum rate of approximately 120 gpm; extraction well EW I-2 is designed for approximately 100 gpm.

The treated water is recharged to the Upper Glacial aquifer through a recharge well near the extraction wells, designated as DW I-1. A complete description of the system is contained in the *Operations and Maintenance Manual for the Industrial Park East Offsite Groundwater Remediation System* (BNL 2004i).

3.2.7.2 Groundwater Monitoring

The monitoring network consists of 12 wells (**Figure 1-2**) that are sampled quarterly and analyzed for VOCs. These wells monitor the VOC plume south of the LIE to Astor Drive in the East Yaphank residential area, as well as the effectiveness of the groundwater treatment systems.

3.2.7.3 Monitoring Well Results

The primary VOCs associated with this portion of the OU III plume are TCA, trichloroethylene, and 1,1-dichloroethylene. Groundwater monitoring for this system was initiated in 2004; however, three of the wells have been monitoring the plume since 1999. Fourth-quarter well data is posted on **Figures 3.2.4-1** and **3.2.6-1**. The complete results are in **Appendix C.** Results for key monitoring wells are as follows:

- Maximum TVOC concentrations during 2005 were found in plume core well 000-514, at 174 μg/L during the first quarter, with TCA as the highest VOC, at 110 μg/L. This well is located about 100 feet west of the extraction wells, but within the capture zone of the wells. The TVOC concentrations in this well continued to decline over the year to a low of 14 μg/L in the fourth quarter.
- Plume core well 122-24, immediately north of the extraction wells, detected TVOC concentrations ranging from 25 μg/L to 37 μg/L during 2005.
- VOCs in plume bypass wells 000-493, 000-494, and 000-495 have remained below the MCL since they were installed in June 2004.

3.2.7.4 System Operations

Operating Parameters

The influent, midpoint, and effluent of the carbon vessels are sampled twice a month during startup. Since there was no combined influent sampling port until January 2005, the extraction well sample data was used to determine VOC concentrations entering the carbon vessels. The extraction wells are sampled monthly. All samples are analyzed for VOCs. In addition; the pH of the influent and effluent samples is measured monthly. Sampling for pH and VOCs adheres to the requirements of the SPDES equivalency permit. All effluent samples during this period of operation were within the permit levels (**Table 3.2.7-1**).

Table 3.2.7-1.
Industrial Park East Pump & Treat System
2005 SPDES Equivalency Permit Levels

Parameters	Permit Limit (µg/L)*	Max. Measured Value (µg/L)
pH (range)	5.5–8.5 SU	5.8–8.2 SU
bromoform	50	<0.50
carbon tetrachloride	5	<0.50
chloroform	5	<0.50
methylene chloride	5	<0.50
tetrachloroethylene	5	<0.50
toluene	5	<0.50
trichloroethylene	10	<0.50
1,2-dichloroethane	5	<0.50
1,1 dichloroethane	5	<0.50
1,1-dichloroethylene	5	<0.50
1,1,1-trichloroethane	5	<0.50

*Maximum allowed by requirements of the SPDES equivalency permit.
Required sampling frequency is monthly for VOCs and pH.

System Operations

The system began routine operations in June of 2004. The following information summarizes the system operations for 2005.

January –September 2005

The system was shut down a few days for two routine carbon changeouts in early January and early June. EW I-1 was off from March 16 to April 12 for a pump replacement. The system was off for repairs from August 25 until September 18. The system operated normally the remainder of the time. Sixty-five million gallons were pumped and treated during the first three quarters of 2005.

October–December 2005

The system was off from October 14 to October 26 for repairs. The system was also off from November 22 to December 12, for development of the diffusion well. The system pumped and treated 18 million gallons of groundwater this quarter.

Extraction Wells Operational Data

During 2005, approximately 83 million gallons were pumped and treated by the IPE system, with an average flow rate of 158 gpm in 2005. **Table F-28** shows the monthly pumping data for the system. VOC concentrations for the IPE extractions wells are provided in **Table F-29**. TVOCs in EW I-1 were below 6 µg/L throughout 2005 and up to 26 µg/L in EW I-2.

3.2.7.5 System Operational Data

System Influent and Effluent

The overall TVOC influent concentrations to the carbon vessels declined during the year, from a high of 16.6 µg/L in March to a low of 7.5 µg/L in December 2005. **Tables F-29** and **F-30** in **Appendix F** present the influent and effluent data.

Cumulative Mass Removal

The mass of VOCs removed from the aquifer was calculated using average flow rates for each monthly monitoring period and influent concentrations to the carbon treatment system. **Table F-28** lists monthly pumpage rates for 2005.

Table F-28 gives total pounds of VOCs removed by the treatment system. **Figure 3.2.7-1** plots mass removal versus time. Approximately 7 pounds of VOCs were removed from the aquifer during 2005.

3.2.7.6 System Evaluation

This system is designed to achieve the overall OU III ROD objectives of minimizing plume growth and meeting MCLs in the Upper Glacial aquifer in 30 years (i.e., 2030) or less. According to the *OU III Explanation of Significant Differences* (BNL 2005b), MCLs within the Magothy aquifer must be met within 65 years (i.e., 2070) or less. The system will address the highest VOC concentration portion of the plume (above 50 μg/L).

The Industrial Park East Pump and Treat System performance during 2005 can be evaluated based on the five major decisions identified for this system from the groundwater DQO process:

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no unusual or unexpected VOC concentrations observed in the monitoring wells associated with the treatment system during 2005.

2.Has the plume been controlled?

Yes. However, an additional monitoring and temporary well will be installed in 2006 to confirm the presence of higher VOC concentrations.

3. Is the System operating as planned?

Yes. The system is operating as planned. Due to the concerns of potentially higher VOC concentrations to the west of the extraction wells, an additional monitoring and temporary well will be installed.

4. Can the groundwater treatment system be shut down?

No, the system has not met all shutdown requirements.

4a. Have asymptotic VOC concentrations been reached in core wells?

No. The system has only been in operation a year and a half.

4b. Is the mean TVOC concentration in core wells less than 50 μg/L (expected by 2025)?

Yes. However, additional monitoring wells will be installed to verify the extent of the higher VOC concentrations.

4c. How many individual plume core wells are above 50 μg/L?

Well 000-514, which is about 100 feet west of the extraction wells, has had TVOC concentrations up to 174 μg/L during 2005. However, by the fourth quarter the TVOC concentration was reduced to 14 μg/L.

4d. During pulsed operation of the system, is there significant concentration rebound in the core wells?

The Industrial Park East System has not been pulsed, to date.

5. Have the groundwater cleanup goals been met? Specifically, have MCLs been achieved in the Upper Glacial aquifer (expected by 2030) and the Magothy aquifer (expected by 2070)?

No. MCLs have not been achieved for individual VOCs in all plume core wells. MCLs are expected to be achieved by 2030 and 2070 for the Upper Glacial and Magothy aquifers, respectively, as required by the OU III ROD and ESD.

3.2.7.7 Recommendations

The following are recommendations for the Industrial Park East Pump and Treat System and groundwater monitoring program.

- As per the recommendation in the *2004 Groundwater Status Report*, BNL will install an additional Magothy monitoring well adjacent to well 000-495, but deeper.
- Install a temporary well near well 000-514 to evaluate concentrations of deeper contamination in this area. If concentrations exceed 50 µg/L in this area, consider installing an additional monitoring well at this location.
- Continue operations at 115 gpm for EWI-1 and 75 gpm for EWI-2.
- No changes are recommended at this time to the monitoring well network and sampling frequency.

3.2.8 North Street Pump and Treat System

The North Street Pump and Treat System addresses a VOC plume that originated at the Former Landfill/Chemical Holes area. The VOC plume is primarily located south of the site boundary, with the leading edge extending south to the vicinity of the Brookhaven Airport. The groundwater pump and treat system began operating in May 2004.

Groundwater treatment consists of two extraction wells operating at a combined pumping rate of approximately 450 gpm. This pumping will capture the higher concentration portion of the VOC plume (i.e., TVOC concentrations greater than 50 µg/L) in the Upper Glacial aquifer and will minimize the potential for VOC migration to the Magothy aquifer.

The North Street plume has been divided into segments for remediation purposes. The area north of Moriches–Middle Island Road is being addressed by the remediation system on North Street, whereas the Airport System handles the area to the south (**Figure 3.0-1**). The Airport System was constructed to address the leading edge of this plume and satisfy the cleanup objectives defined in the OU III ROD (minimize plume growth and meet MCLs in the Upper Glacial aquifer in 30 years or less).

3.2.8.1 System Description

The North Street system consists of two extraction wells. Extracted groundwater is piped through two 20,000-pound GAC units and discharged to two of four injection wells. Both the North Street and North Street East systems share the four injection wells. Extraction well NS-1 is designed to operate at a rate of approximately 200 gpm, and extraction well NS-2 is designed for 250 gpm. A complete description of the system is contained in the *Operations and Maintenance Manual for the North Street/North Street East Offsite Groundwater Treatment Systems* (BNL 2004f).

3.2.8.2 Groundwater Monitoring

Well Network

A network of 30 wells monitors the downgradient portion of the VOC plumes originating from these areas (**Figure 1-2**). The monitoring program also addresses radiological contaminants that may have been introduced to groundwater in the OU IV portion of the site (particularly the Building 650 and 650 sump outfall areas). Wells sampled under the OU III South Boundary and Industrial Park Programs are also utilized for mapping this plume.

Sampling Frequency and Analysis

The 30 wells are sampled and analyzed for VOCs according to the schedule in **Table 1-5**. Twenty-seven wells are sampled and analyzed annually for gross alpha/beta, gamma spectroscopy, and Sr-90. All wells are sampled and analyzed annually for tritium.

3.2.8.3 Monitoring Well Results

The primary VOCs associated with this plume are carbon tetrachloride, PCE, and TCA. **Figure 3.2-1** and **Figure 3.2.10-1** depicts the TVOC plume distribution and includes data from all the monitoring wells. The complete groundwater monitoring well data for 2005 are included in **Appendix C**. A north–south hydrogeologic cross section (H–H') of the plume is provided in **Figure 3.2.8-1.** The location for the cross section is shown in **Figure 3.2-1**. Monitoring well 000-154 had historically shown the highest VOC concentrations (primarily carbon tetrachloride) in the North Street area. TVOC concentrations greater than 1,000 µg/L were observed in 1997 and 1998, but have steadily declined since then to 8 µg/l in the fourth quarter of 2005. Plots of the monitoring well trends in this area are shown in **Figure 3.2.8-2**.

High concentrations of VOCs continue to be observed in wells 000-463, 000-464, and 000-465 immediately upgradient of extraction well NS-1. Concentrations ranged from a low of 83 µg/L in well 000-464 in the fourth quarter of 2005, to a high of 524 µg/L in well 000-465 in the first quarter of 2005.

Values at well 800-63, located about 2,500 feet upgradient of the Airport System, ranged from 62 µg/L in the first quarter of 2005 to 30 µg/L in the third quarter. This suggests that the leading edge of the higher concentration segment has reached this location.

Historically, tritium has been detected in localized off-site areas roughly within the area covered by the North Street VOC plume. Potential sources for this tritium as well as other radionuclides are located in the Former Landfill/Chemical/Animal Holes and OU IV Building 650 areas of the site. Tritium has been detected in the deep Upper Glacial aquifer at concentrations well below the DWS of 20,000 pCi/L.

Historically, the highest tritium concentration was detected in 2001 in temporary well 000-337, at 9,130 pCi/L. This location is approximately 300 feet north of well 000-153. Tritium has been detected historically in well 000-153. In 2005, the tritium concentration in this well declined to 780 pCi/L, from 970 pCi/L in 2004.

3.2.8.4 System Operations

Weekly laboratory analyses are performed on influent, midpoint, and effluent samples from the GAC units. All samples are analyzed for VOCs, and the influent and effluent samples are also analyzed for pH. In addition, the system effluent is analyzed for tritium. **Table 3.2.8-1** provides the effluent limitations for meeting the requirements of the SPDES equivalency permit.. The extraction wells are sampled on a monthly basis.

Table 3.2.8-1
OU III North Street
2005 SPDES Equivalency Permit Levels

Parameters	Permit Limit (µg/L)*	Max. Observed Value (µg/L)
pH (range)	5.5 – 8.5 SU	5.5 - 6.9 SU
carbon tetrachloride	5	ND
chloroform	5	ND
1,1-dichloroethane	5	ND
1,2-dichloroethane	5	ND
1,1-dichloroethylene	5	ND
tetrachloroethylene	5	ND
toluene	5	ND
1,1,1-trichloroethane	5	ND
trichloroethylene	10	ND

*Maximum allowed by requirements equivalent to a SPDES permit.
ND = Not detected above method detection limit of 0.50 µg/L.

Required effluent sampling frequency is monthly for VOCs and pH.

January–September 2005

Routine operations continued from January through September, with approximately 164 million gallons pumped and treated during the first three quarters. The system was off for approximately 1 to 2 days each month to allow for scheduled carbon filter changeouts.

October–December

Routine operations continued from October through November. In December, the system was shut down so the injections wells associated with the system could be cleaned. The system was restarted in January 2006. Approximately 36 million gallons were pumped and treated during this quarter.

3.2.8.5 System Operational Data

The North Street System was in normal operation mode for the entire year. The system was operational from January to December 2005, with only minor shutdowns due to electrical outages, programmable logic controller (PLC) issues, scheduled maintenance, and GAC changeouts.

Extraction Wells

Table F-31 contains the monthly pumping data and mass removal data for the system. VOC concentrations for the extractions wells are provided in **Table F-32** in **Appendix F** (on the CD-ROM). Well NS-1 declined from 109 to 49 µg/L over the period, and well NS-2 remained unchanged, with TVOC values ranging from 17 to 25 µg/L.

System Influent and Effluent

VOC concentrations in 2005 for the NS carbon influent and effluent are summarized in **Tables F-33** and **F-34** in **Appendix F**. The combined influent declined from 75 µg/L in December 2004, to 43 µg/L in November 2005.

The carbon vessels for the system effectively removed all contaminants from the influent groundwater. All effluent data were below the analytical method's detection limit and below the regulatory limit specified in the equivalency permit conditions.

Cumulative Mass Removal

The mass of VOCs removed from the aquifer by the OU III North Street Pump and Treat System was calculated using the average flow rates for each monthly monitoring period, in combination with the TVOC concentration in the carbon unit's influent, to calculate the pounds removed per month. The cumulative mass of VOCs removed by the treatment system vs. time was then plotted (**Figure 3.2.8-3**). During 2005, approximately 200 million gallons of groundwater were pumped and treated by the North Street system, and approximately 72 pounds of VOCs were removed. The data for this figure are summarized in **Table F-31.**

3.2.8.6 System Evaluation

Construction of the OU III North Street Pump and Treat System and installation of additional monitoring wells was completed in May 2004. **Figure 3.2.8-4** compares the TVOC plume from 1997 to 2005. The following significant changes were observed in the plume over this period:

- The trailing edge of the plume has migrated south of the BNL site.
- The high-concentration area (> 100 µg/L) has moved south from well 000-154 and is located within the two extraction wells' combined zone of influence (**Figure 3.2.8-5**).
- The leading edge of the plume, as defined by a TVOC value of 5 µg/L, remains in the vicinity of Flower Hill Drive. This is addressed in **Section 3.2.10**, LIPA/Airport Pump and Treat System.

The OU III North Street Monitoring Program can be evaluated from the five decision rules identified in the groundwater DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no unusual or unexpected VOC or radionuclide concentrations in the monitoring wells associated with this program during 2005.

2. If not, has the plume been controlled?

Yes. Since the cleanup goals have not been met, it must be verified that the plume is not growing. An analysis of the plume perimeter and bypass wells shows that there have been no significant increases in VOC concentrations in 2005; thus, we conclude that that plume has not grown and continues to be controlled.

The leading edge of the plume was defined at Flower Hill Drive at concentrations below the NYS AWQS for individual VOCs. The Airport Pump and Treat System is designed to capture any contaminants migrating south of Flower Hill Drive. All but six homes in the residential area overlying the plume have been connected to public water. These six households are offered annual well sampling.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate?

The hydraulic capture performance of the system is operating as modeled in the system design, and the system has been removing VOCs from the deep Upper Glacial aquifer. It is too early in the system's life cycle to determine whether the aquifer cleanup is proceeding as planned.

4. Are there off-site radionuclides that would trigger additional actions?
No. Based on monitoring well data, radionuclide contamination appears to be limited to isolated occurrences of tritium, primarily in the deep Upper Glacial aquifer, at concentrations below the DWS of 20,000 pCi/L.

5. Can the groundwater treatment system be shut down?
No, the system has not met all shutdown requirements.

5a. Have asymptotic TVOC concentrations been reached in core wells?
No. Asymptotic conditions have not yet been achieved.

5b. Are there individual plume core wells above 50 μg/L TVOC ?
There are currently six plume core wells showing concentrations greater than 50 μg/L.

5c. During pulsed operation of the system, is there significant concentration rebound in the core wells?
The North Street system has not been pulsed, to date.

5d. Have the groundwater cleanup goals been met? Will MCLs be achieved by 2030?
MCLs have not been achieved for individual VOCs in plume core wells. Based on the groundwater modeling, MCLs are expected to be achieved by 2030.

3.2.8.7 Recommendations

The following is recommended for the North Street Pump and Treat System and groundwater monitoring program:

- Change the monitoring well sampling schedule from the startup to O&M phase (core and perimeter wells sampled semiannually and sentinel wells sampled quarterly).

3.2.9 North Street East Pump and Treat System

This section summarizes the 2005 operational and monitoring well data for the OU III North Street East (NSE) groundwater pump and treat system, and presents conclusions and recommendations for its future operation. The system began operation in June 2004 to provide capture and control of the downgradient portion of the OU I VOC plume, which has migrated beyond the BNL site boundary.

3.2.9.1 NSE System Description

The North Street East treatment system consists of two extraction wells piped through two 20,000-gallon GAC units and discharged to injection wells. Both the North Street and North Street East systems discharge the treated water to four injection wells located on North Street. Extraction well NSE-1 is designed to operate at a rate of approximately 200 gpm; extraction well NSE-2 is designed for 100 gpm. A complete description of the system is contained in the *Operations and Maintenance Manual for the North Street/North Street East Offsite Groundwater Treatment Systems* (BNL 2004f).

3.2.9.2 NSE Groundwater Monitoring

The monitoring network consists of 14 wells. It was designed to monitor the VOC plume off site, south of the OU I South Boundary System, as well as the efficiency of the NSE groundwater remediation system (**Figure 1-2**).

3.2.9.3 NSE Monitoring Well Results

Figure 3.1-1 shows the extent of the VOC plume. The plume originated from the Current Landfill and former HWMF (sources in OU I). The on-site segment of the plume is being treated by the OU I South Boundary Remediation system. The off-site segment of the plume located south of BNL is being addressed by the NSE Remediation system. This segment of the plume extends from the vicinity of North Street to south of the LIPA right of way, a distance of approximately 3,700 feet. The maximum width of this segment of the plume is approximately 500 feet. The higher concentrations in this segment of the plume are located between the LIPA right of way and extraction well NSE-1.

Figure 3.1-2 depicts the vertical distribution of VOCs (primarily TCA, DCE, TCE, choroethane, and chloroform) within the deep Upper Glacial aquifer. The transect line for cross-section A–A' is shown in **Figure 3.1-1**. **Figure 3.1-3** gives the historical trends in VOC concentration for key core and bypass wells along the Current Landfill/HWMF/NSE plume. **Appendix C** (see attached CD Rom) contains a complete set of 2005 analytical results for the 14 NSE program wells. Significant findings for 2005 include:

- The plume continues to be bounded by the current network of wells.
- VOC concentrations in well 000-137 remained very low with detections from all four quarters below 1 μg/L. This signifies that the trailing edge of the shallower lobe of this plume has migrated south of North Street (**Figure 3.1-2**). Concentrations in well 000-138 have dropped from 253 μg/L in 1999 to 8 μg/L during the fourth quarter of 2005.
- The maximum TVOC concentration in well 000-124 was 14 μg/L in 2005, down from a high of 487 μg/L in 1998.
- TVOC concentrations in well core well 000-478 were as high as 205 μg/L in 2004 but had dropped to 17 ug/L by December 2005. This well is upgradient of NSE-1.

3.2.9.4 System Operations

Influent, midpoint, and effluent samples from the GAC units are sampled monthly, per SPDES Equivalency Permit requirements. The extraction wells are also sampled monthly. All samples are analyzed for VOCs. In addition, the influent and effluent samples are analyzed for pH. The system effluent is also analyzed for tritium. **Table 3.2.9-1** provides the effluent limitations for meeting the requirements of the SPDES Equivalency Permit.

Table 3.2.9-1.
OU III North Street East
2005 SPDES Equivalency Permit Levels

Parameters	Permit Limit (µg/L)*	Max. Observed Value (µg/L)
pH range	5.5–8.5 SU	5.9– 6.3 SU
carbon tetrachloride	5	ND
chloroform	5	ND
1,1-dichloroethane	5	ND
1,2-dichloroethane	5	ND
1,1-dichloroethylene	5	ND
tetrachloroethylene	5	ND
toluene	5	ND
1,1,1-trichloroethane	5	ND
trichloroethylene	10	ND

*Max. effluent allowed by requirements equivalent to a SPDES permit.
ND = Not Detected above method detection limit of 0.50 µg/L.
Required effluent sampling frequency is monthly for VOCs and pH.

3.2.9.5 System Operational Data

The NSE system operated from January through December 2005. The system was operational throughout 2005 with only minor shutdowns due to electrical outages, PLC issues, and scheduled maintenance. During 2005, approximately 6 pounds of VOCs were removed.

January through September

The system operated normally for the first three quarters of 2005. The system pumped and treated approximately 124 million gallons of water.

October through December

The system operated normally for the last quarter of 2005, with only minor shut downs recorded. In this quarter, the system pumped and treated approximately 39 million gallons of water.

Extraction Wells

During 2005, 163 million gallons were pumped and treated by the NSE system; **Table 2-3** contains the monthly pumping data for the two extraction wells. VOC concentrations for NSE-1 (000-487) and NSE-2 (000-483) are provided in **Table F-35** in **Appendix F** (on the CD-ROM). Declining TVOC trends are noted for both wells during 2005, with concentrations below 10 µg/L reported in both wells during the fourth quarter.

System Influent and Effluent

VOC concentrations for 2005 for the carbon treatment influent and effluent are summarized in **Tables F-36** and **F-37** in **Appendix F**. The carbon treatment system effectively removed all VOCs from the influent groundwater. All effluent concentrations were below the regulatory limit specified in the equivalency permit.

Cumulative Mass Removal

The mass of VOCs removed from the aquifer by the NSE treatment system was calculated. Average flow rates for each monthly monitoring period were used, in combination with the VOC concentration in the system influent, to calculate pounds per month removed (**Table F-38**). The cumulative mass of VOCs removed by the treatment system versus time was then plotted (**Figure 3.2.9-1**). It shows that 6 pounds of VOCs were removed during 2005, with a cumulative total of 11 pounds of VOCs removed since system startup in April 2004.

3.2.9.6 System Evaluation

The system began operations in June 2004 and was planned to run for approximately 10 years. The system is operating as designed. No operating difficulties were experienced beyond normal maintenance, and system effluent concentrations did not exceed SPDES equivalency permit requirements.

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no unusual or unexpected concentrations of contaminants observed in monitoring wells associated with the NSE treatment system.

2. Has the plume been controlled?

Yes. The system has been in operation for about 1.5 years, and an analysis of the plume perimeter and bypass wells shows that there have been no significant increases in VOC concentrations in 2005; thus, we conclude that plume has not grown and is controlled.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate?

The system is operating as modeled in the system design, and the system has been removing VOCs from the deep Upper Glacial aquifer. However, system influent VOC concentrations have been less than originally projected. In addition, the monitoring wells have shown low concentrations following initial startup of the system. Even though it is still early in the remediation process, these are indications that the system may not need to operate as long as originally planned.

4. Can the groundwater treatment system be shut down?

No, the system has not met all shutdown requirements.

4a. Have asymptotic TVOC concentrations been reached in core wells?

No. Asymptotic conditions have not yet been achieved. These conditions are not expected to be achieved for several years.

4b. Are there individual plume core wells above 50 μg/L TVOC ?

Yes. There is one plume core well (000-478) that had TVOC concentrations up to 58 μg/L.

4c. During pulsed operation of the system, is there significant concentration rebound in core wells?

The NSE system has not been pulsed to date.

4d. Have the groundwater cleanup goals been met? Have MCLs been achieved (expected by 2030)?

No. MCLs have not been achieved for individual VOCs in plume core wells. However, MCLs are expected to be achieved by 2030.

3.2.9.7 Recommendation

- Begin pulse pumping of both extraction wells, since the system influent concentrations have remained very low over the past year and 90 percent of the monitoring wells are already below the capture goal of 50 μg/L TVOC. The pulse pumping will consist of having the system on for one month then off in standby mode for the next. This will continue for approximately one year. The extraction wells will continue to be sampled on a monthly basis. If concentrations above the capture goal of 50 μg/L TVOCs are observed in either of the extraction wells, the well(s) will be put back into full-time operation.
- Continue the startup sampling frequency for the monitoring wells.

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3.2.10 LIPA/Airport Pump and Treat System

3.2.10.1 System Description

This project incorporates three separate areas. The LIPA portion encompasses four extraction wells. Three wells (EW-1L, EW-2L, and EW-3L) are for the Upper Glacial portion of the OU III plume and are located along the LIPA right of way (see **Figure 3.2-1**).

The three components of the LIPA/Airport Pump and Treat System are as follows.

1. The Magothy extraction well on Stratler Drive (see **Figure 3.2.10-1**) addresses high-level VOCs identified in the Magothy aquifer immediately upgradient of this well on Carleton Drive. The capture goal for this well is 50 μg/L TVOC.
2. The three LIPA extraction wells (EW-1L, EW-2L, and EW-3L) were installed to address high concentrations of VOCs in the Upper Glacial aquifer that had migrated past the Industrial Park System before that system became operational in 1999. The capture goal for these extraction wells is 50 μg/L TVOC.
3. The five extraction wells in the airport system were installed to address the leading edge of the plumes, which have migrated past the LIPA extraction wells and the North Street extraction wells. These airport system wells were installed to prevent further migration of the plumes. They have a lower capture goal: 10 μg/L TVOC.

The water from these four wells is pumped to the treatment plant, about one mile south on Brookhaven [Town]Airport property, where it is combined with the water from the five airport extraction wells (RTW-1A through -5A) and treated via granular activated carbon. The treated water is released back to the ground via a series of shallow reinjection wells located on Brookhaven Airport and Dowling College property.

A more detailed description of this system is contained in the *Operations and Maintenance Manual for the LIPA/ Airport Groundwater Treatment System* (BNL 2004g).

3.2.10.2 Groundwater Monitoring

Well Network

The monitoring network consists of 45 wells. There are 16 wells associated with the LIPA Upper Glacial wells and was designed to monitor the VOC plume off site, south of the OU III Industrial Park System. The wells are sampled quarterly for VOCs. The airport system network has 23 monitoring wells, which monitor the portions of the plume south of the LIPA and the North Street systems. The Magothy extraction well on Stratler Drive has six monitoring wells associated with its operation. All of these wells are used to monitor and evaluate the effectiveness and progress of the cleanup associated with these three systems. **Figure 1-2** identifies the monitoring wells for these plumes.

Sampling Frequency and Analysis

The monitoring wells for these projects are currently on a quarterly schedule.

3.2.10.3 Monitoring Well Results

The primary VOCs associated with these portions of the plume are carbon tetrachloride, TCA, TCE, and 1,1-dichloroethylene. Groundwater monitoring for these systems was initiated in 2004. Fourth-quarter well data is posted on **Figures 3.2-1** and **3.2.10-1**. The complete results are in **Appendix C**. Results for key monitoring wells are as follows.

- Maximum TVOC concentrations during 2005 for the Magothy extraction well EW-4L on Stratler Drive were detected in January 2005 at 277 μg/L; this had dropped to 107 μg/L by December 2005. Carbon tetrachloride is the primary VOC detected in this well. This is a good indication that the high concentrations observed in Magothy monitoring well 000-130 several years ago are

- being captured by this well. This was the primary objective for installing extraction well EW-4L. All of the Magothy monitoring wells associated with this portion of the plume show concentrations below 50 µg/L, with well 000-130 showing the highest concentration, at 22 µg/L in the fourth quarter of 2005.
- The three Upper Glacial LIPA extraction wells all showed declining VOC concentrations during 2005. Well EW-1L had 49 µg/L in January and 12 µg/L in December. Well EW-2L had 47 µg/L in January and 21 µg/L in December. Well EW-3L had 24 µg/L in January and 13 in December 2005.
- All monitoring wells near the extraction wells for the airport system are below MCLs at this time. However, upgradient monitoring well 800-94, approximately 1,500 feet north of wells RTW-1A and -2A,, had a concentration of 47 µg/L in December 2005, indicating that higher concentrations should be expected at the extraction wells. The five airport extraction wells had VOC concentrations below MCLs throughout 2005.

3.2.10.4 System Operations

The extraction wells were sampled once per month in 2005. The influent, midpoint, and effluent of the carbon units were sampled once per week, along with weekly pH readings. All samples were analyzed for VOCs.

The following is a summary of the OU III Airport/LIPA operations for 2005.

January–August
The system operated normally during this period with no down time other then for routine maintenance and repairs

September–December
The system operated normally. The airport wells began a pulse pumping mode per recommendations in the 2004 annual report. The five airport extraction wells were operated one week per month beginning in September 2005. Several carbon changeouts were performed during this time frame. The LIPA wells continued full-time operations.

Extraction Wells Operational Data
During 2005, approximately 303,238,170 gallons were pumped and treated by the OU III Airport/LIPA system, with an average flow rate of 577 gpm. **Table F-39** shows the weekly pumpdata. VOC concentrations for the airport and LIPA extractions wells are provided in **Table F-40**. VOC levels in all airport extraction wells were below MCLs. **Table 3.2.10.1** shows maximum measured values and the values allowed under the SPDES Equivalency Permit.

Table 3.2.10.1
OU III LIPA/Airport Pump & Treat System
2005 SPDES Equivalency Permit Levels

Parameters	Permit Level (µg/L)*	Max. Measured Value (µg/L)
pH	5.5–7.5 SU	6.45 SU
carbon tetrachloride	5	<0.50
chloroform	7	<0.50
1,1-dichloroethane	5	<0.50
1,1-dichloroethylene	5	<0.50
methylene chloride	5	<0.50
1,1,1-trichloroethane	5	<0.50
trichloroethylene	10	<0.50

*Max. effluent allowed. by the SPDES Equivalent Permit.

3.2.10.5 System Operational Data

System Influent and Effluent
VOC concentrations in 2005 for the carbon influent and effluent are summarized in **Tables F-41** and **F-42** (in **Appendix F**).

The carbon vessels for the system effectively removed all contaminants from the influent groundwater. All effluent data were below the analytical method's detection limit and below the regulatory limit specified in the SPDES equivalency permit.

Cumulative Mass Removal

The mass of TVOCs removed from the aquifer by the OU III Airport/LIPA treatment system was calculated using the average flow rates for each weekly monitoring period (**Table F-39**) in combination with the TVOC concentration in the carbon unit's influent, to calculate the pounds per month removed. The plot of cumulative mass of TVOCs removed vs. time (**Figure 3.2.10-2**) shows that 80 pounds of VOCs were removed during 2005.

Extraction Wells Data Evaluation

Table F-40 in **Appendix F** summarizes the data for the extraction wells.

3.2.10.6 System Evaluation

The airport treatment system was designed to capture the leading edge of the OU III and OUI/IV VOC plumes. However, to date no concentrations of VOCs above MCLs have been detected in the five extraction wells. This was expected, based on the low concentrations of VOCs in the monitoring wells at this location. Some higher concentrations of VOCs have been detected upgradient of these wells. VOC concentrations in the LIPA wells are consistent with the groundwater modeling done for the design of this system.

The OU III Airport/LIPA system performance can be evaluated based on the five major decisions identified for this system resulting from the groundwater DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no unusual or unexpected VOC concentrations observed in the monitoring wells associated with the LIPA/Airport Treatment System during 2005.

2. Has the plume been controlled?

Yes. Based on the results of the *LIPA/Airport Pump Test Report* (Holzmacher 2004), the plumes are being controlled. The capture zones clearly show that the capture goal of 50 µg/L TVOC at the LIPA wells is being met. The leading edge of the plume has not reached the airport extraction wells.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate?

Yes, the system is operating as planned. However, these wells have not been operating long enough to evaluate the progress of aquifer restoration.

4. Can the groundwater treatment system be shut down?

No, the system has not met all shutdown requirements (see below).

4a. Have asymptotic TVOC concentrations been reached in core wells?

There is not enough data to evaluate this at this time.

4b. Is the TVOC concentration in the LIPA core wells less than 50 µg/L (expected by 2025)?

Yes, however the extraction well EW-4L still shows concentrations greater then 50 µg/L

4c. Is the TVOC concentration in the airport core wells less than 10 µg/L ?

No, three airport core wells (800-63, 800-94, and 800-99) have TVOC concentrations greater than 10 µg/L.

4d. During pulsed operation of the system, is there significant concentration rebound in core wells?
The pulse pumping of the airport has not collected enough data to evaluate this. The intent of the current pulse pumping is not to evaluate for rebound but to reduce pumping while the high-concentration segment continues to travel south toward the northern perimeter of the Airport extraction wells.

5. Have the groundwater cleanup goals been met? Have MCLs been achieved (expected by 2030)?
No. MCLs have not been achieved for individual VOCs in plume core wells at LIPA. Although the core wells at the airport are below MCLs, higher concentration portions of the plumes are expected to migrate to this area in the future. Based on model results, MCLs are expected to be achieved by 2030 for the Upper Glacial aquifer, and in the Magothy aquifer by 2070, as required by the OU III ROD and ESD.

3.2.10.7 Recommendations

The following are recommendations for the LIPA/Airport Groundwater Treatment System and groundwater monitoring program:

- Quarterly sampling of the monitoring wells associated with this project should continue in 2006.
- The extraction well sampling should continue on a monthly schedule.
- The leading edge of the plume has not reached the airport extraction wells. Continue the airport extraction wells pulse-pumping of one week per month. This will verify that the higher concentrations have not reached the airport system. If concentrations above the capture goal of 10 μg/L VOCs are observed in any of the extraction wells or the monitoring wells adjacent to them, the well(s) will be put back into full-time operation.

3.2.11 Magothy Aquifer

This section provides a brief summary of the Magothy Aquifer Groundwater Monitoring Program and the proposed remedial approach for addressing the VOC contamination. The 41monitoring wells used to characterize the Magothy are shown on **Figure 3.2.11-1**.

Detailed descriptions of the monitoring well data results and remediation progress are presented in the following sections of this report: Western South Boundary, Middle Road, Airport/LIPA, North Street, North Street East, OU III South Boundary, Industrial Park, Industrial Park East, and Central Monitoring. A brief summary of the results is provided in **Table 3.2.11-1**. Further details of the investigation results are in the *Final Magothy Aquifer Characterization Report* (BNL 2003c).

Table 3.2.11-1. Magothy Aquifer Contamination.

Location	Max. TVOC[a] (ppb[b])	Primary VOCs	Results
Western boundary on site	<5.0	NA	Magothy not impacted. Two monitoring wells serve as adequate outpost/sentinel wells for Suffolk County Water Authority William Floyd wellfield.
Middle Road and south boundary on site	340	PCE, CCl_4	VOCs identified in upper 20 to 40 feet of Magothy at Middle Road area where brown clay is absent. TVOCs also detected at approximately 2,000 ppb in 1999 in lower portion of Upper Glacial. VOCs not detected at south boundary beneath the clay.
North Street off site	50	TCE	Low TVOC concentrations have been detected in localized areas in the upper 30 feet of Magothy below hole in brown clay and downgradient near Vita Drive where clay exists. Leading edge of contamination is around Moriches Middle Island Road.
North Street East off site	30	1,1-DCA; 1,1-DCE	Low TVOC concentrations have been detected at the BNL south boundary to North Street below the brown clay at approximately 40 to 150 feet into the upper Magothy. Tritium also co-located with VOCs upwards of 4,660 picoCuries/liter (pCi/l) (13,600 pCi/l detected in 1998).
Industrial Park East off site and south boundary	570	TCA, CCl_4	Lower VOC concentrations on-site (less than 50 ppb) and higher (more than 500 ppb) off-site in the Industrial Park, where brown clay is absent. Magothy and Upper Glacial contamination is contiguous in Industrial Park.
South of Carleton Drive off site	7,200	CCl_4	High VOC concentrations just south of Carleton Drive where brown clay is absent. Contamination is contiguous between Magothy and Upper Glacial Aquifer.

[a] Total Volatile Organic Compounds
[b] parts per billion

The Magothy Remedy identified in the *Explanation of Significant Differences* (ESD) document calls for the following:

1. Continued operation of the five extraction wells as part of the Upper Glacial treatment systems that provide capture of Magothy VOC contamination (Middle Road, South Boundary, Airport, Industrial Park East, and LIPA)
2. Data from the monitoring wells will continue to be evaluated to ensure protectiveness. **Table 3.2.11-2** describes how each of the Magothy investigation areas is addressed by the DOE's selected Magothy aquifer remedy.
3. Institutional controls and 5-year reviews

Data for all Magothy monitoring wells are presented in **Appendix C**.

Table 3.2.11-2. Magothy Remedy

	Area Investigated	Alternative 2 Selected Remedy
1	Western boundary onsite area	Good well network in place. Continue monitoring and evaluate data.
2	Middle Road and south boundary on-site area	Continue operation of the Magothy extraction well at Middle Road, as well as the two Upper Glacial systems. Continue to monitor the three Magothy monitoring wells at Middle Road and three at the south boundary.
3	North Street off-site area	Continue operation of the two existing Upper Glacial extraction wells on Sleepy Hollow Drive and North Street until cleanup objectives are met. Continue monitoring and evaluate data.
4	North Street East off-site area	Good well network in place. Continue monitoring and evaluate data.
5	Industrial Park East off-site area and south boundary	Continue operation of the industrial park east magothy extraction well until cleanup objectives are achieved. Continue monitoring and evaluate data.
6	South of Carlton Drive off-site area	Continue operation of the LIPA Magothy extraction well on Stratler Drive until cleanup goals are achieved.. This will capture high concentrations of VOCs identified on Carleton Drive and prevent migration of high concentrations of VOCs through the hole in the brown clay and into the Magothy aquifer. Continue monitoring and data evaluation.

3.2.11.1 Monitoring Well Results

There are 41 monitoring wells in the Magothy monitoring program (**Figure 3.2.11-1**). **Figure 3.2.11-2** shows trend plots of several of the key monitoring wells. A discussion of some of the key wells follows.

Well 000-130: This well is on Carleton Drive and has historically had the highest concentrations of carbon tetrachloride observed at BNL, over 7,000 µg/L. Concentrations of VOCs have ranged from 22 to 36 µg/L in 2005. The higher concentrations of carbon tetrachloride observed historically in this well are being captured by the LIPA extraction well on Stratler Drive. A more detailed discussion of this is available in Section 3.2.10, LIPA/Airport Pump & Treat System.

Wells 000-249 and 000-250: These wells are in the industrial park near well UVB-1. Well 000-249 had VOC concentrations ranging from 427 µg/L in March 2005 to a low of 64 µg/L in August. Well 000-250 had VOC concentrations between 3 and 10 µg/L in 2005. Based on analytical data, the higher levels of contamination observed in well 000-249 are being captured by the UVB wells, even though 000-249 is on the edge of the capture zone for these wells. Any contaminants above the capture goal of 50 µg/L that migrate beyond the capture of this system will be captured by the Stratler Drive extraction well.

Wells 000-425 and 000-460: These wells are adjacent to the LIPA Stratler Drive Magothy extraction well. Well 000-425 had concentrations of VOCs ranging from 15 to 21 µg/L during 2005. This well is immediately adjacent to the extraction well.

Well 000-460, located east of the extraction well but within the capture zone, had concentrations ranging from 48 µg/L in August 2005 to <1 µg/l in December.

Well 122-05, located at the eastern edge of the OU III South Boundary System, has shown concentrations of VOCs ranging from 30 to 36 µg/L in 2005.

Well 000-343, south of the OU I South Boundary system, had VOC concentrations between 4 and 5 µg/L in 2005.

Well 115-50, located near the OU I south Boundary extraction wells, had concentrations between 4 and 5 µg/L in 2005.

Wells 000-427 and 000-429 are just south of the industrial Park East system on Carleton Drive. Well 000-427 had concentrations ranging from 6 to 12 µg/L in 2005. Well 00-429 had concentrations ranging from 1 µg/L in March, May, and August, to 38 µg/L in December.

Well 800-92, located about 2,500 feet north of the airport system, had VOC concentrations ranging from 4 µg/L in March to 19 µg/L in December 2005.

3.2.11.2 Recommendations

Continue the current monitoring schedule for the Magothy monitoring program (see **Table 1-5**).

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3.2.12 OU III Central Monitoring

The OU III RI identified several low-level (less than 50 µg/L) VOC source areas and nonpoint contaminant sources within the developed central areas of the BNL site. These sources include spills within the AGS Complex, the Bubble Chamber spill areas, and the Building 208 vapor degreaser. Because these sources are not large enough to warrant a dedicated monitoring program, they are monitored under the OU III Central monitoring program. In addition, this program includes wells 109-03 and 109-04, which are located near the BNL site boundary. They were installed by the Suffolk County Department of Health Services to serve as sentinel wells for the SCWA William Floyd Parkway well field.

3.2.12.1 Groundwater Monitoring

Well Network
The monitoring well network is comprised of 19 wells (**Figure 1-2**). The locations aid in defining the VOC plumes, which extend downgradient from the central areas of the site. This network also is supplemented by data from Environmental Surveillance (ES) program wells that monitor active research and support facilities (**Table 1-6**). Results from the ES programs are provided in **Section 4**.

Sampling Frequency and Analysis
The wells are sampled and analyzed annually for VOCs, and select wells are analyzed semiannually for gross alpha/beta, gamma spectroscopy, tritium, and Sr-90 (**Table 1-5**). Select ES wells in the AGS Complex are typically sampled annually for VOCs in order to complete the northern portion of the OU III VOC plume configuration.

3.2.12.2 Monitoring Well Results

VOC concentrations detected in most of the OU III Central wells are near or below NYS AWQS. The primary constituent in many of the wells in the north-central developed portion of the site is TCA. The following wells displayed significant changes in VOC concentrations in 2004 or were otherwise noteworthy:

- Tritium concentration increases were observed in well 065-02 beginning in July 2004 and continued through 2005, with a maximum concentration of 45,300 pCi/L in July 2005. This increase is the result of an eastward shift in the g-2 tritium plume that is discussed further in Section 3.2.15 of this report (BGRR/WCF Sr-90 Monitoring Program).
- Well 083-02 is near the intersection of Brookhaven Avenue and Upton Road and is screened in the mid to deep Upper Glacial aquifer. This well consistently has contained 10 to 25 µg/L of chloroform since 1997. Potential sources of this contamination may be in the AGS area of the site.
- SCDHS wells 109-03 and 109-04 serve as sentinel wells for the SCWA William Floyd Well Field and are near the eastern BNL property boundary. There have been no detections of VOCs in either well since early 2003, with the exception of chloroform in 2005 at concentrations less than 1 µg/L (the detection limit is 0.5 µg/L for chloroform). No radionuclides were detected in either well in 2005.

3.2.12.3 Groundwater Monitoring Program Evaluation

The evaluation of the OU III Central Monitoring program is based on four major decision rules established for this program using the groundwater DQO process.

1. Was the BNL Groundwater Contingency Plan triggered during 2005?

No. There were no unusual or unexpected VOC or radionuclide concentrations in the monitoring wells associated with this program during 2005. There were tritium concentration increases in well 065-02 that were addressed under the BGRR Sr-90 and g-2 programs.

2. Are there potential impacts to the SCWA William Floyd Parkway well field from on-site contamination?

No. There were no detections of contaminants in the sentinel monitoring wells during 2005, with the exception of low-level chloroform detections.

3. Are the performance objectives met?

No. Individual wells continued to contain VOC concentrations exceeding the NYS AWQS during 2005; therefore, the OU III ROD objectives have not been met.

4. If not, are observed conditions consistent with the attenuation model?

Yes. In the areas of the site where the wells of the OU III Central Monitoring Program are located, the observed TVOC concentrations generally agree with the model-predicted concentrations, with respect to both the plume extent and contaminant concentrations.

3.2.12.4 Recommendation

No changes to the monitoring program are warranted at this time.

3.2.13 Off-Site Monitoring

The OU III Offsite Groundwater Monitoring Program consists of 12 wells that were installed primarily during the OU III RI. Three of the wells (000-97, 000-98, and 000-99) were installed as part of the Sitewide Hydrogeologic Characterization Program. The wells installed during the OU III RI were intended to track the plume core, or perimeter in off-site areas, or to serve as sentinel wells for the leading edge of the plume. The three wells installed as part of the Sitewide Hydrogeologic Characterization are used as plume perimeter wells for the OU III plume. Eight wells that were part of the OU III Off-Site Program during 2003 were incorporated into the groundwater monitoring programs associated with the LIPA and Brookhaven Airport OU III off-site remediation systems during 2005.

3.2.13.1 Groundwater Monitoring

Well Network

The network has 12 wells that monitor the off-site, downgradient extent of the OU III VOC plumes (**Figure 1-2**). Some wells downgradient of the leading edge of the plumes serve as sentinel wells. Their locations and screen depth, in the deep portions of the Upper Glacial aquifer, were selected using the BNL Groundwater Model.

Sampling Frequency and Analysis

The wells are sampled semiannually, and samples are analyzed for VOCs (**Table 1-5**).

3.2.13.2 Monitoring Well Results

The complete results for the monitoring wells in this program can be found in **Appendix C**. The horizontal and vertical extents of the off-site segment of the OU III VOC plume are shown in **Figure 3.2-1** and **Figure 3.2-2**.

The monitoring wells remaining in the OU III Off-Site Program, which are perimeter and sentinel wells, continue to have VOC concentrations below the regulatory limits.

3.2.13.3 Groundwater Monitoring Program Evaluation

There were no unexpected results during 2005 that would have triggered the BNL Groundwater Contingency Plan. The plume remained within the boundaries of the perimeter wells that are currently in place. MTBE was detected at 22 µg/L in well 000-99, which is above the DWS of 10 µg/L. MTBE has been detected in this well at concentrations less than 1 µg/L since early 2004. Based on the depth of this well (screened from 85 to 90 feet below ground surface), the source of this MTBE appears to be from a source south of BNL.

3.2.13.4 Recommendations

No changes to the monitoring program are warranted at this time.

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3.2.14 South Boundary Radionuclide Monitoring Program

The South Boundary Radionuclide Monitoring Program was initiated to confirm that groundwater impacted by radionuclides is not migrating off the southwestern sections of the BNL site. Samples are tested annually for tritium, gamma spectroscopy, and Sr-90. The sampling was conducted in conjunction with the OU III South Boundary and Western South Boundary programs, to eliminate additional costs of collecting samples. The south boundary of the eastern portions of the site is monitored for radionuclides as part of the OU I South Boundary, EDB, and OU V STP groundwater monitoring programs.

3.2.14.1 Groundwater Monitoring

A network of 54 monitoring wells is used to monitor radionuclides from the OU III South Boundary and OU III Western South Boundary programs. The well locations along the southern property boundary are shown in **Figure 3.2.14-1**.

Sampling Frequency and Analysis

The OU III South Boundary Radionuclide Monitoring Program wells were sampled annually for tritium, Sr-90, and gamma spectroscopy (**Table 1-5**).

3.2.14.2 Monitoring Well Results

The radionuclide analytical results for the wells can be found in **Appendix C**. There were no confirmed radionuclide detections during 2005. During June 2005, very low concentrations (0.61 to 1.07 pCi/L) of Sr-90 were reported in three wells: 121-08, 122-31, and 122-32. A data usability review indicates that these results are most likely false positives. Therefore, the values have been flagged to indicate this conclusion.

3.2.14.3 Groundwater Monitoring Program Evaluation

The OU III South Boundary Radionuclide Monitoring Program can be evaluated based on the one decision rule identified for this program resulting from applying the groundwater DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no unexpected results during 2005 to trigger the BNL Groundwater Contingency Plan.

3.2.14.4 Recommendations

No changes are recommended for the OU III South Boundary Radionuclide Monitoring Program. The wells will continue to be sampled on an annual basis for radionuclides.

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3.2.15 BGRR/WCF Strontium-90 Monitoring Program

The OU III Brookhaven Graphite Research Reactor (BGRR)/ Waste Concentration Facility (WCF) project monitors the extent of Sr-90 plumes in groundwater downgradient of these facilities. Some of the wells included in the OU III BGRR/WCF network also are monitored as part of the OU III AOC 29 HFBR and Building 801 programs (see **Sections 3.2.17** and **4.10**). These wells are sampled concurrently for all programs to avoid duplication of effort.

The BGRR/WCF remedy calls for:

1. Installation of five extraction wells using ion exchange to remove Sr-90, with on-site discharge of the clean water
2. Operation of the system to minimize plume growth and meet DWS within 70 years
3. Continued monitoring and evaluation of data to ensure protectiveness
4. Institutional controls and five-year reviews

The analytical results indicate three areas of elevated Sr-90: one from the WCF area, one from an area south of the BGRR Below Ground Ducts (BGD) and Canal House, and one from south of the Pile Fan Sump (PFS) area (**Figure 3.2.15-1**). Variability in groundwater flow directions due to changes in pumping and recharge patterns in the plume vicinity over time have resulted in lateral spreading of the Sr-90 plumes.

3.2.15.1 System Description

Construction of the Sr-90 BGRR/WCF groundwater treatment system was completed in December 2004. Startup testing for the new treatment system began in January of 2005. The *Sr-90 BGRR/WCF/PFS Groundwater Treatment System Start-Up Report* (BNL 2005d) was finalized in April 2005, and full operation of the treatment system began in July 2005. There are two extraction wells (SR-1 and SR-2) south of the WCF and three extraction wells (SR-3, SR-4, and SR-5) south of the BGRR. The treatment system typically operates at an average rate of 25 gpm total from five extraction wells.

Groundwater from the five extraction wells is transported through pipelines to an ion exchange treatment system inside Building 855. The vessels of ion exchange media are designed to treat groundwater contaminated with Sr-90 to below the 8 pCi/L requirements specified in 6 NYCRR Chapter X, Part 703.6: *Groundwater Effluent Limitations for Discharges to Class GA Waters*. In addition, influent is also treated for low-level concentrations (less than 10 µg/L) of VOCs. Originally the VOCs were treated via a tray aeration unit (air stripper). That system was replaced with a liquid phase activated carbon system in September 2005.

Effluent is recharged to the Upper Glacial aquifer via three drywells approximately 850 feet west of Building 855. A New York SPDES equivalency permit regulates this discharge. A complete description of the system is included in the *Operation and Maintenance Manual for the Sr-90 BGRR/WCF/PFS Groundwater Treatment System* (BNL 2005e).

3.2.15.2 Groundwater Monitoring

Well Network

A network of 87 monitoring wells monitors the Sr-90 plumes associated with the BGRR, WCF, and PFS areas. Two of the monitoring wells, located slightly southwest of the WCF and downgradient of the g-2 area (**Figure 1-2**), were installed in January 2006 after tritium from the g-2 plume was captured by extraction well SR-2. In addition, six monitoring wells in the monitoring network had to be abandoned due to construction of the new Center for Functional Nanomaterials (CFN)). New wells will replace the abandoned wells once construction of the CFN is complete.

Sampling Frequency and Analysis

The wells are monitored semiannually; the samples are analyzed for Sr-90 (**Table 1-5**).

3.2.15.3 Monitoring Well/Temporary Well Data

The Sr-90 plume distribution map is shown in **Figure 3.2.15-1**. The distribution of Sr-90 throughout the BGRR, WCF, and PFS areas is depicted based on groundwater data obtained from this characterization effort and fourth-quarter 2005 sampling of the monitoring well network. Historically, the highest Sr-90 concentration (3,150 pCi/L) was collected in 2003 from a temporary well installed approximately 200 feet south of Building 901 and slightly upgradient of the current location of extraction well SR-3. The highest historical Sr-90 concentration in the WCF area (1,560 pCi/L) was in April 2003, from a temporary well installed immediately downgradient of the former underground storage tanks (UST A/B), approximately 25 feet north of Building 811. This area within the WCF is upgradient of the current location of extraction well SR-1. The highest historical Sr-90 concentration in the PFS area (566 pCi/L) was collected in March 1997 from a temporary well installed downgradient of the PFS. In 2005, the highest Sr-90 concentration (574 pCi/L) was from the second-quarter sampling of well 65-175, which is south of the WCF yard. The following cross-sectional views are also provided:

- **Figure 3.2.15-2** (I–I') – A north–south cross section from the BGRR south to Brookhaven Avenue
- **Figure 3.2.15-3** (J–J') – North–south cross section from Building 801 south to Cornell Avenue
- **Figure 3.2.15-4** (K–K') – North–south cross section from WCF south to Cornell Avenue

In addition, historical Sr-90 concentration trend plots for key wells are plotted on the plume distribution map in **Figure 3.2.15-5**.

3.2.15.4 System Operations

Samples from influent, effluent, and midpoint locations of the SR-90 BGRR/WCF treatment system are collected once a week, in accordance with the SPDES equivalency permit. All samples are analyzed for Sr-90 and VOCs. The influent is also analyzed for tritium, and both the influent and effluent are analyzed for pH values. The treatment system experienced elevated pH values (as high as 9.3 SU) in effluent samples during the month of July 2005. The SPDES-specified pH range for effluent from this treatment system is 5.5 to 8.5 SU (**Table 3.2.15-1**). Since August 2005, the effluent pH values have all been below this upper limit. Sr-90 concentrations in 2005 for the system influent and effluent are summarized in **Tables F43** and **F-44** in **Appendix F**. **Table F-45** contains the monthly Sr-90 removal totals for the system.

Table 3.2.15-1.
Sr-90 BGRR Treatment System
2005 SPDES Equivalency Permit Levels

Parameter	Permit Level*	Max. Measured Value
pH range	5.5–8.5 SU	6.7–9.3 SU
Sr-90	8.0 pCi/L	ND
chloroform	7.0 µg/L	<0.5
1,1,1-trichloroethane	5.0 µg/L	<0.5

* Max. effluent allowed by requirements equivalent to a SPDES permit.
ND = Not detected above minimum detectable activity.
SU = Standard Units
Required sampling frequency is weekly for Sr-90, VOCs, and pH. The frequency for Sr-90 and VOCs may change to monthly after 6 months of non-exceedances.

An influent sample collected on October 6, 2005 showed a tritium concentration of 1,930 pCi/L. In response to this detection of tritium, Sr-90 extraction wells SR-1 and SR-1, downgradient of the WCF and near the g-2 tritium plume, were turned off. Fourteen temporary wells and two new monitoring wells were installed to determine tritium concentrations upgradient of extraction well SR-2 and to better define the g-2 tritium plume in this area (**Figure 3.2.15-1)**. Tritium samples were collected from the 14 temporary wells, the two new monitoring wells, and the Sr-90 extraction wells. The data indicate that increased pumping at supply wells 11 and 12 during 2005 had shifted the g-2 tritium plume to the east, bringing it closer to Sr-90 extraction well SR-2. The Sr-90 extraction wells were gradually brought back into full operation. To maintain groundwater flow without further shifting the position of the g-2 tritium plume, the optimum pumping ratio between the western and eastern supply well field will be maintained at an approximate 75% to 25% split.

System Operations

Operations details are given in the O & M manual for this system. Here is a summary of the system operations for 2005.

July–September 2005

The system began operation in July 2005, then was offline from July 19 to July 26 for repair of a float switch. The system was also offline from August 11 to August 16, and September 9 to September 26, for repairs.

October–December 2005

The system was offline for two days in October for minor repairs. On November 23 the system was shut off in order to perform a resin vessel changeout due to break through, and it remained offline for the remainder of the year. The system was restarted January 9, 2006.

3.2.15.5 System Operational Data

The analytical data for the period July 1–December 31, 2005 showed a Sr-90 influent range from 79.7 to 436 pCi/L, with the highest sample collected in August. No Sr-90 was detected in any effluent samples. During this period, approximately 3.5 million gallons of groundwater were processed through the system.

Cumulative Mass Removal

Average flow rates for each monitoring period were used, in combination with the Sr-90 influent concentration, to calculate the number of millicuries removed. During operation, the flow averaged 13.3 gpm from July 1 through December 31, 2005. Approximately 4.15 mCi of Sr-90 (cumulative total) was removed during 2005 (**Figure 3.2.15-6**).

Extraction Wells

Extraction well SR-1 was offline from October 10–19, 2005, and extraction well SR-2 was offline from October 12, 2005–March 9, 2006. The highest tritium concentration detected in extraction well SR-2 (3,020 pCi/L) was on October 13, 2005, and the highest tritium concentration seen in SR-1 (562J pCi/L) was on November 14, 2005. The treatment system influent and these two extraction wells (SR-1 and SR-2) continue to be monitored for Sr-90 and tritium concentrations.

3.2.15.6 Groundwater Monitoring Program Evaluation

The OU III BGRR/WCF Strontium-90 Monitoring Program can be evaluated in the context of eight basic decisions established for this program using the groundwater DQO process

<u>*1. Was the BNL Groundwater Contingency Plan triggered?*</u>

Yes. Tritium concentrations of 1,930 pCi/l from an October 6, 2005 sample were detected in the influent to the treatment system. Due to the presence of tritium from the g-2 plume, the two extraction wells (SR-1 and SR-2) were turned off. A series of 14 temporary and two new monitoring wells were installed to determine tritium concentrations upgradient of extraction well SR-2 and to better define the g-2 tritium plume in this vicinity. After the collection of samples from the temporary wells, the new monitoring wells, and the extraction wells, the extraction wells (SR-1, SR-2) were gradually brought back into full operation. Extraction well SR-1 was offline from October12 through October 19, 2005. Extraction well SR-2 was offline from October12 through March 9, 2006. Increased pumping by supply wells 11 and 12 during 2005 had shifted the g-2 tritium plume further to the east, bringing it closer to Sr-90 extraction well SR-2. To maintain groundwater flow so as not to adversely affect the position of the g-2 tritium plume, the optimum pumping ratio between the western and eastern supply well field will be maintained at an approximate 75% to 25 % split. The highest concentration of tritium in this area was 150,000 pCi/L in January 2006 from a temporary well approximately 75 feet west of extraction well SR-2.

2. Is the extent of the Sr-90 plume still defined by the existing monitoring well network?

Yes. However, six monitoring wells that were previously abandoned will be replaced once the CFN construction is complete.

3. Can Sr-90 contamination impact existing or planned groundwater remediation systems?

No. The nearest downgradient operating groundwater remediation systems are the Carbon Tetrachloride and Building 96 systems, which are located more than 2,000 feet south of the leading edge of the plume and are not expected to be affected. In addition, the proximity of the Sr-90 plume to the g-2 tritium plume could have impacts on potential remedial options for the g-2 tritium plume. This is being further evaluated in the g-2 Focused Feasibility Study.

4. Are the Sr-90 plumes migrating toward BNL supply wells 10, 11, and 12?

No. Sr-90 was not detected in the sentinel wells upgradient of the WCF area. There is no evidence at this time of Sr-90 moving toward the BNL supply wells.

5 .Has the plume been controlled?

Yes.

6. Is the system operating as planned?

Yes. The system is operating as planned except for the temporary shutdown of two extraction wells as a result of the impacts from the g-2 tritium plume.

7. Can the groundwater treatment system be shut down?

No, the system has been in operation for only 6 months.

7a. Have asymptotic VOC concentrations been reached in core wells?

No. The system has been in operation for only 6 months.

7b. Is the mean Sr-90 concentration in core wells less than 175 pCi/L (expected by 2015)?

No. Twenty of 22 plume core wells are below 175 pCi/L for Sr-90.

7c. How many individual plume core wells are above 175 pCi/L?

Two plume core monitoring wells, 065-175 and 075-669, are above 175 pCi/L (at 574 pCi/L and 272 pCi/L, respectively). These wells are downgradient of the WCF and BGRR, respectively. In addition, the influent concentration to the treatment system consistently exceeded this value.

8. Have the groundwater cleanup goals been met? Specifically, have MCLs been achieved in the Upper Glacial aquifer (expected by 2070)?

No. MCLs have not been achieved for Sr-90 in all plume core wells. MCLs are expected to be achieved by 2070, as required by the OU III Explanation of Significant Differences (ESD).

3.2.15.7 Recommendations

The following are recommendations for the BGRR/WCF groundwater monitoring program:

- Maintain the southerly groundwater flow direction by managing the pumping of the BNL supply wells. This will be accomplished via the oversight of the BNL Water and Sanitary Planning Committee.
- Replace abandoned monitoring wells 085-299, 085-300, 085-302, 085-310, 085-311, and 085-312, which were taken out of service due to the construction of the Center for Functional Nanomaterials. New wells will be installed to replace these wells once construction of the CFN is complete.
- Install an additional monitoring well downgradient of the leading edge of the WCF plume. The new well is to be located southwest from the front of the HFBR and downgradient of well 65-189.
- Install an additional monitoring well downgradient of the PFS plume. The new well is to be located in the 75-46 well cluster.

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3.2.16 Chemical/Animal Holes Strontium-90 Treatment System

This section summarizes the operational data from the OU III Chemical/Animal Holes Strontium-90 Treatment System for 2005, and gives conclusions and recommendations for future operation. This system began operation in February 2003.

3.2.16.1 System Description Background

The Chemical/Animal Holes were located in the south-central portion of the BNL property (**Figure 3.2.16-1**). The area consisted of 55 pits located east of the Former Landfill that were used for the disposal of a variety of laboratory chemicals and animal carcasses. The buried waste was excavated in 1997.

Following the excavation, a Sr-90 plume was characterized. The plume is now approximately 565 feet long and 75 feet wide, with a maximum thickness of 15 feet. It is approximately 22 to 45 feet below ground surface. To date, the highest Sr-90 concentration observed in groundwater in this area was 4,720 pCi/L, at well 106-99, in March 2005. The area of higher concentrations appears to be a very narrow band approximately 310 feet long and 35 feet wide (**Figure 3.2.16-1).**

The essential elements of the Sr-90 remediation at the Chemical/Animal Holes are:

1. One extraction well pumping into an ion exchange treatment system to remove Sr-90 from the extracted groundwater, and for on-site discharge of the clean water
2. Operation of the system to minimize plume growth and meet DWS within 40 years
3. Continue to monitor and evaluate the data to ensure protectiveness

Details of operations are provided in the *Strontium-90 Pilot Study Treatment System Operation and Maintenance Manual* (BNL 2004b).

3.2.16.2 Groundwater Monitoring

Well Network

The monitoring well network consists of 36 monitoring wells. **Figure 1-2** shows the monitoring well locations.

Sampling Frequency and Analysis

Six of the 36 monitoring wells were sampled quarterly for Sr-90 and the remaining wells were sampled semiannually. All of the wells are sampled annually for VOCs.

3.2.16.3 Monitoring Well Results

Figure 3.2.16-1 shows the Sr-90 plume distribution. The plume depiction is derived from the third and fourth-quarter monitoring well data. The highest Sr-90 concentration observed in 2005 was 4,720 pCi/L, in well 106-99, as noted above. This well is approximately 30 feet upgradient of extraction well EW-1. This value is not identified on the plume figure, since it was detected in the first quarter. The next highest Sr-90 concentration in 2005 was 1,530 pCi/L, in well 106-49 during the fourth-quarter sampling round. This well is 170 feet downgradient of EW-1.

A high-concentration plume segment of Sr-90 greater than 50 pCi/L extends for a distance of approximately 310 feet from well 106-95 to approximately 90 feet south of well 106-49. This 50 pCi/l contour line is broken up by EW-1. The 50 pCi/l contour line extends approximately 260 feet downgradient of the extraction well. The leading edge of the plume, as defined by the NYS DWS of 8 pCi/L, is approximately 400 feet south of well EW-1.

All monitoring wells in this program are also analyzed annually for VOCs to monitor low-level VOC contamination originating from the Chemical/Animal Holes area. The highest concentration of VOCs was detected in well 106-25, with a TVOC concentration of 4.7 μg/L. The complete results are in **Appendix C**.

3.2.16.4 System Operations

The Strontium-90 Chemical/Animal Holes Treatment System influent, effluent, and midpoint locations were sampled at least once a week, in accordance with the SPDES equivalency permit. All samples are analyzed for Sr-90. In addition, the influent and effluent samples are analyzed for pH values on a weekly basis (**Table 3.2.16-1**). Due to naturally occurring groundwater conditions, there have been several instances where the effluent pH was lower than the permitted level of 6.5 SU. In April 2006, DOE requested from NYSDEC a modification to reduce the lower range of the permitted pH value to 5.0 SU. NYSDEC approval was received and is effective as of May 2006. There have also been a few occasions in the first half of the year where the effluent pH exceeded the permitted level of 8.5 SU. This was due to the ion exchange treatment process and will continue to be monitored. The pH returned to within the upper-level permitted value during the second half of the year. The treatment system consists of one extraction well. Sr-90 concentrations in 2005 for the system influent and effluent are summarized in **Tables F-46** and **F-47** in **Appendix F**. **Table F-48** contains the monthly Sr-90 removal for the system.

Summarized below are the system operations data for 2005. Details for this system are given in the operation and maintenance manual.

Table 3.2.16-1.
Sr-90 Chemical Holes Treatment System
2005 SPDES Equivalency Permit Levels

Parameter	Permit Level*	Max. Measured Value
pH range (SU)	6.5–8.5	6.2–9.1
Sr-90 (pCi/L)	8	1.98

* Max. effluent allowed by requirements equivalent to a SPDES permit.
ND = Not detected above minimum detectable activity.
SU = Standard Units

Required sampling frequencies are weekly and monthly for Sr-90 and pH, respectively.

January–September 2005

The system was shut down from February 9 until May 26 for system repairs and upgrades. The system operated normally for the remainder of June with the extraction well pumping at a rate of 6 gpm.

October–December 2005

During this period the system was off a total of 4 days for various repairs and upgrades. The system was also turned off December 5 and remained off the remainder of the month in order to perform a resin vessel changeout. The remaining ion exchange filter material of UOP-A51, a synthetic resin, was replaced during this changeout to a natural occurring zeolite (Clinoptilolite) because clinoptilolite performs better and is less expensive than the synthetic resin. The system pumped and treated a total of 1.5 million gallons of groundwater during this period.

3.2.16.5 System Operational Data

The analytical data for the period January 1–December 31, 2005 show that Sr-90 in the influent ranged from 31.8 to 566 pCi/L. The high concentration was from a May sample. All effluent samples were well below the SPDES permit level of 8 pCi/L, and normally do not detect Sr-90. However, there were a few detections in the effluent samples during 2 months later in the year, up to a high concentration of 1.98 pCi/L. This was due to the need for a resin vessel changeout. During the year, approximately 1.8 million gallons of groundwater were processed through the system.

Cumulative Mass Removal

Average flow rates for each monitoring period were used, in combination with the Sr-90 concentration, to calculate the number of millicuries (mCi) removed. Flow averaged 6 gpm from January 1 through December 31, 2005. The cumulative total was approximately 0.91 mCi of Sr-90 removed during 2005, and a to-date total of approximately 1.75 mCi (**Figure 3.2.16-3**).

Extraction Well

The Strontium-90 Pilot Study was designed to operate at a maximum of 50 gpm. Based on the results of the initial startup testing during 2003, the treatment system was reduced to an approximate flow rate of 6 gpm. This pumping rate was selected after a capture zone analysis showed a pumping rate of 5 gpm would have a capture zone width of approximately 35 feet, which is capable of capturing the highest concentrations of Sr-90.

3.2.16.6 System Evaluation

The Chemical/Animal Holes Treatment System performance can be evaluated based on the four major decisions identified for this system as part of the DQO process that was used to design the monitoring program.

1. Was the BNL Groundwater Contingency Plan activated?

No. No unusual or unexpected concentrations of contaminants were observed in monitoring wells associated with the Chemical/Animal Holes Treatment System. There was an elevated concentration of 1,530 pCi/L of Sr-90 seen in well 106-49 during the fourth-quarter sampling round. This is being evaluated with the installation of temporary wells downgradient of well 106-49.

2. Has the plume been controlled?

The monitoring data and updated model predictions indicate the plume upgradient of the extraction well is controlled by the single extraction well pumping at 6 gpm. However, monitoring data collected downgradient of the extraction well during 2005 showed significant Sr-90 concentrations (up to 1,530 pCi/L). This Sr-90 was already downgradient of the pilot study extraction well when the well went into operation (**Figure 3.2.16-1**). This is being evaluated with the installation of temporary wells downgradient of well 106-49.

3. *Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate identified in the Explanation of Significant Difference to the OU III Record of Decision?*

The groundwater extraction well is removing contamination at a rate comparable to prior predictions. Several years of groundwater monitoring data will be required to better evaluate the probable Sr-90 desorption isotherm for the aquifer (e.g., linear desorption vs. nonlinear). The period of monitoring data collected to date is rather short to perform a definitive analysis of this phenomenon.

As mentioned above, the significance of the downgradient contamination not captured by the treatment system was evaluated using the groundwater model. The model was used to help evaluate whether this downgradient contamination would leave the BNL property above drinking water standards and whether it would naturally attenuate (via advection, radioactive decay, and dispersion) to less than DWS in less than approximately 40 years. The model was run with and without dispersivity assumptions similar to those experienced at the HFBR tritium plume. The model also assumed a partition coefficient (Kd) value of 2.8 cm^3/gm. The model parameter assumptions are the same as model predictions used for the pilot study. The grid size and the starting concentrations (reflecting the latest data) were changed. The model predictions for 2003 and 2004 are summarized in **Table 3.2.16-2**.

The model predictions suggest that the contamination downgradient of the extraction well may present a risk to achieving the cleanup goal of 40 years. This warrants careful monitoring, as these predictions are sensitive to the starting concentrations in the model.

4. *Have the cleanup goals been met? Can the groundwater treatment system be shut down?*

No. Significant contamination remains upgradient of the extraction well. Left untreated, this contamination would threaten achieving the cleanup goal of within 40 years.

3.2.16.7 Recommendations

The following are the recommendations for the Chemical/Animal Holes Strontium-90 Treatment System and groundwater monitoring program:

- Continue operating the treatment system at 6 gpm.
- Continue the current monitoring well sampling frequency.
- Evaluate temporary well data collected in spring 2006 downgradient of the extraction well, in particular, from monitoring well 106-49. Model this new data with new initial concentrations to compare against previous model predictions (2003 and 2004). The contamination downgradient of the extraction well may present a risk to achieving the cleanup goal of 40 years. New temporary well data and modeling will better define this potential risk. Below is a table summarizing the model predictions from 2003 and 2004.

Table 3.2.16-2.
Summary of Model Predictions

	Pilot Study (12/03), no dispersivity	2004 GSR Model Update, no dispersivity	2004 GSR Model Update, with dispersivity
Year	--------------Peak Sr-90 Concentration (pCi/L)------------		
10	54	110	60
30	16	30	10
40	DWS (<8)	15	DWS (<8)
60	<8	DWS (<8)	<8
85	<1	<4	<1

Notes:
DWS = Drinking Water Standard
GSR = Groundwater Status Report
85 years is the approximate transport time of the plume to the BNL south property boundary.
The refined model predicts that the pilot extraction well pumping at 6 gpm controls the contamination upgradient of the extraction well. It also uses a Sr-90 migration rate of 29 ft/year.

3.2.17 HFBR Tritium Monitoring

In late 1996, tritium was detected in monitoring wells near the HFBR. The source of the release was traced to the HFBR spent fuel pool. In response, the fuel rods were removed and the spent fuel pool was drained. In May 1997, a three-well groundwater pump and recharge system was constructed on Princeton Avenue approximately 3,700 feet downgradient of the HFBR to capture tritium and assure that the plume would not move off site. Extracted water was recharged at the RA V recharge basin. Groundwater modeling projected that the tritium plume would attenuate naturally to below DWS (20,000 pCi/L) before reaching the site boundary. The extraction system was placed on standby status in September 2000, as groundwater monitoring data demonstrated that the plume was not growing.

As described in the OU III ROD, the selected remedy to address the HFBR tritium plume included implementing monitoring and low-flow extraction programs to prevent or minimize the plume's growth. Beginning in June 2000 and ending April 2001, 20 low-flow extraction events removed 95,000 gallons of tritiated water with concentrations greater than 750,000 pCi/L. This water was sent off site for disposal. The trigger level for low-flow extraction has not been exceeded since April 2001. The OU III ROD contingencies are defined as a detection of tritium above 25,000 pCi/L in monitoring wells at the Chilled Water Plant Road, or above 20,000 pCi/L in monitoring wells along Weaver Drive. Exceedances of these levels will necessitate implementing the specific contingencies described in the ROD, including possible reactivation of the Princeton Avenue pump and recharge system.

Groundwater flow in the vicinity of the HFBR is primarily to the south and east. In general, groundwater flow is toward the south or southeast (**Figures 2-2** and **2-3**). Evaluation of groundwater flow and quality data indicates that the downgradient portion of the tritium plume (south of Brookhaven Avenue) has shifted east since 1997 in response to changing flows to the HO recharge basin, the OU III recharge basin, and the reduced pumping of BNLs eastern supply wells 10, 11, and 12.

During the first three quarters of 2005 there was increased pumping from the eastern supply well field that affected the central portion of the site, including the g-2 tritium and BGRR Sr-90 plumes (see **Sections 3.2.15** and **4.1.5**), and to a lesser extent the uppermost portion of the HFBR tritium plume. The net effect was a shift to the east in groundwater flow that resulted in the tritium plume shifting east of the Cornell Avenue monitoring wells during the middle of 2005. Indications in early 2006 are that the re-establishment of pumping from the western supply well field in October 2005 has resulted in a return to previous groundwater flow conditions, as evidenced by increasing tritium concentrations in the easternmost Cornell Avenue wells.

3.2.17.1 Groundwater Monitoring

Well Network

A monitoring well network of 159 wells is used to evaluate the extent of the plume, monitor the source area, and verify the predicted attenuation of the plume (**Figure 1-2**). Due to the proximity of the HFBR to pumping and recharge operations, the plume is subjected to changing hydraulic stresses, which have warranted an extensive monitoring network.

Sampling Frequency and Analysis

Sampling details for the well network are contained in **Table 1-5**. Select wells are also analyzed for VOCs as part of the Carbon Tetrachloride and Middle Road programs.

3.2.17.2 Monitoring Well Data

The extent of the tritium plume is shown on **Figure 3.2.17-1**. This figure summarizes data collected during the fourth quarter of 2005. Monitoring well data were supplemented with data obtained from 23 temporary wells installed from February through April 2006. The temporary wells were undertaken as part of a comprehensive effort to characterize the extent of the eastward shift in the plume over the past several years in response to changes in supply well pumpage in Basin HO and the RA V Basin dating back to 1999, and to define the present location of the high concentration segment of the plume. The temporary wells were installed east of the existing monitoring well network along transects established at Temple Place, the Building 480 parking lot, the Building 86 area, east of the Chilled Water Facility Road, and east of Weaver Drive, as shown in **Figure 3.2.17-1**. **Appendix C** has the complete set of monitoring well data. Data from temporary wells installed in 2006 are summarized in **Table 3.2.17-1**. A north to south cross-sectional view of the plume centerline is shown in **Figure 3.2.17-2**.

HFBR to Brookhaven Avenue

Tritium concentrations directly downgradient from the HFBR have remained low since the first quarter of 2004, when a concentration of 378,000 pCi/L was detected in well 075-43. The increase corresponded with a significant elevation increase in the water table from July 2003 to July 2004, which apparently mobilized tritium residing in the vadose zone beneath the HFBR. The water table has not experienced any significant elevation increases since this time frame with the exception of a slight rise in early 2005 (**Figure 3.2.17-3**). This water table flushing mechanism results in relatively small slugs of tritium that migrate south from the HFBR in groundwater. The highest detection of tritium in 2005 was during January at a concentration of 243,000 pCi/L.

The groundwater characterization effort in early 2006 revealed that the centerline of the tritium plume from the HFBR to Brookhaven Avenue had shifted to the east of the monitoring well network, based partly on the concentrations observed in temporary wells GP-281, GP-274, and GP-275 (**Figure 3.2.17-1**). Monitoring data from the first quarter of 2006 indicate that the plume is shifting back to the west along Cornell Avenue. The installation of temporary wells to the east of the Cornell Avenue monitoring wells is not possible due to extensive underground utilities in the area.

Brookhaven Avenue to Weaver Drive

The monitoring well network in this area was supplemented with three temporary well transects during February to April 2006. These transects were located to the east of Bell Avenue, east of Chilled Water Facility Road, and east of Weaver Drive. The locations of temporary wells are shown on **Figure 3.2.17-1**. The purpose of these transects was twofold: to characterize the eastward shift of the plume since the monitoring well network was originally installed, and to characterize the location and nature of the high-concentration segment of the plume that had been addressed by low-flow pumping back in 2000–2001.

Data from these three temporary well transects show that the centerline of the plume from south of Brookhaven Avenue to the vicinity of Weaver Drive has largely shifted east of the existing monitoring well network. It was not possible to characterize the extreme eastern edge of the plume to less than detectable concentrations at either Bell Avenue or Chilled Water Facility Road due to the presence of building structures. However, the eastern edge was characterized along the Weaver Drive transect at VP-300.

In early 2006, the highest concentration segment of the HFBR tritium plume appears to be located at or just to the south of Chilled Water Facility Road. The highest tritium concentration detected was 80,000 pCi/L, in temporary well VP-278. This detection exceeded the OU III ROD contingency trigger level of 25,000 pCi/L of tritium at Chilled Water Facility Road and initiated an assessment of the need to reactivate the Princeton Avenue pump and recharge system. As part of this assessment, an additional temporary well transect was installed east of Weaver Drive. The highest tritium concentration detected in this area was 16,200 pCi/L, in temporary well VP-297. This detection is less than the 20,000 pCi/L OU III ROD contingency trigger level for Weaver Drive that requires the reactivation of the Princeton Avenue pump and recharge wells.

Tritium concentration trend plots are shown for key wells located along the centerline of the plume in **Figure 3.2.17-4**. An examination of the tritium trends for these wells and others since roughly the 2000–2001 time-frame indicates an eastward shift of the plume centerline.

3.2.17.3 Groundwater Monitoring Program Evaluation

The OU III HFBR Tritium Monitoring Program can be evaluated based on five major decision rules established for this program using the groundwater DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?

Yes. The BNL Groundwater Contingency Plan was triggered during February 2006 with the detection of tritium at a concentration of 80,000 pCi/L in a temporary well located east of the Chilled Water Facility. This detection triggered the ROD contingency of evaluating the need to restart the Princeton Avenue pump and recharge wells.

2. Is the tritium plume growing?

No. Based on the position of the 1,000 pCi/L isocontour line, the plume is not growing. See **Figure 3.2.17-5** for the plume distribution comparison between 1997 and 2005.

2a. Princeton Avenue Pump and Recharge Well Reactivation Evaluation

The first OU III ROD contingency requires an evaluation of the need to reactivate the Princeton Avenue pump and recharge wells if tritium concentrations exceed 25,000 pCi/L at the Chilled Water Facility Road. There were several detections of tritium exceeding this trigger value (ranging up to 80,000 pCi/L) during a groundwater characterization effort implemented in early 2006.

The first part of the evaluation was to determine whether the second OU III ROD contingency of exceeding 20,000 pCi/L at Weaver Drive had occurred. Temporary wells were installed to the east of Weaver Drive, downgradient of the detections at Chilled Water Facility Road, as discussed above. It appears that the leading edge of the hot-spot portion of the tritium plume is located between Chilled Water Facility Road and Weaver Drive, based on the results of these temporary well samples. These results are consistent with the natural attenuation model as stated above.

The leading edge of the 20,000 pCi/L isocontour is approximately 3 to 4 years travel time in groundwater from reaching the Princeton Avenue pump and recharge wells. In addition, the centerline of the plume, south of Brookhaven Avenue, has gradually shifted to the east since 1997 in response to significantly reduced flows to the HO recharge basin, the use of the OU III recharge basin, and the overall reduction in pumping from supply wells 10, 11, and 12 located in the eastern well field. This shift has placed the centerline of the plume to the east of the monitoring well network, as was verified by the groundwater characterization work completed in early 2006. The eastward shift will need to be evaluated from the standpoint of whether the Princeton Avenue pump and recharge wells are optimally located to intercept the plume, should it reach that location. Based on the tritium concentrations observed at Weaver Drive and the travel time of the leading edge of the plume to Princeton Avenue, the immediate reactivation of the pump and recharge wells is not warranted. However, several steps to prepare for potential reactivation of the pump and recharge wells and modifications to the groundwater monitoring program are recommended. See Section 3.2.17.4 for recommendations on groundwater monitoring modifications and preparation for potential reactivation of the pump and recharge wells.

3. Are observed conditions consistent with the attenuation model?

Yes. The BNL groundwater model 2003 update predicted that the remnants of the hot spot would reach Weaver Drive in approximately the late 2005 time frame at concentrations between 30,000 and 60,000 pCi/L. A comparison between observed conditions during the late 2005/early 2006 time frame and model predictions is shown in **Figure 3.2.17-6**. Observed conditions with respect to both tritium concentrations and hot-spot position match the model predictions reasonably well. The observed concentration of 16,200 pCi/L at Weaver Drive in March 2006 is less than the model predicted range of 30,000 to 60,000 pCi/L; however; this is consistent with the model historically under-predicting concentrations in the near field and over-predicting in the far field.

4. Is the tritium plume migrating toward the zone of influence of BNL water supply wells 10, 11, and 12?

No. Groundwater flow in this area was to the south throughout 2005 (**Figure 2-2**). Tritium was detected at up to 3,080 pCi/L during the last three quarters of 2004 in monitoring well 065-40, located upgradient of the HFBR. Since that time, tritium has not been detected in this well. Based on groundwater flow conditions, this tritium is originating from the AGS area to the north.

5. Has any segment of the plume migrated beyond the current monitoring network?

Yes. During some portion of 2005 the plume shifted to the east of the monitoring well network along Cornell Avenue and at all locations from Bell Avenue south to Weaver Drive. The eastward plume shift observed in the area from the HFBR to Temple Place resulted, in part, from the modification in supply well pumpage from the preferred western well field to the eastern well field during the first three quarters of 2005. Based on first-quarter 2006 data from monitoring wells in this area, indications are that the plume is shifting back to the west in response to the reestablishment of supply well pumping from the western well field during the fall of 2005.

3.2.17.4 Recommendations

The following are recommendations for the HFBR tritium plume.

- Up to eight temporary wells will be installed and sampled to the east of Weaver Drive and Chilled Water Facility Road on a semiannual basis beginning in October 2006. This data will be used to track the centerline of the tritium plume, to monitor for exceedance of the 20,000 pCi/L OU III ROD contingency trigger value at Weaver Drive, and to assess the trailing edge of the hot spot as it moves through the Chilled Water Facility Road area. It is anticipated that the semiannual installation and sampling of temporary wells will be necessary for up to a 2-year duration, at which time the nature and extent of the plume will be reevaluated with respect to monitoring frequency. The flexibility afforded by the installation of temporary wells over permanent wells is preferred, due to the narrow width of the plume and documented history of small flow changes resulting in monitoring well locations quickly being rendered less than optimal.
- Select monitoring wells along Cornell Avenue will continue to be monitored quarterly to track the centerline of residual tritium moving south from the HFBR. Several additional temporary wells will be installed along Temple Place if, based on the monitoring well data, it is determined that the plume has shifted outside of this line of monitoring wells.
- An evaluation will be performed utilizing the BNL groundwater model to determine whether the HFBR tritium pump and recharge wells (EW-10, -11, and -12) are located to intercept the tritium plume should the 20,000 pCi/L trigger value concentration be exceeded at Weaver Drive and the system reactivated. This evaluation will included a recommendation for modifications to this pump and recharge system, if necessary.
- The eastward shift of the HFBR plume since 1997 has resulted in much of the central and western portion of the monitoring well network being located outside of the plume. It is recommended that the focus of the groundwater monitoring program be shifted to key wells in the eastern portion of the monitoring well network. As a result, the sampling of the western wells will be reduced to either an annual frequency or suspended indefinitely, and focus monitoring on

- optimally located wells (based on current plume position) to the east in conjunction with the sampling of temporary wells semi-annually.

  There is now a sampling history of 6 to 9 years for most of the wells in the program. Given the current knowledge of the position of the plume, based on the recent characterization data and the extensive volume of historical data, it is recommended that the sampling frequencies be reduced in the following manner:

  1. Reduce the sampling frequency for wells significantly west of the current plume to either annually or suspend sampling altogether. No monitoring wells will be abandoned at this time and the flexibility will remain for these sampling frequencies to increase should the plume shift back to the west.
  2. Maintain quarterly sampling frequencies only for those wells immediately downgradient of the HFBR and in a position to intercept tritium as it is flushed from the vadose zone beneath the building. Also maintain quarterly frequencies for sentinel wells in the vicinity of Princeton Avenue.
  3. Based on the large volume of historical data, reduce remaining monitoring to semiannual. Based on current knowledge of the plume position, the semiannual installation of temporary wells, and the rate of plume movement, this frequency will be sufficient to meet the goals of the OU III ROD.

- **Table 3.2.17-2** summarizes the last detection of tritium, the last detection above 1,000 pCi/L, and the last detection above the 20,000 pCi/L DWS for each monitoring well. The table also lists the current sampling frequency and the proposed modified frequency based on the above recommendations and analysis of historical data. The monitoring program will be assessed twice a year and the regulatory agencies will be briefed, based on an analysis of data collection efforts and changes to the plume. Recommendations for additional modifications to the monitoring program will then be addressed in the appropriate quarterly system operation reports.
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3.3 OPERABLE UNIT IV

3.3.1 Post Closure Monitoring (Former OU IV AS/SVE System)

The OU IV Air Sparge system was shut down on August 08, 2001, and further monitoring was continued as per *OU IV Remediation Area 1 Proposed Supplemental Remedial Effort – Work Plan* (BNL 2001e). The *Petition for Closure and Termination of Formal Post Closure Monitoring of OU IV Air Sparge/Soil Vapor Extraction Remediation System* (BNL 2002a) was submitted to the regulatory agencies in June 2002. BNL received regulatory approval in July 2003 and decommissioned the system in December 2003.

A Five-Year Review Report for OU IV was submitted to the regulators in June 2002. Following revisions made based on regulator comments, a final report was approved in September 2003. This report included changes to the continued groundwater monitoring program.

3.3.1.1 Groundwater Monitoring

Well Network

The *Final CERCLA Five Year Review Report for OU IV* (BNL 2003e) stated that monitoring under this program should continue for three monitoring wells: 076-04, 076-06, and 076-185.

Monitoring wells 076-18 and 076-19 continue to be monitored under the BNL Facility Monitoring Program for the Central Steam Facility. The remaining monitoring wells were either included under the radionuclide monitoring under the OU IV AOC 6 Program or abandoned as per the final report (BNL 2003e).

Sampling Frequency and Analysis

The following monitoring requirements from the *Final CERCLA Five Year Review Report for OU IV* (BNL 2003e) have been implemented:

- Wells 076-04 and 076-06 will continue to be monitored quarterly for VOCs and SVOCs. If concentrations remain below MCLs for a 1-year period, the sampling frequency will be reduced to semiannual for a period of up to 5 years.
- Well 076-185 will continue to be monitored for VOCs on a semiannual basis.

3.3.1.2 Monitoring Well Results

Post-closure quarterly sampling of monitoring wells was conducted for 2005. The complete groundwater data are given in **Appendix C**. Here is a brief summary of the results.

- Well 076-04 – No samples exceeded the VOCs standards for the four quarters of sampling. No SVOCs were detected above the reporting limit.
- Well 076-06 – No samples exceeded the VOCs standards for the four quarters of sampling. No SVOCs were detected above the reporting limit.
- Well 076-185 – There was detection of a VOC exceeding MCLs. Cis-1,2-dichloroethylene was detected at a concentration of 6 µg/L in February of 2005, which is above the standard of 5 µg/L. This compound remained below the MCL or at nondetectable concentrations for the remainder of 2005.
- Wells 076-18 and 076-19 – There were no detections of VOCs in these wells during the semiannual sampling.

3.3.1.3 Post-Closure Monitoring Evaluation

The system can be evaluated based on the decision rule identified during the groundwater DQO process.

1. Was the BNL Contingency Plan triggered?

No. There were no unexpected VOC concentrations in groundwater during 2005.

3.3.1.4 Recommendations

The *Final CERCLA Five Year Review Report for OU IV* (BNL 2003e) required that wells 076-04 and 076-06 would continue to be monitored quarterly for VOCs and SVOCs. If concentrations remain below MCLs for a 1-year period, the sampling frequency would be reduced to semiannual for up to 5 years. The VOC concentrations in each of these two wells remained below MCLs during 2005. Therefore, it is recommended that the 2006 sampling frequency for VOCs and SVOCs be reduced to semiannual. Well 076-185 will continue to be sampled for VOCs semiannually, and wells 076-18 and 076-19 will continue to be monitored under the BNL Facility Monitoring Program on a semiannual basis.

3.3.2 Building 650 Strontium-90 Monitoring Program

The Building 650 Strontium-90 Monitoring Program monitors a Sr-90 plume emanating from a source area known as the former Building 650 Sump Outfall Area. This area was a depression at the terminus of a discharge pipe from the building. The pipe conveyed discharges from a concrete pad where radioactively contaminated clothing and equipment were decontaminated, beginning in 1959.

Remediation (by excavation) of the contaminated soils associated with the Building 650 sump outfall and removal of the pipe leading to the outfall, as well as soil, concrete, and asphalt associated with the former decontamination pad behind Building 650, were completed in 2002.

3.3.2.1 Groundwater Monitoring

Well Network
The network consists of 28 wells used to monitor the Sr-90 concentrations originating from the former Building 650 sump and sump outfall area. (**Figure 1-2**).

Sampling Frequency and Analysis
During 2005, the wells were monitored semiannually and the samples were analyzed for gross alpha/beta, gamma spectroscopy, tritium, and Sr-90 (**Table 1-5**).

3.3.2.2 Monitoring Well Results

The complete results from radionuclide sampling can be found in **Appendix C**. The overall extent of the Sr-90 plume originating from the Building 650 sump outfall has not changed significantly over the past several years, as it continues to migrate slowly to the south (**Figure 3.3.2-1**). The highest Sr-90 concentrations were detected in well 076-169, at 21.5 pCi/L, in February 2005. In general, the concentrations in wells associated with the Building 650 sump and sump outfall displayed stable to declining trends during 2005 (**Figure 3.3.2-2**).

Sr-90 concentrations in well 076-28 are shown in **Figure 3.3.2-2**. This well is immediately north of Building 650, adjacent to a former decontamination pad where contaminated soils were removed in 2002. Periodic increases in Sr-90 concentrations have been observed in this well over the past several years. These increases may be in response to periodic water table rises that flush out residual Sr-90 residing in the unsaturated zone. This water table flushing process has been observed in several former source areas across the site, including the HFBRR, BGRR, and g-2.

3.3.2.3 Groundwater Monitoring Program Evaluation

The system can be evaluated based on the three decision rules identified from the groundwater DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no unexpected Sr-90 concentrations in groundwater during 2005.

2. Were performance objectives met?

No. The performance objective for this project is to achieve Sr-90 concentrations below the NYS DWS of 8 pCi/L. Currently, two wells exceed this limit. Therefore, the performance objectives have yet to be achieved. The removal of contaminated soils in 2002 alleviated some of the source of groundwater contamination.

3. If not, are observed conditions consistent with the attenuation model?

Yes. The observed data are consistent with the attenuation model in terms of the extent of Sr-90 contamination.

3.3.2.4 Recommendation

The recommendation for the Building 650 Strontium-90 Groundwater Monitoring Program is to continue monitoring and reduce the frequency of sampling for monitoring wells 076-07, 076-09, 076-10, 076-22, 076-181, 076-182, 076-184, and 076-265 to annual.

3.4 OPERABLE UNIT V

3.4.1 Sewage Treatment Plant Monitoring Program

Historically, BNL's STP received discharges of contaminants from routine operations. Releases of contaminants to groundwater—in particular, VOCs, metals, and radionuclides—occurred via the STP sand filter beds and discharges to the Peconic River. The OU V project monitors the identified groundwater contamination downgradient of the STP.

3.4.2 Groundwater Monitoring

Well Locations

A monitoring network of 34 wells was designed to follow groundwater contamination downgradient of the STP, at the boundary, and off site (**Figure 1-2**). Sentinel wells are situated downgradient of the leading edge of the off-site VOC plume. BNL's Groundwater Model was used to aid in placing these wells.

Sampling Frequency and Analysis

Wells are sampled semiannually and samples are analyzed for VOCs, perchlorate, and tritium (**Table 1-5**).

3.4.3 Monitoring Well Results

The OU V wells were sampled during two rounds in 2005. **Appendix C** contains the complete data. The VOC plume consists of an area of TVOCs less than 20 μg/L that extends from an area south and east of the STP southeast to the vicinity of the Long Island Expressway (**Figure 3.4-1**). During 2005, the highest TVOC concentration was 19 μg/L in well 000-122, located just north of the expressway. In general, VOC concentrations in on-site plume core wells continued to decrease. The TVOC concentrations in off-site plume core well 000-122 showed an increasing trend from 2003 through the first quarter 2005, but concentrations decreased during the third quarter sampling round (**Figure 3.4-2)**. The only individual VOCs detected at levels exceeding NYS AWQS were TCA, TCE, 1,2,3-trichloropropane, and 1,2-dichloropropane. Since 1998, the latter two compounds have been detected in shallow off-site sentinel well 600-25. During 2005, 1,2,3-trichloropropane was observed at an estimated detection of 0.41 μg/L, which exceeds the NYS AWQS of 0.05 μg/L. 1,2-dichloropropane was detected at concentrations of 1.1 and 1.2 μg/L, exceeding the NYS AWQS of 1 μg/L. Based on the shallow depth of the well and its location approximately 4,000 feet southeast of the BNL site boundary, there appears to be an off-site source for this contamination. The contamination was not observed in either of the two deeper monitoring wells in this cluster. There have been no significant changes to the VOC plume over the past several years (**Figure 3.4-3**).

In August 2004, the 34 OU V monitoring wells were sampled and analyzed for perchlorate in response to a request from SCDHS. In June of that year, perchlorate had been detected in SCDHS monitoring well EG-A (off site and east of BNL) in a sample from the deep section of the Upper Glacial aquifer. Perchlorate was detected during the August 2004 sampling event in four of the 34 BNL wells (049-06, 050-02, 061-04, and 061-05), with concentrations ranging between 5.0 and 12.7 μg/L. The NYSDOH Action Level for perchlorate in drinking water supply wells is 18 μg/L.

In 2005, eight OU V wells (000-122, 000-123, 049-05, 049-06, 050-01, 050-02, 061-04, and 061-05) were analyzed for perchlorate during two sampling rounds. The compound was detected in wells 049-06 and 061-05, both of which monitor the deep portion of the Upper Glacial aquifer. Well 049-06 is near the eastern firebreak road and well 061-05 is at the eastern site boundary. The maximum perchlorate concentration, from well 061-05, was 10.8 μg/L—again, below the NYSDOH action level. The same eight OU V wells will be sampled for perchlorate again in 2006.

Tritium has historically been detected at low concentrations in monitoring wells 49-06, 50-02, and 61-05. The maximum tritium concentration during 2005 was 2,210 pCi/L, in well 049-06; this is approximately one-tenth the DWS of 20,000 pCi/L. Tritium was not detected in the off-site monitoring wells.

3.4.4 Groundwater Monitoring Program Evaluation

1. Was the BNL Groundwater Contingency Plan triggered?
No. There were no unexpected contaminant concentrations in groundwater during 2005.

2. Were the performance objectives met?
No. The performance objective for this program is to attain DWS for VOCs in groundwater in the Upper Glacial aquifer within 30 years, through monitored natural attenuation. These standards continue to be exceeded in two of the monitoring wells.

3. Is the extent of the plume still defined by the existing monitoring well network?
Yes. The leading edge of the plume is southeast of well 000-122 (south of the Long Island Expressway). Currently, two well clusters serve as sentinel wells for this plume along South Street and Wading River Road.

3.4.5 Recommendations

The routine monitoring program will continue unchanged for 2006. In addition, it is recommended that eight OU V monitoring wells continue to be analyzed for perchlorate in 2006.

3.5 OPERABLE UNIT VI EDB PUMP AND TREAT SYSTEM

The OU VI EDB Program monitors the extent of an ethylene dibromide (EDB) plume in groundwater currently extending from just south of the site boundary, off-site south of North Street. EDB was used during the 1970s as a fumigant for the BNL Biology Department's agricultural fields located in the southeastern portion of the site. In 1995 and 1996, low levels of EDB were detected in groundwater near the fields. Higher levels were found migrating toward the southern site boundary and off site to the south. In addition, the depth of the plume increased within the Upper Glacial aquifer to the south.

3.5.1 System Description

A groundwater remediation system to address the off-site EDB plume began routine operations in August 2004. The OU VI Treatment System consists of two extraction wells and two recharge wells. A complete description of the system is included in the *Operation and Maintenance Manual for the OU VI EDB Groundwater Treatment System* (BNL 2004e).

3.5.2 Groundwater Monitoring

Well Locations

A network of 33 wells monitor the EDB plume from the source area in the Biology Department's agricultural fields to locations on private property south of North Street (**Figure 3.5-1**).

Sampling Frequency and Analysis

The wells are monitored quarterly, and analyzed for EDB by EPA Method 504.2. Samples are analyzed annually for VOCs and tritium (**Table 1-5**).

3.5.3 Monitoring Well Results

Appendix C contains the complete results of the quarterly sampling program. The distribution of the EDB plume is shown for the fourth quarter of 2005 (**Figure 3.5-1**). The leading edge of the plume is currently being captured by extraction wells EW-1E and -2E. The plume is located in the deep Upper Glacial aquifer and is generally moving horizontally, as depicted on cross section M–M' (**Figure 3.5-2)**. The highest EDB concentration observed during 2005 was 3.4 µg/L, in well 000-284. This is less than the maximum EDB concentration reported in 2004 of 4.1 µg/L, in well 000-284. The federal DWS for EDB is 0.05 µg/L.

The southward migration of the plume can be observed by analyzing the trends in **Figure 3.5-3**. EDB is increasing in well 000-507, indicating that the core of the plume is located between well 000-507 and wells 000-283 and 000-284. Comparing the plume's distribution from 1999 to 2005 in **Figure 3.5-4** also illustrates the southward movement of the plume.

It should also be noted that EDB was detected during 2005 at concentrations up to 0.14 µg/L in perimeter well 000-498. This indicates that the plumes western perimeter extends slightly further west than originally thought and possibly just outside the capture zone of EW-1E.

The wells are sampled annually for VOCs in addition to quarterly EDB analyses. There were no detections of VOCs besides EDB above MCLs in any of the wells (**Appendix C**).

The wells are sampled annually for tritium. There were no confirmed detections observed in 2005.

3.5.4 System Operational Data

The extraction wells are currently sampled every month. The influent and effluent of the carbon treatment system were sampled weekly. All samples were analyzed for VOCs and EDB. The effluent sample is analyzed weekly for pH. **Table 3.5-1** provides the effluent limitations for meeting the requirements of the SPDES permit equivalency.

Table 3.5-1
OU VI EDB Pump & Treat System
2005 SPDES Equivalency Permit Levels

Parameters	Permit Limit	Max. Measured Value
pH (range)	5.0 – 8.5 SU	5.4 – 6.91 SU
ethylene dibromide	5.0 µg/L	<0.50 µg/L
chloroform	7.0 µg/L	1.4 µg/L
1,1-dichloroethene	5.0 µg/L	<0.50 µg/L
1,1,1-trichloroethane	5.0 µg/L	<0.50 µg/L

*Maximum allowed by requirements equivalent to a SPDES permit. Required sampling frequency is monthly for VOCs and pH.

Extraction Wells

During 2005, 158 million gallons were pumped and treated by the OU VI EDB System, with an average flow rate of 300 gpm. **Table 2-3** contains the monthly pumping data for the two extraction wells. VOC concentrations for EW-1E (000-503) and EW-2E (000-504) are provided in **Table F-49** in **Appendix F** (on the CD-ROM). There were several detections of EDB in the extraction well influent during 2005, with a maximum of 0.3 µg/L in EW-2E.

System Influent and Effluent

All discharge parameters were below the regulatory limit specified in the SPDES equivalency permit. Influent and effluent results are reported in **Tables F-49 and F-50**, respectively.

Cumulative Mass Removal

EDB was only detected in extraction wells during five sampling events in 2005. No cumulative mass calculations were performed, based on the lack of EDB detections in the system influent. Several low-level VOCs not attributable to BNL were detected; the results are potentially due to analytical lab contamination and were all below MCLs.

3.5.5 System Evaluation Data

The OU VI EDB System was designed to capture and remediate the EDB plume as it travels off site south of BNL with the regional groundwater flow. Startup of the system was initiated in August 2004, and it is planned to run for approximately 10 years. Therefore, the system is still in the early part of its life cycle. The system is operating as designed; no operating difficulties were experienced beyond normal maintenance, and no permit equivalencies have been exceeded.

The OU VI EDB System performance can be evaluated based on the five major decisions identified in the groundwater DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no unusual or unexpected concentrations of contaminants observed in monitoring wells associated with the OU VI EDB plume treatment system.

2. If not, has the plume been controlled?

Yes. An analysis of data from the plume perimeter and bypass wells shows no detections of EDB in 2005 except in perimeter well 000-498, located northwest of EW-1E near the edge of the current capture zone for that extraction well. Perimeter well 000-498 is located approximately 1 to 2 years of groundwater travel time from EW-1E. If any EDB in this area were to bypass the EW-1E capture zone, it most likely would not have done so at this time. Other than in the vicinity of 000-498, we conclude that that plume has not grown and continues to be controlled.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate?

The hydraulic capture performance of the system is operating as described in the Startup Report. EDB was detected in extraction wells EW-1E and EW-2E for the first time in 2005. As the system has been operating less than 2 years, it is still too early to determine if the aquifer is being restored at the planned rate.

4. Can the groundwater treatment system be shut down?

No, the system has only been operating for 1.5 years and has not met all shutdown requirements.

4a. Have asymptotic EDB concentrations been reached in plume core wells?

No. Asymptotic conditions have not yet been achieved.

4b. Are there individual plume core wells above 0.05 μg/L EDB ?

There are currently eight plume core wells with concentrations greater than 0.05 μg/L.

4c. During pulsed operation of the system, is there significant concentration rebound in core wells?

The OU VI EDB system has not been pulsed to date.

4d. Have the groundwater cleanup goals been met? Have MCLs been achieved by 2030?

No, MCLs have not been achieved for individual VOCs in plume core wells. MCLs are expected to be achieved by 2030, as required by the OU VI ROD.

3.5.6 Recommendations

- Due to the detection of EDB in well 000-498, which is near the edge of the capture zone for extraction well EW-1E, increase the pumping rate at EW-1E to increase the capture zone. An evaluation will be performed to determine if the existing pump is adequate or whether a larger pump is required. Pumping at this rate will extend the capture zone sufficiently westward such that any EDB in this area will be captured and treated by the remediation system.
- As of August 2006, the OU VI EDB system will have been in operation for 2 years. Beginning with the third quarter of 2006, the groundwater monitoring program will move into the O&M phase (see **Table 1-7**). The sampling frequency for plume core and perimeter wells (**Table 1-5**) will be reduced from quarterly to semiannually. The exception to this will be well 000-498, which will remain at a quarterly sampling frequency until further notice. Sentinel well sampling will remain at a quarterly frequency and the analytical parameters will remain unchanged.
- Based on the absence of any tritium detections in OU VI monitoring wells dating back to 1997, this parameter will be dropped from the program. The exception will be wells 099-06, 099-10, 099-11, 100-12, and 100-13 (all located on the south boundary). These wells will be incorporated into the OU III South Boundary Radionuclide monitoring program and analyzed for tritium annually. The inclusion of these wells will allow for radionuclide monitoring across the entire downgradient site boundary.
- Monitoring wells 800-54, 800-24, and 800-25 will be dropped from the program, as they are no longer deemed to be providing value. This is due both to the establishment of hydraulic control of the plume at EW-1E and EW-2E and the fact that these three wells are not positioned, either horizontally or vertically with respect to the plume, to intercept EDB should it reach these locations.

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3.6 SITE BACKGROUND MONITORING

Background water quality has been monitored since 1990. Historically, low levels of VOCs were routinely detected in several background wells that are screened in the deeper portions of the Upper Glacial aquifer.

3.6.1 Groundwater Monitoring

Well Network

The 2005 program included 10 wells located in the northwestern portion of the BNL property and adjacent off-site areas (**Figure 1-2**). Background quality is defined as the quality of groundwater that is completely unaffected by BNL's operations.

Sampling Frequency and Analysis

The samples were collected annually and analyzed for VOCs (**Table 1-5**).

3.6.2 Monitoring Well Results

The complete groundwater data for 2005 is provided in **Appendix C**. There were detections of low levels of several VOCs in the site background wells. All VOC detections were below NYS AWQS. The highest concentration detected was methyl-tert-butyl ether (MTBE) at 4.4 µg/L in well 017-01.

While radionuclides are no longer analyzed in background wells, historic results are presented for reference purposes. **Table 3.6-1** summarizes the range of radionuclide values detected in background wells from 1996 through 2001.

3.6.3 Monitoring Program Evaluation

The program can be evaluated using the decision rule developed as part of the groundwater DQO process.

1. Is groundwater quality at BNL being impacted by off-site, upgradient source(s) of contamination?

No. There were no VOCs detected in site background wells above NYS AWQS during 2005. Based on these results, there is no current impact to BNL groundwater quality from upgradient contaminant sources.

3.6.4 Recommendations

No modifications are recommended for this monitoring program.

Table 3.6-1.
Radiological Background Monitoring, 1996 – 2001

Parameter	Activity Range (pCi/L)	Contract-Required Detection Limit
Cesium-137	<MDA to 7.24	12
Gross alpha	<MDA to 2.66	1.5
Gross beta	<MDA to 6.41	4.0
Strontium-90	<MDA to 3.84	0.8
Tritium	<MDA	1,000

Notes:
<MDA = Less than minimum detectable activity

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3.7 CURRENT AND FORMER LANDFILL GROUNDWATER MONITORING

Groundwater monitoring data from both the Current and Former Landfills are discussed in detail in the *BNL 2005 Environmental Monitoring Report, Current and Former Landfill Areas* (BNL 2006a). This report can be found in **Appendix H**. The complete groundwater monitoring results for these programs are included in **Appendix C**.

3.7.1 Current Landfill Summary

Data show that, in general, contaminant concentrations have been decreasing following the capping of the landfill in 1995. By the end of 2005 the landfill had been capped for 11 years. Groundwater quality has been slowly improving. The trend in the data suggests that the cap is effective in mitigating contamination. The following is a summary of the results from the samples collected during 2005:

- VOCs such as benzene and chloroethane continue to be detected in downgradient wells 087-11, 087-23, 087-27, 088-109, and 088-110 at concentrations above groundwater standards. The maximum VOC concentration (chloroethane) in 2005 was 94 µg/L, in well 088-109. TVOC concentrations in these five wells have ranged between nondetectable to 113.5 µg/L over the past several years, indicating that low-level VOCs continue to emanate from the landfill. The continued presence of these leachate indicators is expected and normal.
- Landfill water chemistry parameters and metals (which include total dissolved solids, total suspended solids, alkalinity, ammonia, iron and manganese) evaluated during the year suggest that leachate continues to emanate from the landfill. The continued presence of these leachate indicators is expected and normal.
- Tritium and Sr-90 continue to be detected in the wells downgradient of the Current Landfill, but at concentrations well below groundwater standards. These concentrations were consistent with those observed in 2004.
- Since 1998, there have been no detections of VOCs, metals, water chemistry parameters, or radionuclides exceeding groundwater standards in wells 087-24, 088-22, and 088-23. These wells are all screened in the mid-to deep-Upper Glacial aquifer to monitor the vertical extent of contamination from the Current Landfill.
- Although low levels of contaminants continue to be detected, the landfill controls are effective, as evidenced by the improving quality of groundwater downgradient of the landfill.

3.7.2 Current Landfill Recommendation

No changes to the current sampling schedule are recommended.

3.7.3 Former Landfill Summary

Data show that contaminant concentrations have been decreasing following the capping of the landfill in 1996. Contaminant concentrations downgradient of this landfill were relatively low prior to capping, primarily due to it being approximately 50 years old. The trend in the data suggests that the cap is effective in mitigating the remaining contamination from entering the groundwater. Based on the declining VOC and Sr-90 concentration trends in downgradient wells, it appears that the landfill cap is performing as planned. The following is a summary of the results from the samples collected during 2005:

- The Former Landfill is not a significant source of VOC contamination. No VOCs were detected above groundwater standards in 2005. VOC concentrations in the downgradient wells were at or near the minimum detectable limits.

- Landfill-leachate indicators in downgradient wells continue to be detected at concentrations above background, indicating some continued generation of leachate. However, the leachate concentrations are very low and remain stable. This low level of generation is expected, given the age of the landfill and that is is capped.
- The Former Landfill no longer appears to be a source of Sr-90 contamination. Sr-90 was only detected in a single downgradient well (097-64), at a concentration below the standard of 8 pCi/L.
- The implemented landfill controls are effective, as evidenced by the improving quality of groundwater downgradient of the landfill.
- The Sr-90 plume (as defined by concentrations exceeding 8 pCi/L) has migrated south of well 097-64 and continues to attenuate. The Sr-90 concentration in well 097-64 reached a historic high of 12 pCi/L in January 1998 and has been below 8 pCi/L since January 2000. Model results indicate that this plume will degrade to below 8 pCi/L before reaching the southern boundary of the site.

3.7.4 Former Landfill Recommendation

There are no recommended changes to the sampling schedule.

4.0 ENVIRONMENTAL SURVEILLANCE PROGRAM SUMMARY

During 2005, the Environmental Surveillance (ES) Program at BNL monitored the groundwater quality at 10 active research and support facilities. New York State operating permits require groundwater monitoring at two support facilities (the Major Petroleum Facility and the Waste Management Facility); the remaining eight research and support facilities are monitored in accordance with DOE Order 450.1, *Environmental Protection Program*. This Order requires the Laboratory to establish environmental monitoring programs at facilities that can potentially impact environmental quality, and to demonstrate compliance with DOE requirements and the applicable federal, state, and local laws and regulations. BNL is implementing this part of the Environmental Management System to collect information on groundwater quality, and will use the data to determine whether current engineered and administrative controls effectively protect groundwater quality and whether additional corrective actions are needed.

During 2005, 125 groundwater surveillance wells were monitored during 285 individual sampling events. Information on groundwater quality at each of the monitored research and support facilities is described below. **Table 1-6** summarizes the ES Groundwater Monitoring Program by project.

4.1 Alternating Gradient Synchrotron (AGS) Complex

The structures that constitute the AGS Complex include Building 912, AGS Booster Beam Stop, 914 Transfer Tunnel, g-2 experimental area, E-20 Catcher, former U-Line Target, and the J-10 Beam Stop. Activated soil has been created near a number of these areas as the result of secondary particles (primarily neutrons) produced at beam targets and beam stops. A number of radionuclides can be produced by the interaction of secondary particles with the soil that surrounds these experimental areas. Once produced in the soils, some radionuclides can be leached from the soils by rainwater, and carried to the groundwater. The leaching processes are usually quite slow; therefore, only radionuclides with relatively long half-lives such as tritium (12.3 years) and sodium-22 (2.6 years) are likely to be detected in groundwater. Of the two radionuclides, tritium is more easily leached from the activated soils by rainwater and does not bind to soil particles. When tritium enters the water table, it migrates at the same rate as groundwater flow. Sodium-22 does not leach out of the soil as readily as tritium, and migrates at a slower rate in the groundwater. To prevent rainwater from leaching these radionuclides from the soil, impermeable caps have been constructed over many of the soil activation areas, as specified in the Standards Based Management System subject area entitled *Accelerator Safety*. BNL uses 56 groundwater monitoring wells to evaluate the impact of current and historical operations at the AGS beam stop and target areas. The locations of permanent monitoring wells are shown on **Figure 4-1**.

During 2005, all 56 AGS monitoring wells were used to evaluate groundwater quality near areas of potential soil activation within the AGS Complex. Following the 1999 installation of an improved monitoring well network at the AGS, BNL detected three tritium plumes that originated from activated soil shielding at the g-2 experimental area, the former U-Line beam stop, and the former E-20 Catcher. The subsequent installation of impermeable caps over these soil activation areas has resulted in a reduction of tritium levels to less than the 20,000 pCi/L drinking water standard in the Former U-Line and E-20 Catcher areas. As discussed below, tritium concentrations higher than 20,000 pCi/L continue to be detected downgradient of the g-2(VQ-12 magnet) soil activation area (see **Section 4.1.5**).

Historical surface spills and discharges of solvents to several cesspools and recharge basins near the AGS contaminated soil and groundwater with VOCs. VOC contamination is monitored under the Environmental Restoration Program's Operable Unit III Central groundwater monitoring program (see **Section 3.2.9**).

4.1.1 AGS Building 912

Building 912 consists of five interconnected structures that have been used to house as many as four experimental beam lines (A, B, C, and D Lines). A typical beam line consists of bending and focusing electromagnets, vacuum pipes, instrumentation, high-voltage electrostatic devices, beam targets, radiation shielding, cooling water systems, and experimental detectors. These beam lines stopped operations in 2002, and plans are being developed to reconfigure the experiment area for new experiments.

Beam loss and the production of secondary particles at proton target areas result in the activation of adjacent equipment, the floor, and probably the soil beneath the floor. The highest levels of soil activation beneath Building 912 are expected at the B-Line target cave. Stormwater infiltration around the building is controlled by paving and stormwater drainage systems that direct most of the water to recharge basins north of the AGS complex. Therefore, it is believed that the potentially activated soil underlying the beam targets and stops is adequately protected from surface water infiltration.

4.1.1.1 AGS Building 912 Groundwater Monitoring

Well Network

Seventeen shallow Upper Glacial aquifer wells are upgradient and downgradient of Building 912 (**Figure 4-1**). Upgradient wells are positioned to monitor potential tritium contamination from sources such as the g-2 area and the former U-Line experimental area. The downgradient wells are positioned to monitor significant beam stop and target areas in Building 912.

Sampling Frequency and Analysis

During 2005, Building 912 wells that were used to help track the g-2 tritium plume were sampled quarterly, whereas the remaining wells were sampled semiannually. The groundwater samples were analyzed for tritium (**Table 1-6**).

4.1.1.2 AGS Building 912 Monitoring Well Results

Other than tritium contamination that is traceable to the g-2 source area, groundwater surveillance data for 2005 indicate that appreciable levels of tritium are not being released from activated soil beneath the experimental floor of Building 912. Although tritium was not detected in most wells, trace levels were detected in one sample from well 065-125 (420 pCi/L) and one sample from well 065-126 (300 pCi/L). The g-2 tritium plume has been tracked from the VQ-12 magnet source, beneath a portion of Building 912, to an area south of the Waste Concentration Facility (**Figure 4-1**). Tritium from this plume was detected downgradient of Building 912 (in wells 065-121, -122, -123, -124, -321, -322, -323, and -324), with a maximum concentration of 87,700 pCi/L in the October 2005 sample from well 065-124. As described in Section 4.1.5, possible remedial actions for the g-2 tritium plume will be evaluated in a Focused Feasibility Study that is scheduled for completion in early 2006.

4.1.1.3 AGS Building 912 Groundwater Monitoring Program Evaluation

As noted above, in areas not impacted by the g-2 tritium plume, tritium was either nondetectable or only observed at trace levels. These results indicate that the building and associated stormwater management operations are effectively preventing rainwater from infiltrating potentially activated soil below the experimental hall. For 2006, the monitoring frequency for the Building 912 wells not used to track the g-2 tritium plume will be reduced from semiannual to annual.

4.1.2 AGS Booster Beam Stop

The AGS Booster is a circular accelerator with a circumference of nearly 660 feet. It is connected to the northwest portion of the main AGS ring and to the Linear Accelerator (Linac). The AGS Booster, which has been in operation since 1994, receives either a proton beam from the Linac or heavy ions from the Tandem Van de Graaff generator. The booster accelerates protons and heavy ions before injecting them into the main AGS ring. In order to dispose of the beam during studies, a beam scraper system, consisting of a beam kicker and an absorber block, was originally constructed at the 10 to 11 o'clock portion of the booster. In 1999, the beam stop was repositioned to the south side (6 o'clock section) of the booster ring to accommodate the construction of the NASA Space Radiation Laboratory (NSRL) tunnel in the original beam stop location.

The AGS Booster beam stop is an area where the interaction of secondary particles and soil surrounding the booster tunnel can result in the activation of that soil. Although internal shielding around the beam stop was designed to keep secondary particle interactions with the soil to very low levels, a landfill-type geomembrane cap was constructed over the original beam stop region to prevent stormwater infiltration into potentially activated soil. When the beam stop was repositioned to the 6 o'clock region of Booster, a coated concrete cap was constructed over the new beam stop area to prevent stormwater infiltration.

4.1.2.1 AGS Booster Groundwater Monitoring

Well Network

Two shallow Upper Glacial aquifer monitoring wells (064-51 and 064-52) are approximately 50 feet downgradient of the current beam stop (**Figure 4-1**). One of the upgradient wells for the Brookhaven Linac Isotope Producer facility (well 054-61) is also used to provide data on background tritium concentrations.

Sampling Frequency and Analysis

During 2005, the booster area wells were monitored semiannually (**Table 1-6**). All of the groundwater samples were analyzed for tritium.

4.1.2.2 AGS Booster Monitoring Well Results

Although low levels (up to 1,340 pCi/L) of tritium were detected downgradient of the AGS Booster stop during 2001 and 2002, tritium was not detected at concentrations above the MDL during 2003 through 2005 (**Figure 4-2**). The tritium that was detected in 2001 and 2002 was probably related to a short-term uncovering of activated soil shielding at the former AGS Booster beam stop location (northwestern section of the booster) during construction of the beam line tunnel that leads from the booster to the NSRL. This work, which began in September 1999 and was completed by October 1999, may have allowed rainwater to infiltrate the low-level activated soil shielding that surrounds the former beam stop location.

4.1.2.3 AGS Booster Groundwater Monitoring Program Evaluation

The low-levels of tritium detected during 2001 and 2002 near the AGS Booster Beam Stop were likely related to a short-term uncovering of activated soil shielding near the former booster beam stop area during the construction of the tunnel leading from the booster to NSRL. This work, which began in September 1999 and was completed by October 1999, may have allowed rainwater to infiltrate the low-level activated soil shielding.[1] Tritium has not been detected in the Booster area monitoring wells since 2003. Starting in 2006, the monitoring frequency will be reduced from semiannual to annual.

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[1] Before construction of the NSRL tunnel commenced, soil samples were collected by drilling through the tunnel wall near the booster beam stop to verify that the tritium and sodium-22 levels were within acceptable limits for worker safety and environmental protection.

Figure 4-2.
Maximum Tritium Concentrations Downgradient of AGS Booster Beam Stop (Wells 064-51 and 064-52).

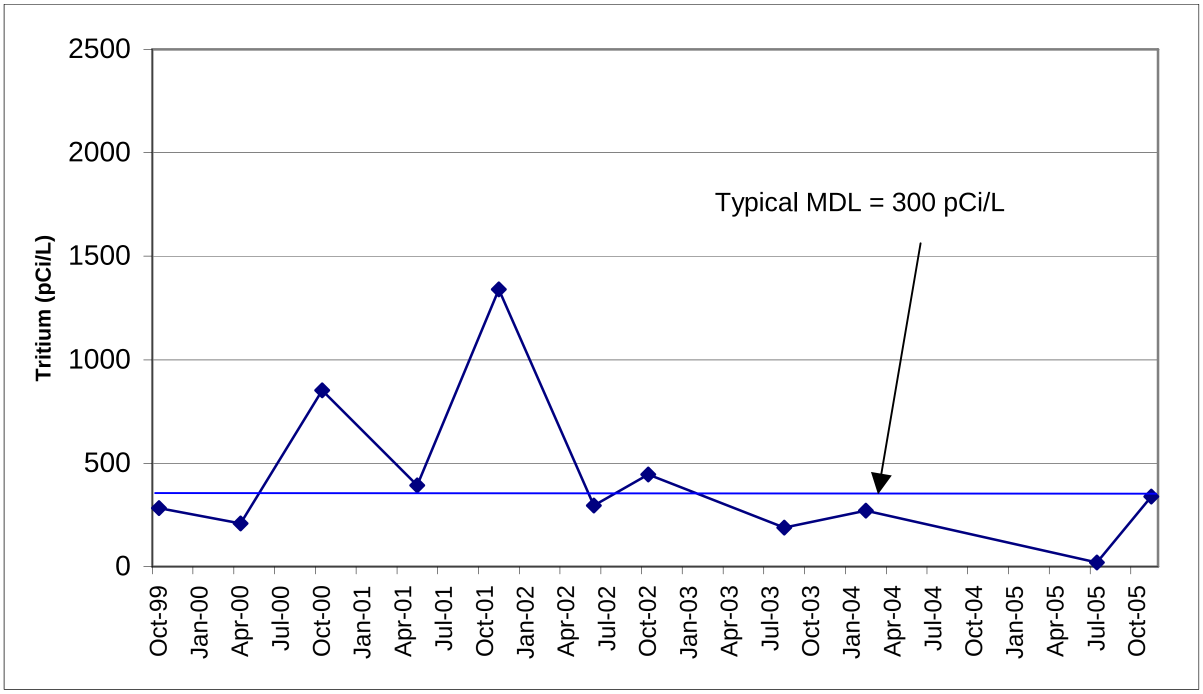
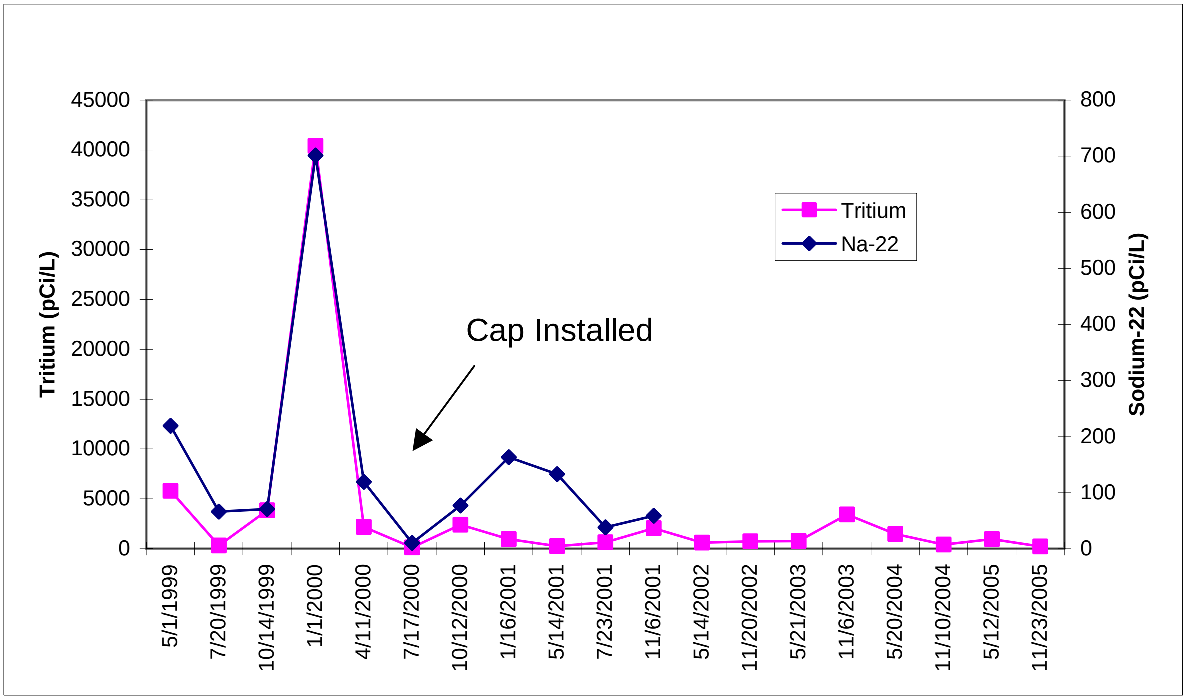


Figure 4-3.
Maximum Tritium and Sodium-22 Concentrations in Temporary and Permanent Monitoring Wells Downgradient of the Former E-20 Catcher.



4.1.3 AGS E-20 Catcher

The E-20 beam catcher was used from 1984 to 1999, and was located at the 5 o'clock position of the AGS ring (**Figure 4-1**). The E-20 Catcher was a minimum aperture area of the AGS ring, and was used to pick up or "scrape" protons that move out of acceptable pathways. The E-20 Catcher picked up about 80 to 90 percent of all losses resulting from beam injection, transition, and ejection in the AGS Ring.

Like other beam loss areas in the AGS complex, the soil surrounding the E-20 Catcher became activated by the interaction with secondary particles. In late 1999, tritium and sodium-22 were detected in wells approximately 100 feet downgradient of the former E-20 Catcher. The highest levels of tritium and sodium-22 were 5,800 pCi/L and 219 pCi/L, respectively. To further evaluate the extent of contamination, temporary wells were installed in January 2000. Tritium and sodium-22 levels in the temporary wells were found to exceed the DWS, with concentrations of 40,400 pCi/L and 704 pCi/L, respectively. In April 2000, a temporary impermeable cap was installed over the E-20 Catcher soil activation area. A permanent cap was constructed by October 2000, and an additional downgradient well was installed for improved long-term monitoring.

4.1.3.1 AGS E-20 Catcher Groundwater Monitoring

Well Network

To verify the effectiveness of the impermeable cap over the E-20 Catcher, the area is monitored by shallow Upper Glacial aquifer wells 064-55, -56, and -80. These wells are approximately 100 feet downgradient of the source area (**Figure 4-1**).

Sampling Frequency and Analysis

During 2005, the E-20 Catcher wells were monitored semiannually, and the samples were analyzed for tritium (**Table 1-6**).

4.1.3.2 AGS E-20 Catcher Monitoring Well Results

Following the installation of the cap in 2000, tritium and sodium-22 concentrations decreased to levels below applicable NYS AWQS (**Figure 4-3**). During 2005, the maximum observed tritium concentration was 970 pCi/L, detected in well 064-80.

4.1.3.3 AGS E-20 Catcher Monitoring Program Evaluation

The reduction in tritium concentrations since the impermeable cap was constructed over the E-20 Catcher area in 2000 indicates that the cap has been effective in preventing additional rainwater infiltration into the activated soil that surrounds that portion of the AGS tunnel. Starting in 2006, the monitoring frequency for the E-20 Catcher wells will be reduced from semiannual to annual.

4.1.4 AGS Building 914

Building 914 houses the transfer line between the AGS Ring and the Booster. Due to beam loss near the extraction (kicker) magnet, the extraction area of Building 914 is heavily shielded with iron. Because the extraction area is housed in a large building, most soil activation is expected to be below the floor of the building, where it will be protected from water infiltration.

4.1.4.1 AGS Building 914 Groundwater Monitoring

Well Network

Groundwater quality in the Building 914 transfer line area is monitored by five shallow Upper Glacial aquifer wells; two upgradient wells, and three downgradient wells (**Figure 4-1**).

Sampling Frequency and Analysis

During 2005, the Building 914 area wells were monitored semiannually and samples were analyzed for tritium (**Table 1-6**).

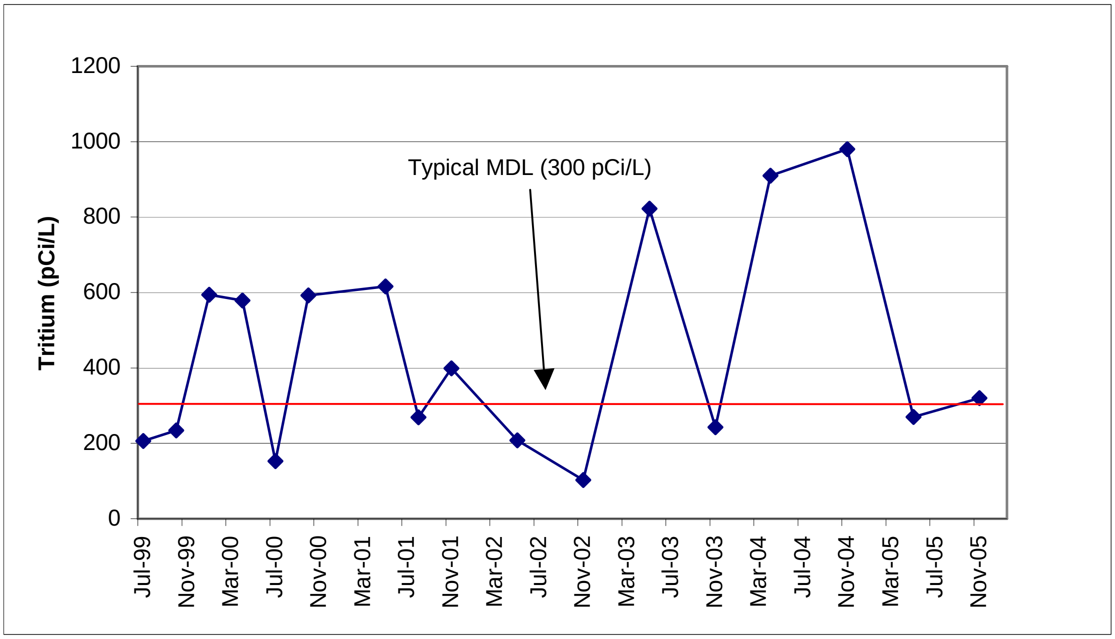
4.1.4.2 AGS Building 914 Monitoring Well Results

Low levels of tritium have been detected in groundwater downgradient of the Building 914 transfer tunnel since January 2000 (**Figure 4-4**). During 2005, the maximum tritium concentration was 270 pCi/L, in a sample from downgradient well 064-53.

4.1.4.3 AGS Building 914 Groundwater Monitoring Program Evaluation

Groundwater monitoring downgradient of Building 914 continues to indicate that the building structure and associated stormwater controls are effectively preventing significant rainwater infiltration into activated soil below the building. However, the detection of trace levels of tritium since 2003 suggests that some rainwater may be infiltrating the activated soil. Continued monitoring is required. Starting in 2006, the monitoring frequency for the E-20 Catcher wells will be reduced from semiannual to annual.

Figure 4-4.
Maximum Tritium Concentrations Downgradient of 914 Transfer Tunnel (Wells 064-03, -53, and -54).



4.1.5 g-2 Beam Stop and VQ-12 Magnet Area

The g-2 experiment operated from April 1997 until April 2001. The g-2 beam stop is composed of iron, and is covered by soil. Like other beam loss areas in the AGS complex, the g-2 beam stop was an area where the soil surrounding the stop would have become activated by the interaction with secondary particles. To prevent rainwater from infiltrating the soil surrounding the beam stop, BNL installed a gunite (blown concrete) cap over the stop area before the start of beam line operations.

In November 1999, monitoring wells approximately 250 feet downgradient of the g-2 experimental area detected the presence of tritium and sodium-22 in the groundwater. A groundwater investigation conducted during November and December 1999 revealed a narrow plume of tritium with a maximum tritium concentration of 1,800,000 pCi/L. Sodium-22 was also detected, but at a concentration of only 60 pCi/L, or 15 percent of the 400 pCi/L DWS.

Following the discovery, an investigation into the source of the contamination revealed that the tritium originated from activated soil shielding adjacent to the g-2 experiment's VQ-12 Magnet. This section of the beam line was not a designed beam loss area, and the gunite cap installed over the nearby beam stop did not protect the VQ-12 area. In December 1999, an impermeable cap was installed over the VQ-12 soil activation area. This cap was joined to the existing beam stop cap. In September 2000, the activated soil shielding and associated tritium plume were designated as new sub-Area of Concern 16T. Following this designation, DOE agreed to conduct studies to determine the adequacy of the corrective actions taken to date and the need for further actions. A Focused Feasibility Study will be prepared in early 2006. Any decisions for corrective actions will be documented in a Record of Decision.

4.1.5.1 g-2 Beam Stop and VQ-12 Magnet Area Groundwater Monitoring

Well Network

Groundwater quality downgradient of the g-2 beam stop is monitored using three downgradient wells, and the tritium plume originating from the VQ-12 magnet area is monitored using 23 downgradient wells (**Figure 4-1**).

Sampling Frequency and Analysis

During 2005, the g-2 beam stop wells were monitored semiannually, and g-2 tritium plume wells were monitored quarterly. All samples were analyzed for tritium (**Table 1-6**).

4.1.5.2 g-2 Beam Stop and VQ-12 Magnet Area Monitoring Well Results

g-2 Tritium Plume

Samples collected during 2005 from wells approximately 150 feet downgradient of the VQ-12 area indicate that although tritium continues to be released to the groundwater, tritium concentrations are much lower than those observed in July 2002, when a tritium concentration of 3,440,000 pCi/L was observed in well 054-07. During 2003, tritium concentrations showed a steady decline from a maximum of 1,040,000 pCi/L in January to 113,000 pCi/L in October. Since June 2004, tritium concentrations in wells directly downgradient of the source area have been less than 150,000 pCi/L, with samples from six of eight quarterly monitoring periods being less than 100,000 pCi/L (**Figure 4-5**). In the area immediately downgradient of Building 912, a distance of approximately 600 feet from the VQ-12 source area, the maximum tritium concentration observed during 2005 was 87,700 pCi/L, in well 065-124 (**Figure 4-6**). **Figure 4-1** shows the position of the g-2 tritium plume in the fourth quarter of 2005. The segmented nature of the tritium plume resulted from up to four distinct periods of tritium release (also referred to as slug releases). The leading segment of tritium contamination was released in 1999 before the impermeable cap was installed over the VQ-12 area, whereas subsequent releases appear to be related to the flushing of residual tritium from the vadose zone following periodic, significant rises in the local water table (**Figure 4-5**).

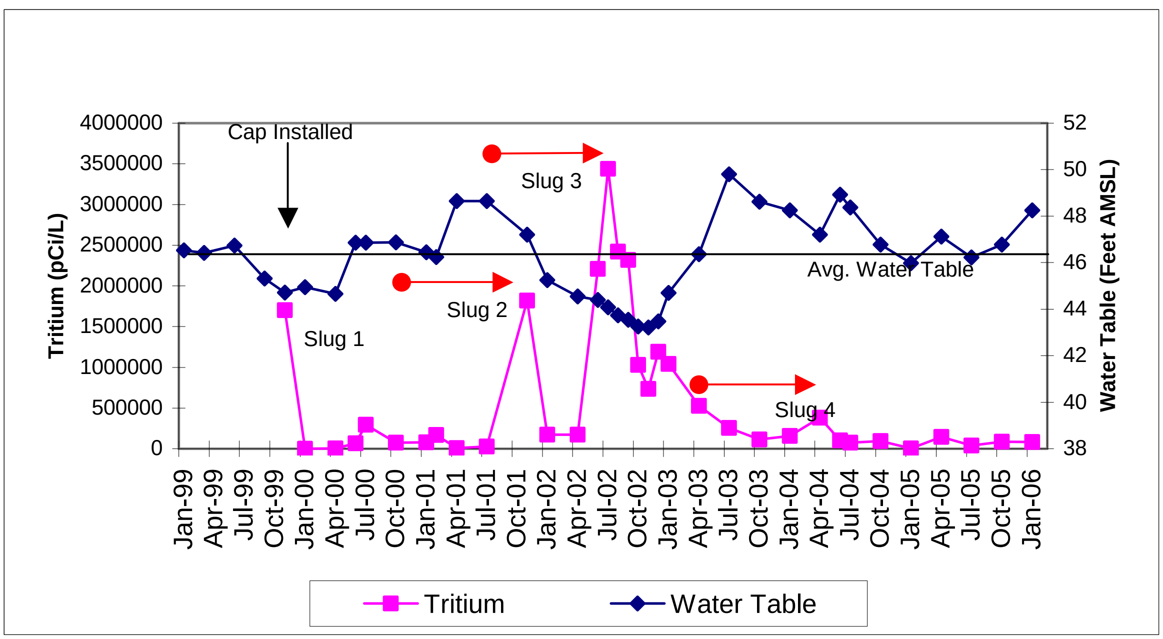
g-2 Beam Stop

During 2005, tritium was not detected in any samples from the three monitoring wells located downgradient of the g-2 beam stop.

4.1.5.3 g-2 Beam Stop and VQ-12 Magnet Area Groundwater Monitoring Program Evaluation

Monitoring of wells downgradient of the g-2 beam stop indicates that the cap is effectively preventing rainwater from infiltrating the activated soil shielding. Inspections of the cap and review of its design have concluded that the cap over the VQ-12 area has not failed and is properly positioned. Although the cap prevents rainwater infiltration into the activated soil-shielding zone, a comparison of tritium levels in the source area monitoring wells and the water table elevation data suggests that periodic natural fluctuations in the water table have released residual tritium from the deep vadose zone (i.e., unsaturated soil immediately above the water table). It is believed that this tritium was mobilized to the soil close to the water table before the cap was put in place in December 1999. Once the cap was in place, the lack of additional rainwater infiltration kept the tritium in the vadose zone from migrating into the groundwater until the significant rise in water table mobilized it. There appears to be good correlation between high tritium concentrations detected in monitoring wells immediately downgradient of VQ-12, and the groundwater table elevation about 1 year before the sampling (**Figure 4-5**). The groundwater travel time from beneath the source to the monitoring wells is about 1 year. Water levels in the central BNL area in mid 2000, mid 2001 and July 2003, were near the highest observed in 49 years of record by the USGS. Additional details on the vadose zone release hypothesis and possible remedial actions for the g-2 tritium plume will be provided in a Focused Feasibility Study scheduled for completion in 2006. Starting in 2006, the monitoring frequency for the E-20 Catcher wells will be reduced from semiannual to annual. Wells used monitor the VQ12 source area and to track the g-2 tritium plume will continue to be sampled on a quarterly basis.

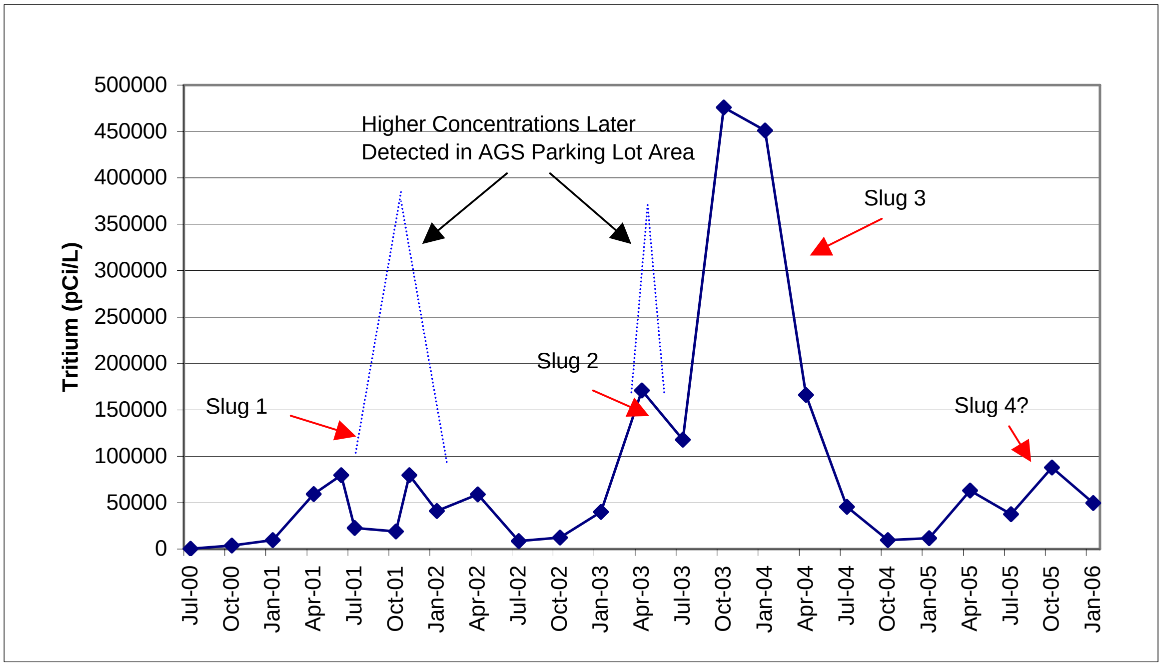
Figure 4-5.
Maximum Tritium Concentrations in Permanent and Temporary Wells Downgradient of the g-2/VQ-12 Source Area (West Side of Building 912A).



Note 1: Slug 1 was released prior to capping the VQ-12 source area.

Note 2: Arrows indicate ~ 1 year of travel time from VQ-12 source area to first set of monitoring wells near Bldg. 912A (e.g., well 054-07).

Figure 4-6.
g-2 Tritium Plume Concentrations Downgradient of Building 912.



Note: Blue lines represent two small, narrow zones of high tritium concentrations (representing Slugs 1 and 2) that were missed at this monitoring location during mid to late 2001 and early 2003 monitoring. Tritium concentrations up to 415,000 pCi/L were later detected in Geoprobe wells installed in the AGS parking lot in July 2003 (Slug 1), and up to 518,000 pCi/L in May 2004 (Slug 2).

4.1.6 AGS J-10 Beam Stop

In 1998, BNL established a new beam stop at the J-10 (12 o'clock) section of the AGS Ring, replacing E-20 as the preferred repository for any beam that might be lost in the AGS Ring (**Figure 4-1**). Activation products are likely to be produced in the soil surrounding the tunnel adjacent to the J-10 beam stop. The J-10 beam stop is subject to the same injection, transition, ejection and studies losses that occurred at the former E-20 Catcher, discussed earlier. The ability of rainwater to infiltrate potentially activated soil surrounding the J-10 stop is likely to be significantly reduced because the AGS tunnel has been covered by layers of soil-crete (a sand and concrete mixture). BNL also constructed a gunite cap over remaining exposed soil areas overlying the J-10 region before beam stop operations began.

4.1.6.1 AGS J-10 Beam Stop Groundwater Monitoring

Well Network

The monitoring well network for the J-10 beam stop consists of one upgradient (054-62) and two downgradient wells (054-63 and 054-64) (**Figure 4-1**).

Sampling Frequency and Analysis

During 2005, the three J-10 beam stop wells were monitored semiannually and the samples were analyzed for tritium (**Table 1-6**).

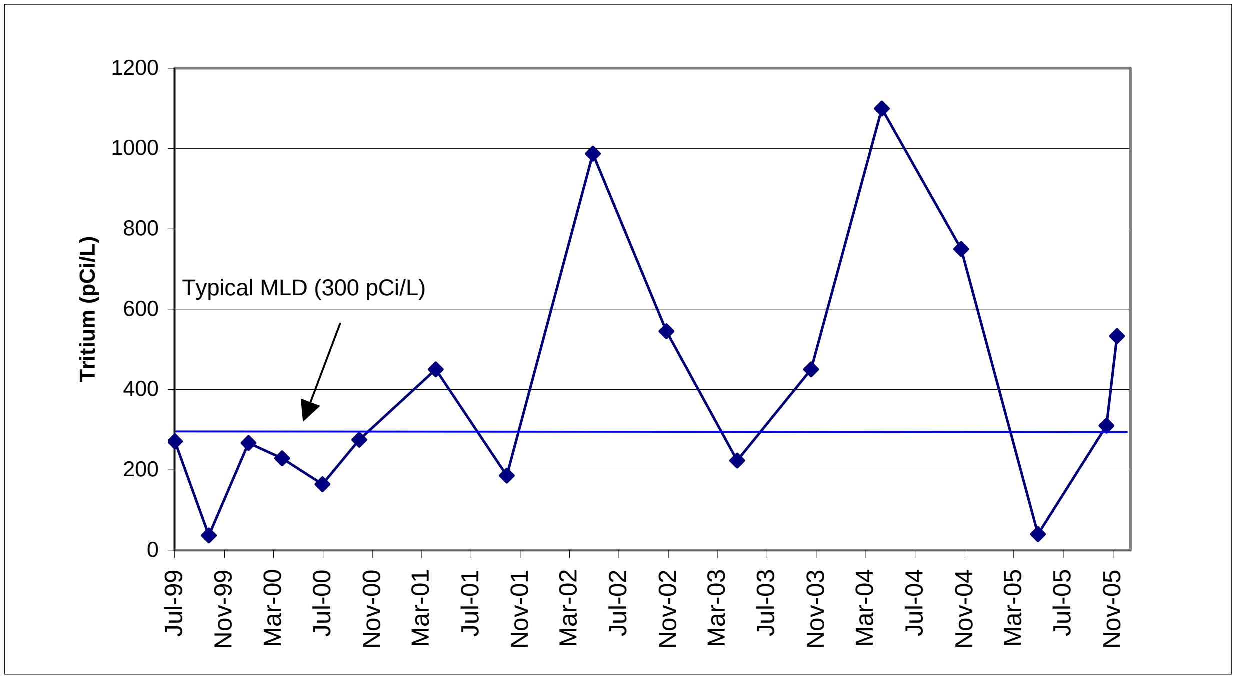
4.1.6.2 AGS J-10 Beam Stop Monitoring Well Results

Since 2001, low levels of tritium have been routinely detected in groundwater downgradient of the J-10 beam stop (**Figure 4-7**). During 2005, the maximum tritium concentration was 533 pCi/L.

4.1.6.3 AGS J-10 Beam Stop Monitoring Program Evaluation

Available groundwater monitoring data suggest that the engineered controls in place at J-10 are preventing significant rainwater infiltration into the activated soil shielding. However, the detection of tritium during 2002 and 2004 at concentrations of approximately 1,000 pCi/L suggests that some rainwater may be infiltrating the activated soil. Starting in 2006, the monitoring frequency for the J-10 Beam Stop area wells will be reduced from semiannual to annual.

Figure 4-7.
Maximum Tritium Concentrations in Wells 054-63 and 054-64, Downgradient of the J-10 Beam Stop.



4.1.7 Former AGS U-Line Beam Target and Stop Areas

The U-Line beam target area was in operation from 1974 through 1986. During its operation, a proton beam from the AGS would first strike a target and the resulting secondary particles would be selected by an arrangement of two magnetic "horns" and collimators immediately downstream of the target. Secondary particles desired for research would be focused by the horns, and other particles would either strike the collimators or be de-focused and enter the surrounding shielding. The entire assembly was in a ground-level tunnel covered with an earthen berm. Internal shielding was stacked around the horns. Although the U-Line beam target has not been in operation since 1986, the associated tunnel, shielding, and overlying soil remain in place. The former U-Line beam target, horns, and beam stop are areas where the interaction of secondary particles with soil surrounding the tunnel resulted in production of tritium and sodium-22.

In late 1999, BNL installed new monitoring wells downgradient of the target area to evaluate whether residual activated soil shielding was impacting groundwater quality. Subsequent monitoring found low levels of tritium and sodium-22, but at concentrations well below the applicable DWS. In early 2000, BNL installed four temporary wells downgradient of the former U-Line beam stop, which is approximately 200 feet north of the target area. Tritium was detected at concentrations up to 71,600 pCi/L. Sodium-22 was not detected in any of the samples. In May 2000, a temporary impermeable cap was installed over the U-Line beam stop soil activation area to prevent additional rainwater infiltration and the continued leaching of radionuclides out of the soil and into groundwater. By October 2000, a permanent cap was constructed over the U-Line beam stop area, and two additional permanent wells were installed to provide improved long-term monitoring of this source area.

4.1.7.1 Former AGS U-Line Beam Groundwater Monitoring

Well Network

The former U-Line area is monitored by one upgradient and six downgradient wells. Three of the downgradient wells monitor the target area, and three wells monitor the beam stop area (**Figure 4-1**). Several Building 912 area wells (054-69, 055-14, 055-31, and 055-32) are also used to monitor low levels of tritium originating from the former U-Line area.

Sampling Frequency and Analysis

During 2005, the former U-Line area wells were monitored semiannually and the samples were analyzed for tritium (**Table 1-6**).

4.1.7.2 Former AGS U-Line Beam Groundwater Monitoring Well Results

U-Line Target Area

Low levels of tritium have been routinely detected in wells downgradient of the former U-Line beam target since monitoring began in 2000 (**Figure 4-8**). The highest tritium concentration during 2005 was 770 pCi/L, in well 054-130 approximately 200 feet downgradient of the target area.

U-Line Beam Stop Area

Since the cap was installed over the former U-line stop in 2000, tritium concentrations in downgradient wells have been well below the 20,000 pCi/L DWS (**Figure 4-9**). During 2005, the maximum observed tritium concentration in wells downgradient of the U-Line target area was 2,900 pCi/L, in well 054-168.

4.1.7.3 Former U-Line Beam Groundwater Monitoring Program Evaluation

Although low levels of tritium continue to be detected downgradient of the former U-Line target, these concentrations are well below the 20,000 pCi/L DWS. Furthermore, the significant decrease in tritium concentrations since 2000 indicates that the impermeable cap has been effective in stopping rainwater infiltration into the residual activated soil. Starting in 2006, the monitoring frequency for the U-line area wells will be reduced from semiannual to annual.

Figure 4-8:
Maximum Tritium Concentrations in Well 054-129, Downgradient of the Former U-Line Beam Target.

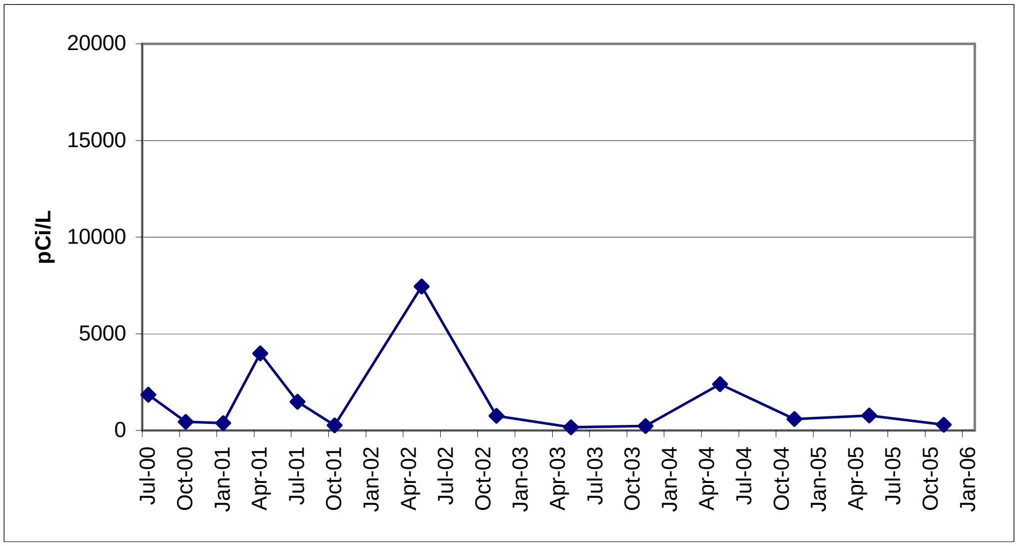
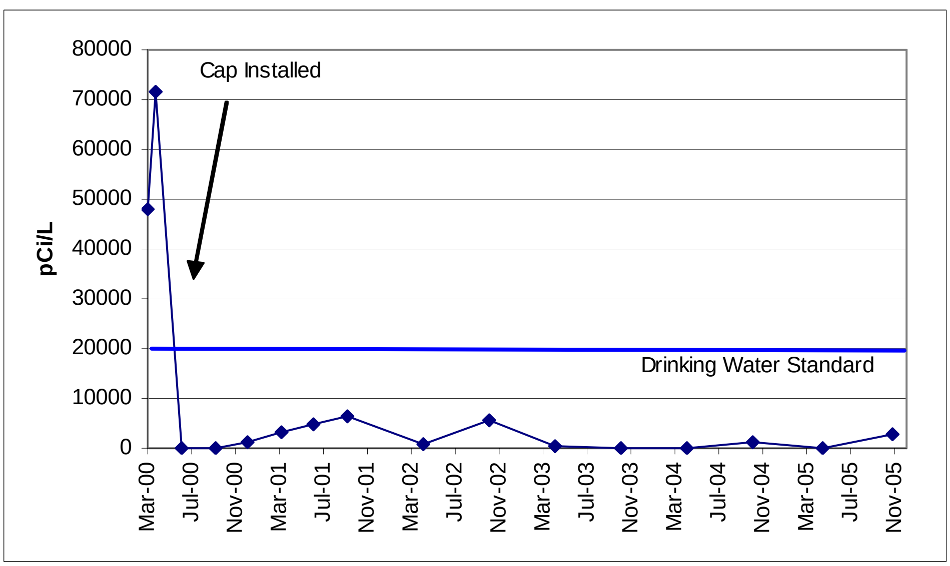


Figure 4-9.
Maximum Tritium Concentrations in Temporary & Permanent Wells Downgradient of U-Line Beam Stop.



4.2 Brookhaven Linac Isotope Producer Area

When the Brookhaven Linac Isotope Producer (BLIP) is operating, the Linac delivers a beam of protons that impinge on a series of targets in the BLIP target vessel, positioned at the bottom of a 30-ft underground tank. The targets rest inside a water-filled 18-in. diameter shaft that runs the length of the tank, and are cooled by a 300-gal closed loop primary cooling system. During irradiation, several radionuclides are produced in the cooling water, and soil immediately outside the tank is activated by the production of secondary particles at the target.

As part of a 1985 redesign of the vessel, leak detection devices were installed and the open space between the water-filled shaft and the vessel's outer wall became a secondary containment system for the primary vessel. The BLIP target vessel system conforms to Suffolk County Article 12 requirements, and is registered with SCDHS. The BLIP facility also has a 500-gal underground storage tank (UST) for liquid radioactive waste (change-out water from the BLIP primary system). The waste tank and its associated piping system conform to Article 12 requirements and are registered with SCDHS.

In 1998, BNL conducted an extensive evaluation of groundwater quality near the BLIP facility. Tritium concentrations of 52,000 pCi/L and sodium-22 up to 151 pCi/L were detected in a temporary well installed approximately 50 feet downgradient of the BLIP target vessel. Due to the activation of the soil shielding surrounding the BLIP target vessel and the detection of tritium and sodium-22 in groundwater, the BLIP facility was designated as Area of Concern (AOC) 16K under the Environmental Restoration Program.

Starting in 1998, BNL improved the stormwater management program at BLIP in an effort to prevent rainwater infiltration of the activated soil below the building. The BLIP building's roof drains were redirected away from the building, existing paved areas on the south side of the building were resealed, and a gunite cap was installed on the remaining three sides of the building. In May and June 2000, BNL undertook additional protective measures by injecting a colloidal silica grout (known as a Viscous Liquid Barrier) into the activated soil. The grout reduces the permeability of the soil, thus further reducing the potential of rainwater leaching radionuclides if the stormwater controls fail.

As an added measure of protection, the Medical Department and Collider–Accelerator Department constructed a new protective cap over the Linac to BLIP spur in late 2004, and a cap over the Linac to Booster transition will be constructed following the planned installation of the IBIS beam line at Linac. Direct soil measurements and beam loss calculations suggest that the tritium and sodium-22 concentrations in soils surrounding these beam lines could result in stormwater leachate concentrations that exceed the "5 percent" criteria described in the *Accelerator Safety* SBMS (Site-Based Management System) subject area.[2] When completed, this integrated cap system will join the BLIP and Booster caps.

4.2.1 BLIP Groundwater Monitoring

Well Network

The monitoring well network for the BLIP facility consists of two upgradient and five downgradient wells. These wells provide a means of verifying that the engineered and administrative controls described above are effective in protecting groundwater quality (**Figure 4-1**).

Sampling Frequency and Analysis

During 2005, most of the BLIP area wells were monitored quarterly. Because the tritium concentration in well 064-67 (immediately downgradient of BLIP) increased to 46,500 pCi/L in July 2005, well 064-67 was monitored one additional time for confirmatory sampling. All samples were analyzed for tritium, and select samples from several wells were analyzed for sodium-22 (**Table 1-6**).

4.2.2 BLIP Monitoring Well Results

Monitoring data collected from January 1999 to July 2000 indicated that the corrective actions taken during 1998 were highly effective in preventing the release of tritium and sodium-22 from the activated soil surrounding the BLIP target vessel. Prior to May 2000, tritium and sodium-22 concentrations in

[2] The BNL *Accelerator Safety* SBMS subject area requires stormwater controls where rainwater infiltration into activated soil shielding could result in leachate concentrations that exceed 5 percent of the drinking water standard (i.e., >1,000 pCi/L for tritium and 20 pCi/L for sodium-22).

wells located directly downgradient of BLIP were <3,000 pCi/L and <5 pCi/L, respectively. However, significant increases in tritium and sodium-22 concentrations were observed in groundwater samples collected after the silica grout injection process that took place in late May and early June 2000 (**Figure 4-10**). This suggests that tritium and sodium-22 in the soil pore water near the target vessel were displaced by the grout. Samples collected in July 2000 indicated tritium and sodium-22 concentrations of 5,700 pCi/L and 57 pCi/L, respectively. By October 2000, tritium concentrations increased to a maximum of 56,500 pCi/L in samples from monitoring well 064-67, located approximately 40 feet downgradient of the BLIP vessel. By December 2000, tritium concentrations in wells immediately downgradient of BLIP dropped to below the 20,000 pCi/L drinking water standard, and remained below this level throughout all of 2001 and 2002. From 2003 through 2005, there were several periods when tritium concentrations once again exceeded the 20,000 pCi/L standard in wells immediately downgradient of BLIP. Tritium reached a maximum concentration of 42,900 pCi/L in October 2003, 24,500 pCi/L in January 2004, and 46,500 pCi/L in July 2005 (**Figure 4-10**).

Figure 4-10.
Maximum Tritium Concentrations in Wells ~ 40 feet Downgradient of BLIP Target Vessel.

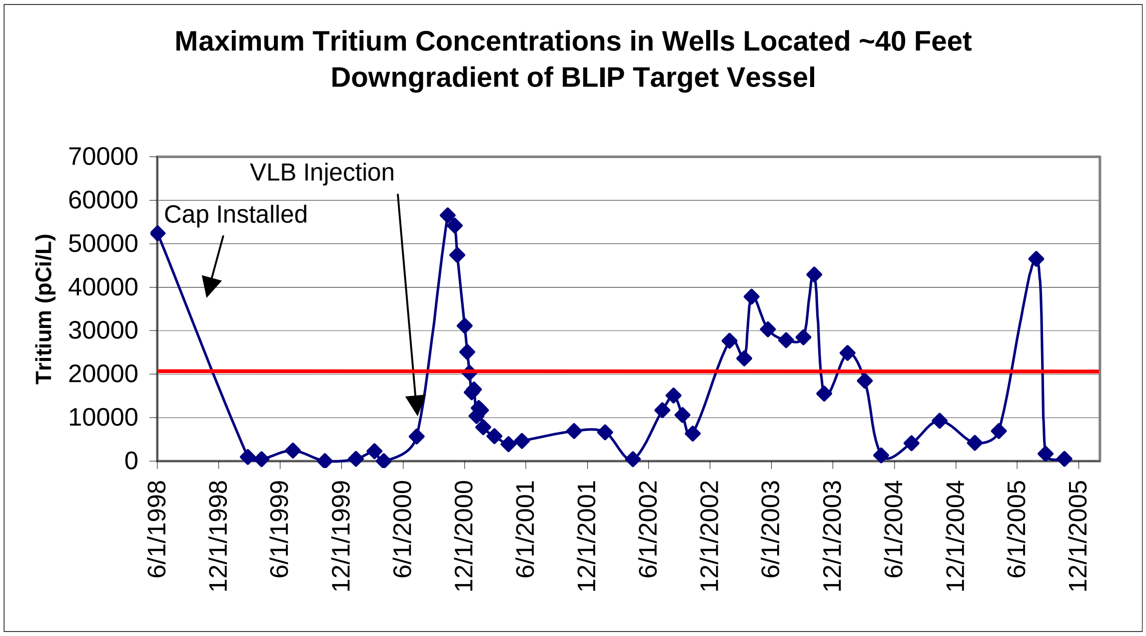
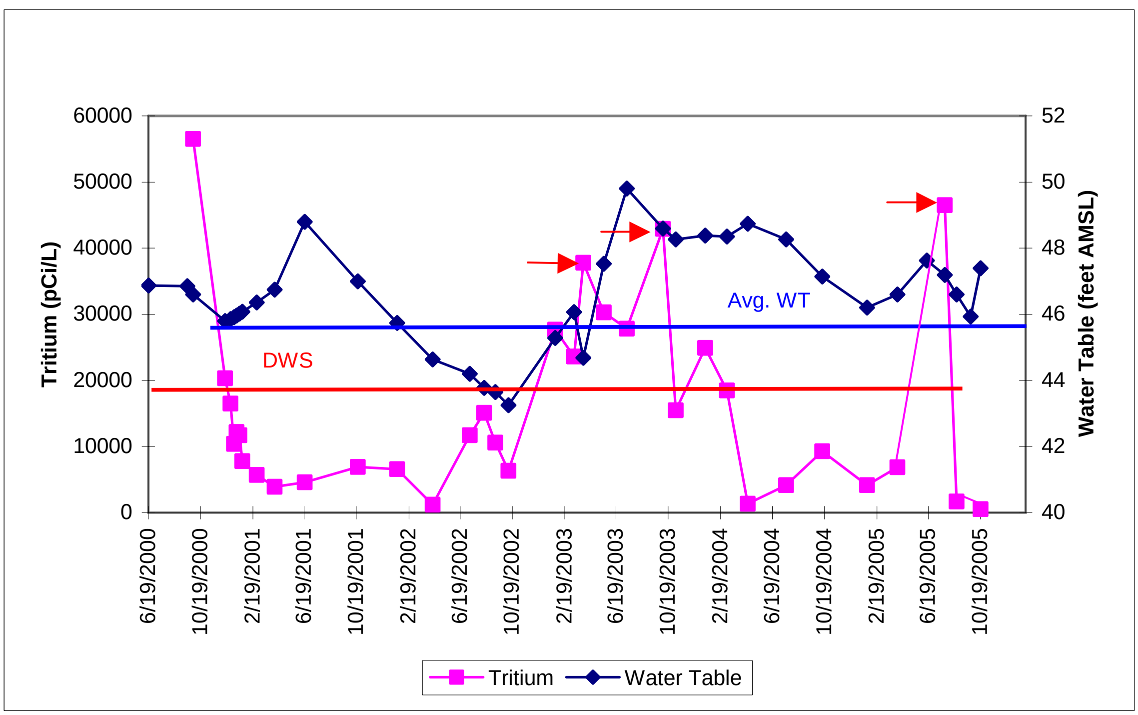


Figure 4-11.
Tritium Concentrations vs. Water Table Position, 40 Feet Downgradient of the BLIP Target Vessel.



Note 1: Arrows indicate approximate groundwater travel time from directly below the BLIP target to the first set of monitoring wells (e.g., well 064-67). Travel time is approximately 89 days, based on a distance of 40 feet and groundwater velocity of 0.45 ft/day.

4.2.3 BLIP Groundwater Monitoring Program Evaluation

The gunite cap, paved areas, and roof drains at BLIP are in good condition and are effectively controlling stormwater infiltration. Although direct inspection of the silica grout is not possible, it is expected to be in good condition and would be effective in preventing significant leaching of tritium from the activation zone should the primary stormwater controls fail. A comparison of tritium concentrations to changes in water table position suggests that the 2003 increase in tritium concentrations is probably associated with the 6.5-foot increase in water table elevation that occurred between November 2002 and July 2003 (**Figure 4-11**). As the water table rose, older tritium that had leached from the soil before capping in 1987 or that was released during the grout injection project may have been flushed from the soil close to the water table. The amount of tritium remaining in the vadose zone close to the water table is expected to decline over time, due to this flushing mechanism and by natural radioactive decay. During 2005, the elevation of the water table in the BLIP area once again increased, and tritium concentrations in groundwater subsequently increased to 46,500 pCi/L. Until the tritium levels in groundwater routinely remain below the 20,000 pCi/L DWS, BNL will continue to monitor the BLIP wells on a quarterly basis.

4.3 Relativistic Heavy Ion Collider (RHIC)

Beam line interaction with the Relativistic Heavy Ion Collider (RHIC) collimators and beam stops produces secondary particles that interact with soil surrounding the 8 o'clock and 10 o'clock portions of the RHIC tunnel, and the W-Line stop (**Figure 4-12**). These interactions result in the production of tritium and sodium-22, which could be leached out of the soil by rainwater. Before RHIC operations began, BNL installed impermeable caps over these beam loss areas to reduce the potential impact to groundwater quality.

4.3.1 RHIC Groundwater Monitoring

Well Network

Thirteen shallow wells are used to verify that the engineered (i.e., impermeable caps) and operational controls implemented at the RHIC beam stops and collimators are effective in protecting groundwater quality. Six of the monitoring wells are located in the 10 o'clock beam stop area, six wells in the collimator area, and one well downgradient of the W-Line beam stop (**Figure 4-12**). As an extension to the groundwater monitoring program, surface water samples are also collected from the Peconic River both upstream (location HY) and downstream (location HV) of the beam stop area to verify that potentially contaminated groundwater is not being discharged into the Peconic River stream bed during high water table conditions.

Sampling Frequency and Analysis

During 2005, groundwater samples were collected from most of the 13 RHIC monitoring wells on a semiannual schedule, and the samples were analyzed for tritium (**Table 1-6**). One additional round of samples was collected from wells 025-03 and 025-04, located near the 10 o'clock beam stop areas following an abnormally high level of rainfall in October 2005. This sampling was to evaluate whether the resulting high water levels in the area released tritium from the activated soils. Routine analysis for sodium-22 was dropped from the groundwater surveillance program in 2002 because tritium is the best indicator of possible cap failure (i.e., tritium is more leachable than sodium-22, and it migrates at the same rate as groundwater). Surface water samples were collected quarterly and analyzed for tritium and gamma-emitting radionuclides (such as sodium-22).

4.3.2 RHIC Monitoring Well Results

As in past years, no tritium was detected in any of the groundwater samples, including the samples collected from the beam stop area wells following the heavy rains of October 2005. No tritium or sodium-22 was detected in surface water sample from downstream location HV.

4.3.3 RHIC Groundwater Monitoring Program Evaluation

Groundwater and surface water monitoring data continue to demonstrate that the impermeable caps installed over the RHIC beam stop and collimator areas are effective in preventing rainwater infiltration into the potentially activated soil shielding. For 2006, groundwater samples will continue to be collected on a semiannual basis. Additional samples will be collected from the wells downgradient of the southern 10 o'clock area beam stop to verify that tritium was not released by the rise in the water table following the October 2005 rain event.

4.4 Brookhaven Medical Research Reactor (BMRR)

The Brookhaven Medical Research Reactor (BMRR) was a 3-megawatt light water reactor that was used for biomedical research. Research operations at the BMRR stopped in December 2000. All spent fuel was removed in 2003 and plans are underway to drain the primary cooling water system. BNL is preparing plans to permanently decommission the facility.

The BMRR's primary cooling water system consists of a recirculation piping system that contains 2,550 gallons of water. The cooling water contains approximately five curies of tritium. Unlike the High Flux Beam Reactor, the BMRR does not have a spent fuel storage canal or pressurized imbedded piping systems that contain radioactive liquids. Historically, fuel elements that required storage were either stored within the reactor vessel, or were transferred to the HFBR spent fuel canal. The BMRR's primary cooling water system piping is fully exposed in the containment structure, and is accessible for routine visual inspections. When the BMRR was operational, excess heat was transferred by means of heat exchangers with once-through (secondary) cooling water, which was obtained from nearby process supply wells or the BNL Chilled Water System. This secondary water was discharged to recharge basin HP located 800 feet south of the Medical Department complex, and was monitored as part of the SPDES program. All cooling water discharges from the BMRR stopped in December 2000.

In 1997, tritium was detected in wells installed directly downgradient (within 30 feet) of the BMRR. The maximum tritium concentration observed during 1997 was 11,800 pCi/L, almost one-half of the DWS of 20,000 pCi/L. The highest observed tritium concentration since the start of groundwater monitoring was 17,100 pCi/L in October 1999. The tritium currently detected in groundwater is believed to have originated from the historical discharge of small amounts of BMRR primary cooling water to a basement floor drain and sump system that may have leaked. Although the last discharge of primary cooling water to the floor drain system occurred in 1987, the floor drains continued to be used for secondary (nonradioactive) cooling water until 1997. The infiltration of this water may have promoted the movement of residual tritium from the soil surrounding the floor drain piping system to the groundwater. The floor drains were permanently sealed in 1998 to prevent any accidental future releases to the underlying soil.

4.4.1 BMRR Groundwater Monitoring

Well Network

The monitoring well network for the BMRR facility consists of one upgradient and three downgradient wells (**Figure 4-13**). Samples collected from the four groundwater monitoring wells are used to determine whether residual tritium in the soils below the BMRR is impacting groundwater quality.

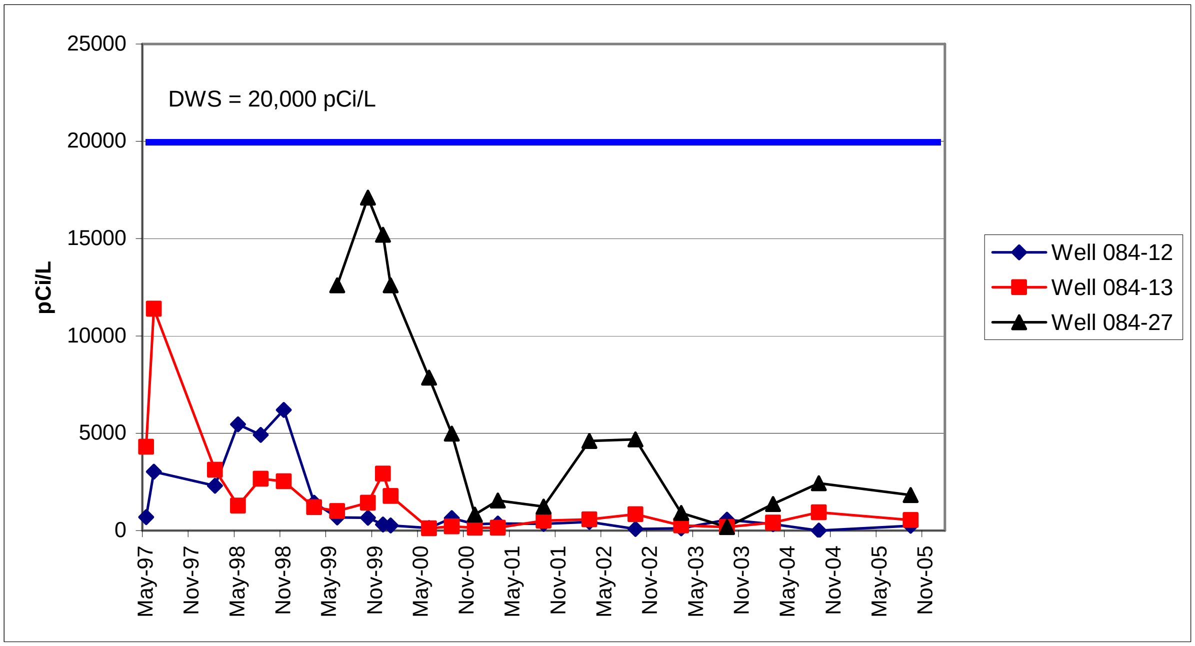
Sampling Frequency and Analysis

During 2005, the BMRR wells were monitored semiannually and the samples were analyzed for tritium (**Table 1-6**).

4.4.2 BMRR Monitoring Well Results

Monitoring results for sampling conducted during 2005 indicate that tritium concentrations continued to be well below the 20,000 pCi/L DWS. Detectable levels of tritium were observed in two of the three downgradient wells, with the maximum value of 1,830 pCi/L detected in well 084-27 (**Figure 4-14**). Note that groundwater monitoring conducted from 1997 though 2001 did not detect any other reactor-related radionuclides. Therefore monitoring for 2002–2005 focused on tracking tritium concentrations in the groundwater.

Figure 4-14.
Tritium Concentrations Downgradient of the BMRR from 1997–2005.



4.4.3 BMRR Groundwater Monitoring Program Evaluation

Tritium concentrations in groundwater have never exceeded the 20,000 pCi/L drinking water standard, and have remained <5,000 pCi/L since 2001. The BMRR structure is effectively reducing rainwater infiltration into the underlying soils, and therefore reducing the movement of residual tritium from the soil to the groundwater. The monitoring frequency will be reduced to annual starting in 2006, and reduced further to once every two years starting in 2007.

4.5 Sewage Treatment Plant

The STP processes sanitary wastewater from BNL's research and support facilities. Treated effluent from the STP is discharged to the Peconic River under a NYSDEC SPDES permit (NY-0005835). On average, 1.25 million gallons per day (MGD) are processed during the summer and 0.72 MGD are processed daily during the rest of the year. Before discharge into the Peconic River, the sanitary waste stream is fully treated by 1) primary clarification to remove settleable solids and floatable materials, 2) aerobic oxidation for secondary removal of the biological matter and nitrification of ammonia, 3) secondary clarification, 4) sand filtration for final effluent polishing, and 5) ultraviolet disinfection for bacterial control. Oxygen levels are regulated during the treatment process to remove nitrogen biologically, using nitrate-bound oxygen for respiration.

Wastewater from the STP clarifier is released to the sand filter beds, where water percolates through 3 feet of sand before being recovered by an underlying clay tile drain system, which transports the water to the discharge point at the Peconic River (SPDES Outfall 001). Approximately 15 percent of the water released to the filter beds is either lost to evaporation or to direct groundwater recharge. At the present time, six sand filter beds are used in rotation.

Two emergency hold-up ponds are located east of the sand filter bed area. The hold-up ponds are used to store sanitary waste in the event of an upset condition or if the influent contains contaminants in concentrations exceeding BNL administrative limits and/or SPDES permit effluent release criteria. The hold-up ponds have a combined holding capacity of nearly 8 million gallons of water, and provide the Laboratory with the ability to divert all sanitary system effluent for approximately one week. The hold-up ponds are equipped with fabric-reinforced plastic liners that are heat-welded along all seams. As part of the Phase III Sewage Treatment Plant Upgrades project in 2001, the liners were enhanced by the addition of new primary liners and a leak detection system. The older liners now serve as secondary containment.

4.5.1 STP Groundwater

Well Network

The STP's groundwater monitoring program is designed to provide a secondary means of verifying that STP operations are not impacting environmental quality. Six wells are used to monitor groundwater quality in the filter bed area and three wells are monitored in the holding pond area (**Figure 4-15**).

Sampling Frequency and Analysis

During 2004, the six STP filter bed area wells were monitored semiannually and the three holding pond area wells were sampled annually. The samples were analyzed for VOCs, anions, metals, tritium, gross alpha, gross beta, and gamma emitting radionuclides (**Table 1-6**).

4.5.2 STP Monitoring Well Results

Radiological Analyses

Radioactivity levels in samples collected from most of the STP wells during 2005 were generally typical of ambient (background) levels. Higher than normal gross alpha and gross beta levels were detected in the sampled from filter bed area monitoring well 038-02, at maximum concentrations of 57 pCi/L and 78 pCi/L, respectively. Well 038-02 is screened in fine-grained material above a localized low permeability (silt and clay) deposit, and these elevated gross alpha and gross beta values are likely due to naturally occurring radionuclides common to these deposits. No Laboratory-related gamma emitting radionuclides or tritium was detected in any of the STP groundwater monitoring wells.

Nonradiological Analyses

During 2005, all water quality and most metals concentrations were below the applicable NYS AWQS or drinking water standards. Sodium concentrations were above the 20 mg/L water quality standard in both samples from filter bed area well 039-86, at a maximum concentration of 32 mg/L.

Low levels of nitrates were detected in most STP area wells, with a maximum concentration of 6.9 mg/L detected in filter bed area monitoring well 039-02. The NYS AWQS for nitrate is 10 mg/L. No VOCs were detected above the NYS AWQS in any of the STP monitoring wells.

In 2004, perchlorate was detected in four of 34 OU V monitoring wells located downgradient of the STP near the eastern firebreak road and site boundary, with concentrations ranging between 5 µg/L and 12.7 µg/L. The NYSDOH Action Level for perchlorate in drinking water supply wells is 18 µg/L. Perchlorate was not detected in any of the STP or nearby Live Fire Range monitoring wells. During 2005, perchlorate was detected in only two OU V wells (049-06 and 061-05), both of which monitor the deep portion of the Upper Glacial aquifer. Well 049-06 is near the eastern firebreak road and well 061-05 is at the eastern site boundary. The maximum perchlorate concentration was detected in well 061-05, at 10.8 µg/L (for details see **Section 3.4**).

4.5.3 STP Groundwater Monitoring Program Evaluation

Monitoring results for 2005 indicate that STP operations are not having a significant impact on groundwater quality, and that the BNL administrative and engineered controls designed to prevent the discharge of chemicals and radionuclides to the sanitary system continue to be highly effective. No changes to the monitoring frequency are proposed for 2006.

4.6 Motor Pool Maintenance Area

The Motor Pool (Building 423) and Site Maintenance facility (Building 326) are attached structures located along West Princeton Avenue (**Figure 4-16**). The Motor Pool area consists of a five-bay automotive repair shop, which includes office and storage spaces. The Site Maintenance facility provides office space, supply storage, locker room, and lunchroom facilities for custodial, grounds, and heavy equipment personnel. Both facilities have been used continuously since 1947.

Potential environmental concerns at the Motor Pool include 1) the historical use of USTs to store gasoline, diesel fuel, and waste oil, 2) hydraulic fluids used for lift stations, and 3) the use of solvents for parts cleaning. In August 1989, the gasoline and waste oil USTs, pump islands, and associated piping were upgraded to conform to Suffolk County Article 12 requirements for secondary containment, leak detection devices, and overfill alarms. Following the removal of the old USTs, there were no obvious signs of soil contamination. The present tank inventory includes two 8,000-gallon USTs used to store unleaded gasoline, one 260-gallon aboveground storage tank used for waste oil, and one 3,000-gal UST for No. 2 fuel oil. The Motor Pool facility has five vehicle lift stations. The hydraulic fluid reservoirs for the lifts are located above ground.

Since 1996, several small-scale hydraulic oil and diesel oil spills have been remediated at the Motor Pool. The only known environmental concern associated with the Site Maintenance facility (Building 326) was the December 1996 discovery of a historic oil spill directly south of the building. In an effort to investigate the potential impact that this spill had on groundwater quality, four wells were installed downgradient of the spill site. Although the solvent TCA was detected in the groundwater at concentrations above NYS AWQS, petroleum hydrocarbons were not detected.

4.6.1 Motor Pool Maintenance Area Groundwater Monitoring

Well Network

The Motor Pool facility’s groundwater monitoring program for the UST area is designed to confirm that the engineered and institutional controls are effective in preventing contamination of the aquifer. Two shallow Upper Glacial aquifer wells (102-05 and 102-06) are used to monitor for potential contaminant releases from the UST area (**Figure 4-16**).

Groundwater quality downgradient of Building 423 and Building 326 is monitored using four wells (102-10, 102-11, 102-12, and 102-13). The program is designed to periodically assess existing solvent contamination that resulted from historical vehicle maintenance operations, and to confirm that the current engineered and institutional controls are effective in preventing additional contamination of the aquifer.

Sampling Frequency and Analysis

During 2005, the UST area wells were monitored semiannually, and the samples were analyzed for VOCs. The wells were also checked for the presence of floating petroleum hydrocarbons on a semiannual basis (**Table 1-6**). The Building 423/326 area wells were monitored annually, and the samples were analyzed for VOCs.

4.6.2 Motor Pool Monitoring Well Results

Underground Storage Tank Area

During 2005, MTBE was the only chemical related to gasoline products detected in groundwater downgradient of the gasoline UST area (**Figure 4-17**). Although MTBE concentrations had reached a maximum of nearly 34 µg/L (the NYS AWQS is 10 µg/L) during 2003, MTBE concentrations decreased to <2 µg/L by October 2004. As in past years, low levels of the solvent TCA were also detected, but at concentrations that continued to be below the NYS AWQS of 5 µg/L. Wells 102-05 and 102-06 were also tested for the presence of floating petroleum hydrocarbons. As in previous years, no floating product was observed.

Building 423/326 Area

During 2005, TCA was detected in all four wells, at a maximum concentration of 32.7 µg/L in well 102-12 (**Figure 4-18**). Up to 11.9 µg/L DCA was detected in wells 102-11, 102-12 and 102-13. The gasoline additive MTBE was detected in all four wells, at concentrations up to 3.9 µg/L, well below the NYS AWQS of 10 µg/L. It is believed that the TCA, DCA, and MTBE originate from historical vehicle maintenance operations.

Figure 4-17.
VOC Concentration Trends Downgradient of the Gasoline UST Area.

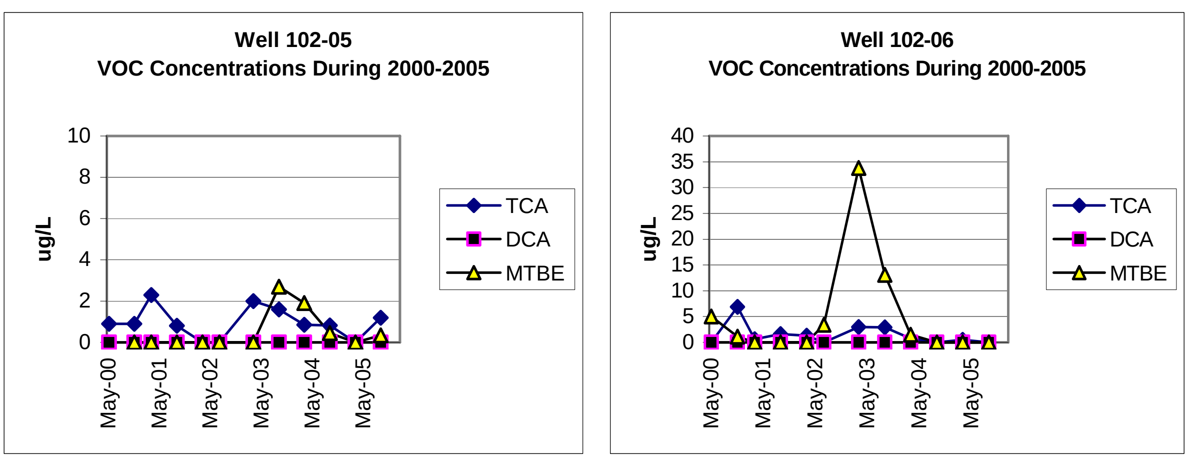
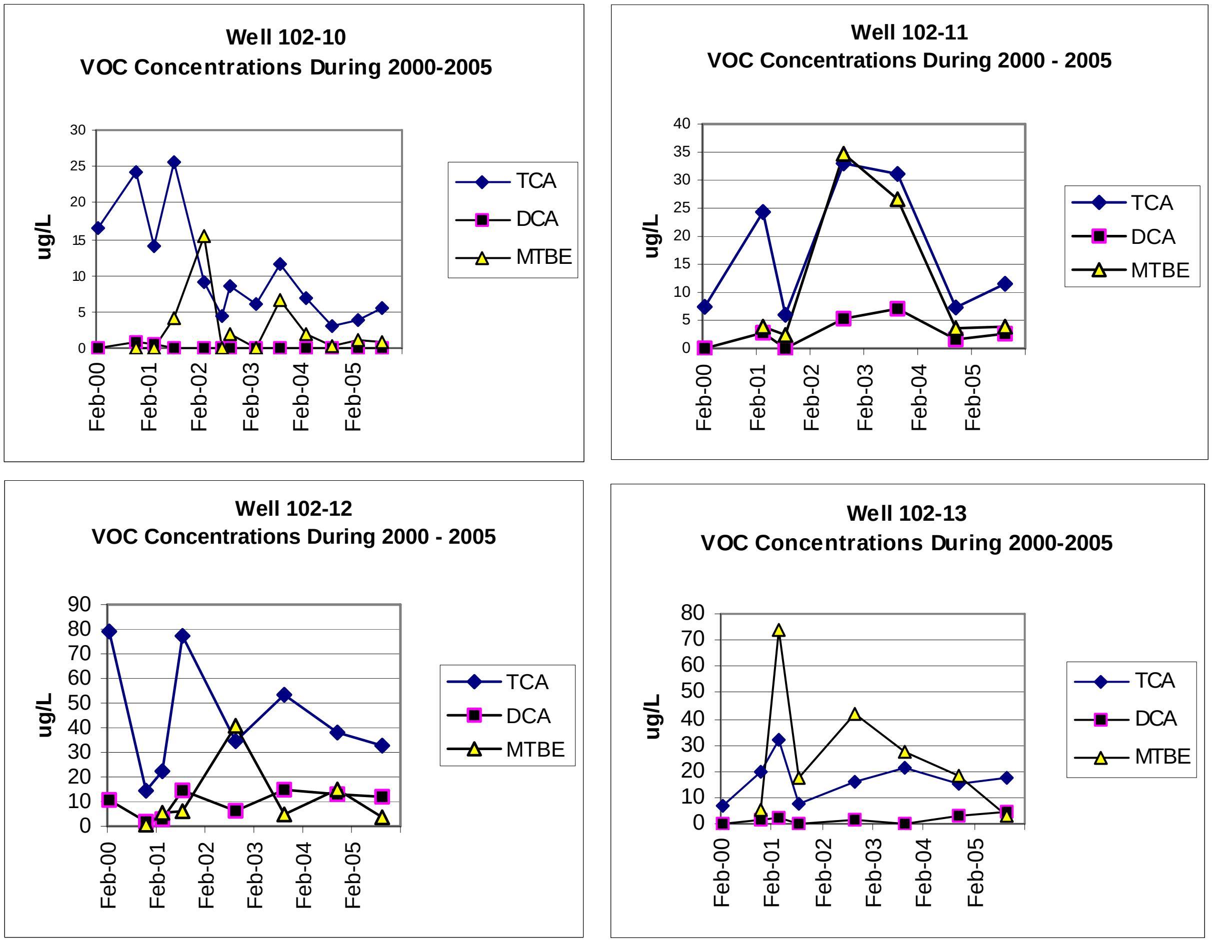


Figure 4-18.
VOC Concentration Trends in Wells Downgradient of Building 323/326.



4.6.3 Motor Pool Monitoring Program Evaluation

Analysis of groundwater samples collected at the Motor Pool facility during 2005 indicates that releases from historical operations continue to impact groundwater quality. There were no reported gasoline or motor oil losses or spills that could affect groundwater quality, and all waste oils and used solvents generated from current operations are being properly stored and recycled. The gasoline USTs have electronic leak detection systems, and there is a daily product reconciliation (i.e., an accounting of the volume of gasoline stored in USTs and volume of gasoline sold). The MTBE and TCA that is periodically detected in the groundwater near the UST area is likely to have originated from historical spills near Buildings 423/326. No changes to the monitoring frequency are proposed for 2006.

4.7 On-Site Service Station

Building 630 is a commercial automobile service station, privately operated under a contract with BNL. The station was built in 1966, and is used for automobile repair and gasoline sales.

Potential environmental concerns at the service station include the historical use of USTs for the storage of gasoline and waste oil, hydraulic fluids used for lift stations, and the use of solvents for parts cleaning. When the service station was built in 1966, the UST inventory consisted of one 6,000-gal and two 8,000-gal tanks for storing gasoline, and one 500-gal tank for used motor oil. An inventory discrepancy discovered in 1967 suggested that up to 8,000 gallons of gasoline might have leaked from one of the USTs. There are no records of remedial actions other than the replacement of the tank, and the loss of 8,000 gallons of gasoline has never been confirmed. In August 1989, the USTs, pump islands, and associated piping were upgraded to conform to Suffolk County Article 12 requirements for secondary containment, leak detection devices, and overfill alarms. During the removal of the old USTs, there were no obvious signs of soil contamination.

The current tank inventory includes three 8,000-gal USTs for storing unleaded gasoline, and one 500-gal UST used for waste oil. The facility has three hydraulic vehicle lift stations.

Groundwater quality in the service station area has been impacted by historical small-scale spills of oils, gasoline, and solvents, and by carbon tetrachloride contamination associated with a nearby UST that was used as part of an experiment conducted in the 1950s. In April 1998, BNL removed a UST from an area approximately 200 feet northwest (upgradient) of the service station. Although there are indications that the tank was releasing small quantities of carbon tetrachloride before its removal, a significant increase in carbon tetrachloride concentrations in groundwater indicated that additional amounts of this chemical were inadvertently released during the excavation and removal process. BNL started to remediate the carbon tetrachloride plume in October 1999 (see **Section 3.2.1**).

4.7.1 Service Station Groundwater Monitoring

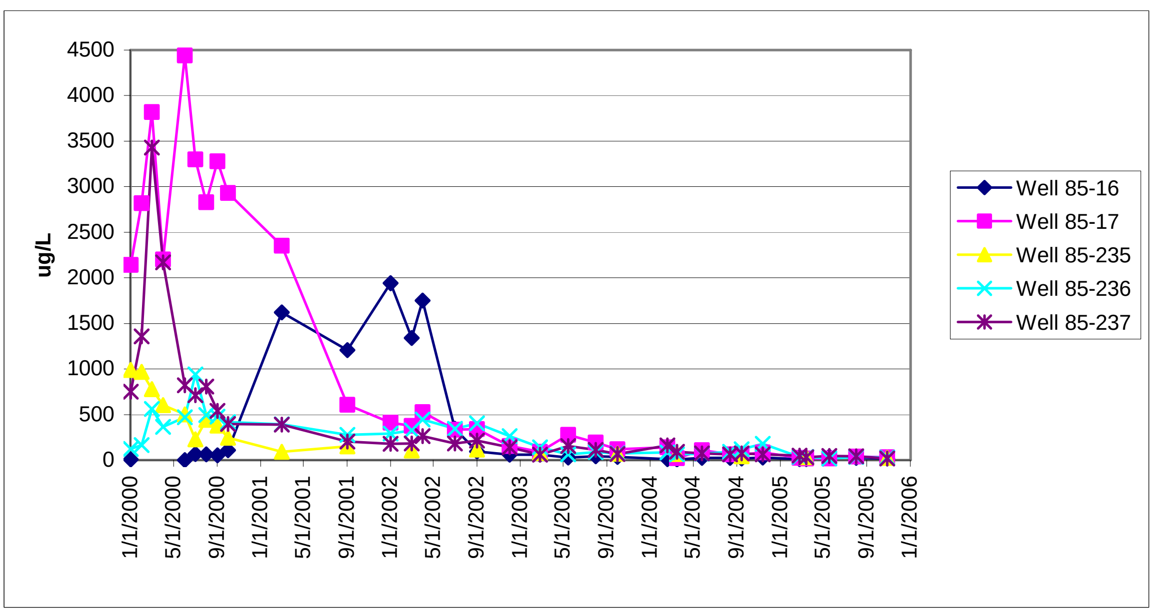
Well Network

The service station's groundwater monitoring program is designed to confirm that the engineered and institutional controls in place are effective in preventing contamination of the aquifer. Five wells are used to monitor for potential contaminant releases (**Figure 4-19**).

Sampling Frequency and Analysis

During 2005, the service station facility wells were monitored quarterly, primarily by the Environmental Restoration program as part of the Carbon Tetrachloride plume monitoring project. The samples were analyzed for VOCs (**Table 1-6**). Three of the wells near the gasoline USTs were also checked semiannually for the presence of floating petroleum hydrocarbons.

Figure 4-20.
Carbon Tetrachloride Concentration Trends in Service Station Monitoring Wells.



4.7.2 Service Station Monitoring Well Results

During 2005, carbon tetrachloride (and its breakdown product, chloroform) continued to be observed in the service station monitoring wells (**Figure 4-20**). The maximum carbon tetrachloride concentration was 48 μg/L, observed in the February 2005 sample from well 085-237. This level is considerably less than those observed during 2000, when carbon tetrachloride concentrations in wells near the service station approached 4,500 μg/L. The reduction in carbon tetrachloride concentrations reflects the effectiveness of the groundwater restoration system (see **Section 3.2.1**), which achieved its cleanup objectives and was shut down in August 2004.

In addition to the carbon tetrachloride contamination originating from the former UST area, groundwater quality has been affected by a variety of VOCs that appear to be related to historical service station operations. During 2005, petroleum-related compounds continued to be detected in the groundwater (**Figures 4-21**, **4-22**, and **4-23**). The highest VOC concentrations were detected in well 085-236 in March 2005, with m/p xylene at 30 μg/L, o-xylene at 15 μg/L, 1,2,4-trimethylbenzene at 20 μg/L, 1,3,5-trimethylbenzene at 5.5 μg/L, and the solvent tetrachloroethylene at a concentration of 5.5 μg/L.

Low levels of the gasoline additive MTBE continued to be detected in all service station area wells, but at concentrations significantly lower than in 2003, when MTBE levels reached a maximum concentration of 144 μg/L. During 2005, the highest MTBE level was detected in wells 085-236 and 085-237, at concentrations of 0.6 μg/L each (**Figures 4-25** and **4-26**). The NYS AWQS for MTBE is 10 μg/L. As in previous years, no SVOCs or floating product were detected.

4.7.3 Service Station Groundwater Monitoring Program Evaluation

Analysis of groundwater samples collected at the service station facility during 2005 indicates that releases from historical operations continue to impact groundwater quality. There were no reported gasoline or motor oil losses or spills that could affect groundwater quality, and all waste oils and used solvents generated from current operations are being properly stored and recycled. The gasoline USTs have electronic leak detection systems, and there is a daily product reconciliation (i.e., an accounting of the volume of gasoline stored in USTs and volume of gasoline sold). It is believed that the petroleum hydrocarbon-related compounds and solvents detected in groundwater originate from historical vehicle maintenance operations before improved chemical storage and handling controls were implemented in the 1980s. No changes to the monitoring frequency are proposed for 2006.

Figure 4-21.
Downgradient Well 085-17: Trend of Service Station-Related VOCs. Note that carbon tetrachloride originating from the upgradient carbon tetrachloride UST source area is not included.

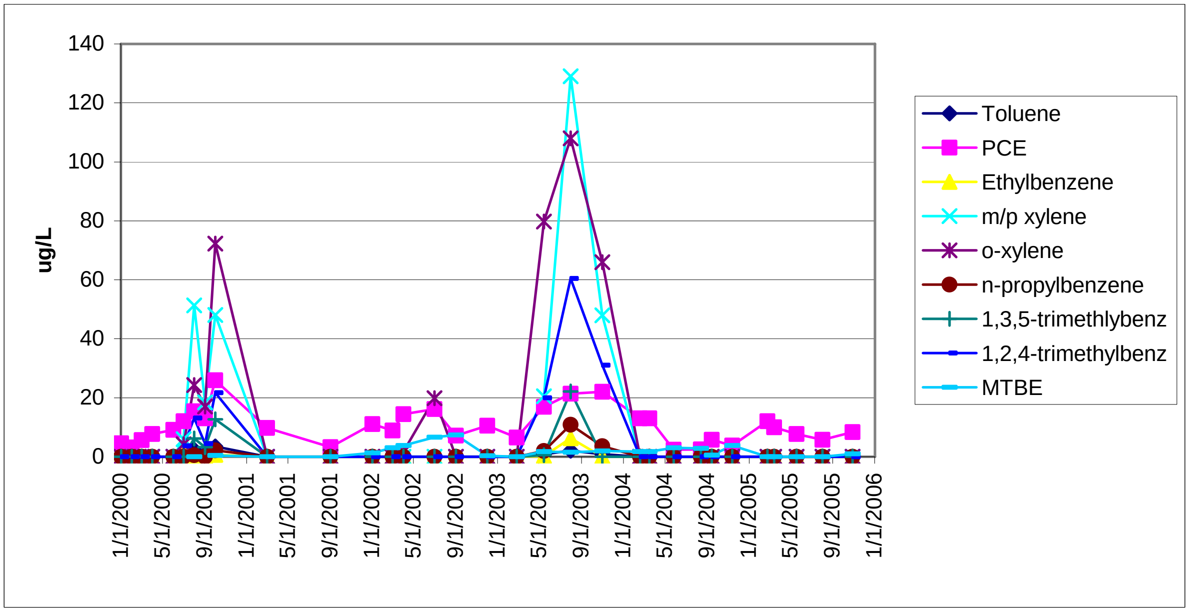


Figure 4-22.
Downgradient Well 085-236: Trend of Service Station-Related VOCs. Note that carbon tetrachloride from the upgradient carbon tetrachloride UST source area is not included.

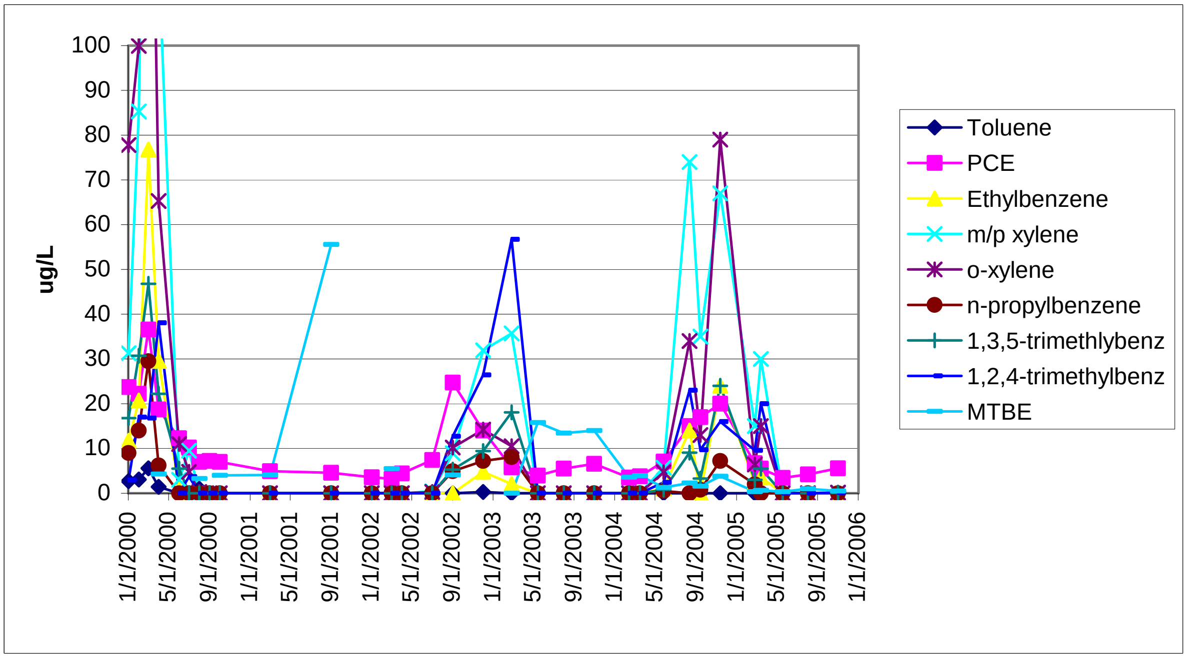
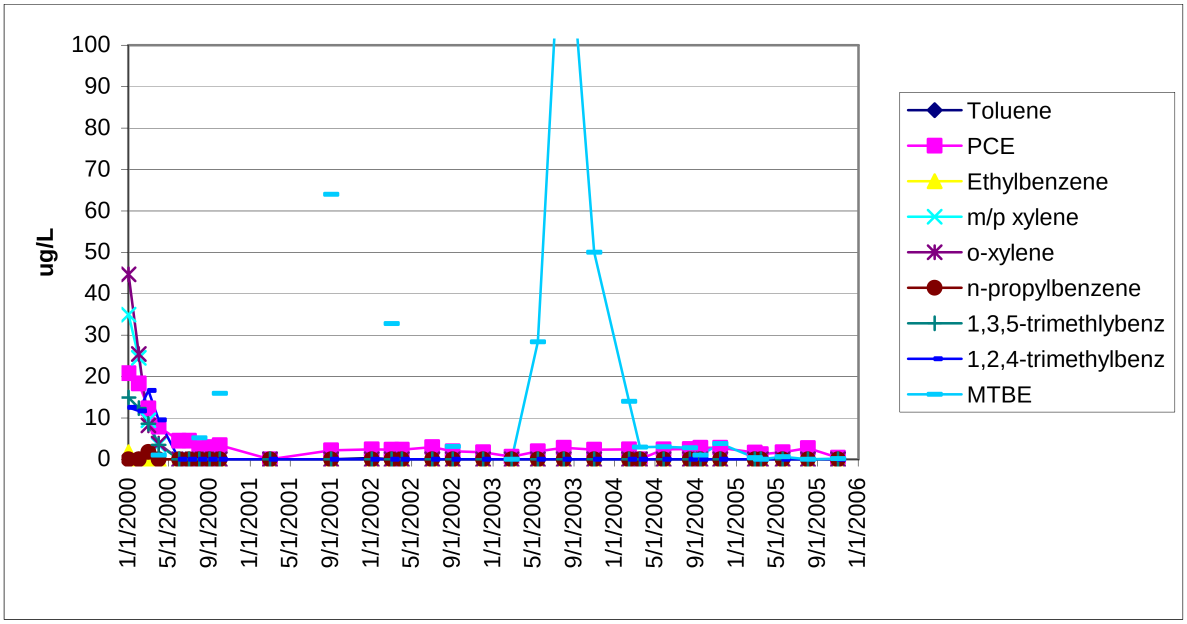


Figure 4-23. **Downgradient Well 085-237: Trend of Service Station-Related VOCs.** Note that carbon tetrachloride originating from the upgradient carbon tetrachloride UST source area is not included.



4.8 Major Petroleum Facility Area

The Major Petroleum Facility (MPF) is the holding area for fuel oil used at the Central Steam Facility (CSF). The fuel oil is held in a network of seven aboveground storage tanks, which have a combined capacity of up to 2.3 million gallons of No. 6 fuel oil and 60,000 gallons of No. 2 fuel oil. The tanks are connected to the CSF by aboveground pipelines that have secondary containment and leak detection devices. All of the fuel storage tanks are positioned in bermed containment areas that have a capacity to hold >110 percent of the volume of the largest tank located there. The bermed areas have bentonite clay liners consisting of either Environmat™ (bentonite clay sandwiched between geotextile material) or bentonite clay mixed into the native soil to form an impervious soil/clay layer. As of December 1996, all fuel-unloading operations were consolidated to one centralized building that has secondary containment features. The MPF is operated under NYSDEC Permit #1-1700 and, as required by law, a Spill Prevention and Countermeasures (SPCC) Plan and a Facility Response Plan have been developed for the facility. Groundwater quality near the MPF has been impacted by several oil and solvent spills: 1) the 1977 fuel oil/solvent spill to the east of the MPF that was remediated under the Environmental Restoration Program (see **Section 3.3.1**); and 2) by solvent spills near the CSF.

4.8.1 MPF Groundwater Monitoring

Well Network

Eight shallow Upper Glacial aquifer wells are used to confirm that the engineered and institutional controls in place are effective in preventing contamination of the aquifer (**Figure 4-24**).

Sampling Frequency and Analysis

Groundwater contaminants from the fuel oil products stored at the MPF can travel both as free product and in dissolved form with advective groundwater flow. Historically, the Special License Conditions for the MPF required semiannual sampling for SVOCs and monthly monitoring for floating petroleum. Samples were also periodically tested for VOCs as part of the Environmental Surveillance Program. In early 2002, NYSDEC expanded the required list of routine analyses to include VOCs, including testing for MTBE (**Table 1-6**). MTBE was a common gasoline additive until January 2004, and it was occasionally introduced to fuel oil as a contaminant during the storage and transportation process.

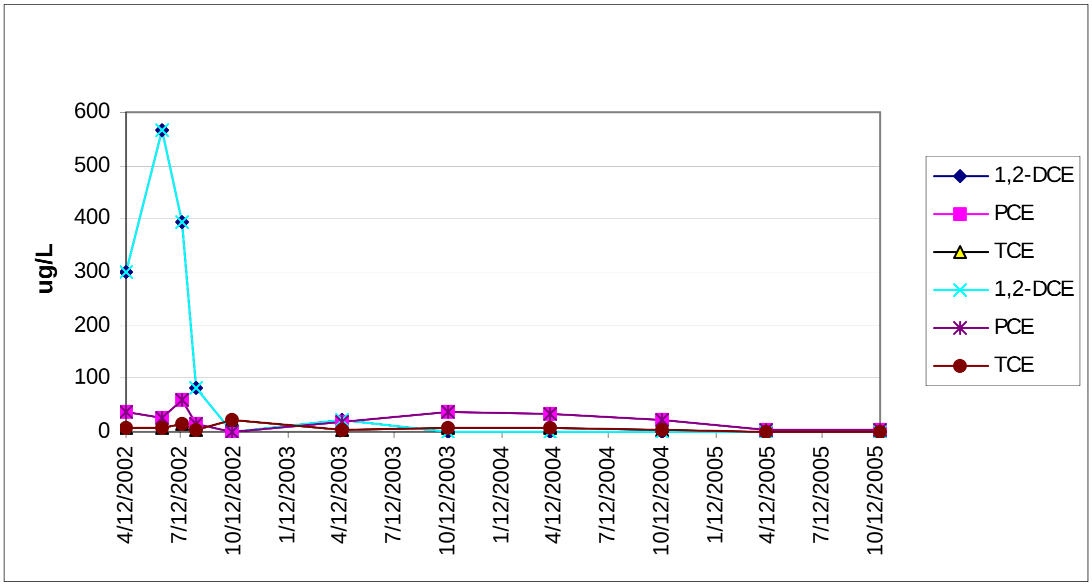
4.8.2 MPF Monitoring Well Results

BNL sampled the MPF wells in April and October 2005. The samples were tested for SVOCs and VOCs. As in the past, no SVOCs were detected, and no floating product was observed. Trace levels of TCA (up to 1.3 µg/L) and chloroform (up to 2.9 µg/L) continued to be detected in upgradient well 075-25. These compounds are related to historical spills near building 650. As in past years, several solvents continued to be detected in downgradient well 076-380. PCE was detected at concentrations up to 5.5 µg/L, slightly above NYS AWQS of 5 µg/L. Levels of both TCE and the PCE breakdown product trans-1,2-dichloroethene dropped to non-detectable levels by the end of 2005 (**Figure 4-25**). In nearby OU IV monitoring well 076-185, PCE was detected up to 2.9 µg/L, and trans-1,2-dichloroethene was detected up to 6.3 µg/L. These solvents are believed to have originated from documented historical spills near the CSF building; their presence in groundwater is not the result of recent CSF or MPF operations.

4.8.3 MPF Monitoring Program Evaluation

Groundwater monitoring at the MPF continues to show that fuel storage and distribution operations are not impacting groundwater quality. The low levels of PCE (including its breakdown product trans-1,2-dichloroethene) and TCE are likely to have originated from historical solvent spills near Building 610. The historical nature of this contamination is supported by: 1) degreasing agents such as PCE have not been used at the CSF in many years, 2) PCE has been detected in well 076-19 since the early 1990s, and 3) trans-1,2-dichloroethene is a breakdown product of PCE. A number of historical spill sites near the CSF were identified in the late 1990s, and the contaminated soil was excavated in accordance with regulatory requirements. For 2006, monitoring will continue as required by the NYS operating permit.

Figure 4-25.
VOC Concentrations Downgradient of the Major Petroleum Facility, in Well 076-380.



4.9 Waste Management Facility

The WMF is designed to safely handle, repackage, and temporarily store BNL-derived wastes prior to shipment to off-site disposal or treatment facilities. The WMF is a state-of-the-art facility, with administrative and engineered controls that meet all applicable federal, state, and local environmental protection requirements. The WMF consists of four buildings: the Operations Building, Reclamation Building (for radioactive waste), RCRA Waste Building, and the Mixed Waste Building.

Groundwater monitoring is a requirement of the RCRA Part B permit issued for WMF operations. The groundwater monitoring program for the WMF is designed to supplement the engineered and institutional controls by providing additional means of detecting potential contaminant releases from the facility. The WMF is located adjacent to BNL Potable Supply Wells 11 and 12, which are south of East Fifth Avenue and just north of the WMF site. Because of the proximity of the WMF to these wells, it is imperative that the engineered and institutional controls implemented at the WMF are effective in ensuring that waste handling operations do not degrade the quality of the soil and groundwater in this area.

4.9.1 WMF Groundwater Monitoring

Well Network

Eight wells are used to monitor groundwater quality near the WMF (**Figure 4-26**). Three wells are used to assess background water quality, and five wells are positioned downgradient of the three waste handling and storage buildings. Note, the groundwater flow directions depicted in **Figure 4-26** reflect a period when supply wells 11 and 12 are not in operation. As required by the groundwater monitoring plan for the WMF, supply wells 11 and 12 are operated continuously for a two-week period prior to sampling the monitoring wells in order to establish the necessary northward flow patterns. A complete set of monitoring data and groundwater flow maps are provided in the *2005 Groundwater Monitoring Report for the Waste Management Facility* (BNL 2006b). BNL is currently evaluating the installation of additional wells for the WMF that would eliminate the need for two weeks of supply pumping prior to collecting groundwater samples.

Sampling Frequency and Analysis

During 2005, the WMF wells were monitored two times. Groundwater samples were analyzed twice for VOCs, tritium, gamma spectroscopy, gross alpha, and gross beta, and one time for metals and anions (**Table 1-6**).

4.9.2 WMF Monitoring Well Results

Radiological Analyses

Gross alpha and beta concentrations in samples from both upgradient and downgradient monitoring wells are consistent with background concentrations, and no BNL-related gamma-emitting radionuclides were identified. During 2003, tritium levels in Reclamation Building area monitoring well 056-23 increased from 407 pCi/L in February to 1,120 pCi/L in August (**Figure 4-27**). Low levels of tritium were also occasionally detected in upgradient well 066-07 (**Figure 4-28**). These tritium concentrations were well below the 20,000 pCi/L drinking water standard. Tritium concentrations in well 056-23 reached a maximum level of 2,430 pCi/L in November 2003, then decreased to 350 pCi/L by February 2004. Tritium was not detected in any of the WMF monitoring well samples collected in August 2004 and all of 2005. No tritium was detected in samples from nearby supply wells 11 and 12.

Figure 4-27.
Tritium Concentration Trends in Well 056-23 Downgradient of Waste Management Facility.

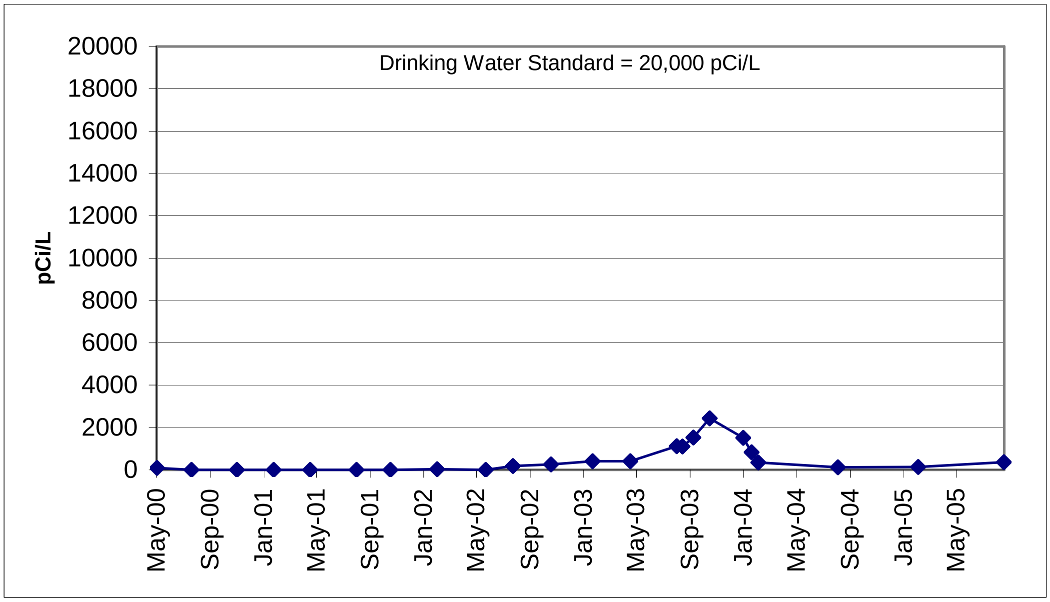
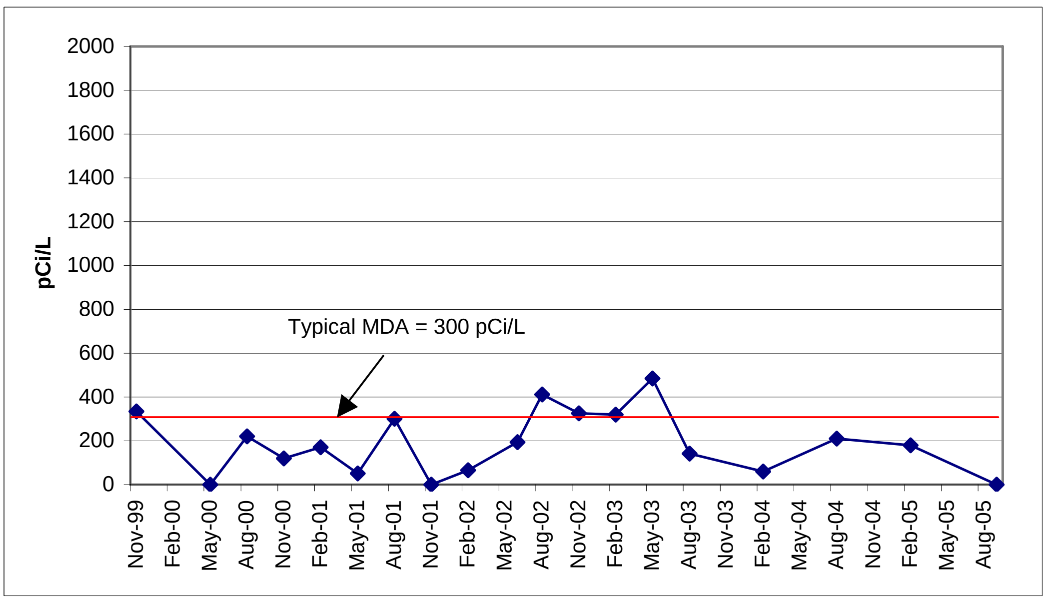


Figure 4-28.
Tritium Concentration Trends in Well 066-07, Upgradient of Waste Management Facility.



Nonradiological Analyses

All anions (chlorides, sulfates, and nitrates) and most metals concentrations were below applicable NYS AWQS. As in past years, sodium was detected in shallow upgradient well 055-03 at concentrations above the NYS AWQS of 20 mg/L, with a maximum concentration of 30 mg/L in the September 2005 sample. Well 055-03 is near a road, and the elevated sodium concentrations are likely due to road salting operations. During 2005, no VOCs were detected at concentrations above NYS AWQS. Low levels of chloroform (up to 1.5 µg/L) were occasionally detected in two of three upgradient wells and in all five downgradient wells. The NYS AWQS for TCA is 5 µg/L.

4.9.3 WMF Groundwater Monitoring Program Evaluation

Groundwater monitoring results for 2005 were consistent with previous years' monitoring, and continued to show that WMF operations were not affecting groundwater quality. There were no outdoor or indoor spills at the facility that could have impacted soil or groundwater quality. Except for sodium detected in one well, all chemical and radionuclide concentrations were below NYS AWQS or DWS. During 2005, tritium was not detected in any of the monitoring wells. Although a definitive source for the tritium has not been identified, a thorough review of waste management operations suggests that the tritium was not released from the WMF. For 2006, monitoring will continue as required by the RCRA Part B Permit.

4.10 Building 801

In early December 2001, approximately 8,000 gallons of stormwater seeped into the basement of Building 801. Analysis of the floodwater indicated that the water contained Cs-137, Sr-90, and tritium at concentrations of 784 pCi/L, 594 pCi/L, and 25,000 pCi/L, respectively. It is believed that the floodwater became contaminated when it came into contact with the basement floor, which contains significant residual contamination from historical radiological spills. When the floodwater was pumped from the basement on March 8, 2002, approximately 4,950 gallons of contaminated water were removed. Taking into account possible losses due to evaporation, estimates were that between 1,350 and 2,750 gallons of contaminated floodwater might have seeped into the soil below Building 801. To evaluate the potential impact to groundwater quality of such a release, BNL installed a new water table well immediately downgradient of the building and monitored several nearby wells.

4.10.1 Building 801 Groundwater Monitoring

Well Network

From May through October 2002, three existing downgradient wells were sampled. Well 065-169 is approximately 10 feet south of Building 801, whereas wells 065-37 and 065-170 are approximately 80 feet downgradient of the building (see **Figure 3.2.15**). These wells were installed in 1999 to monitor historical releases from the Waste Concentration Facility and the former Pile Fan Sump area. Well 065-37 is screened close to the water table, whereas wells 065-169 and 065-170 are screened approximately 10 feet below the water table. Because well 065-37 is not ideally screened at the water table to properly monitor a nearby contaminant source area, a new shallower well, 065-325, was installed in early October 2002.

Sampling Frequency and Analysis

During 2005, Building 801 monitoring well 065-325 was sampled three times under the Environmental Surveillance Program (**Table 1-6**). The samples were analyzed for gross alpha, gross beta, Sr-90, Cs-137, and tritium. Monitoring wells 065-37, -169, and -170 were sampled semiannually under the Environmental Restoration Program, and the samples were analyzed for Sr-90 and Cs-137.

4.10.2 Building 801 Monitoring Well Results

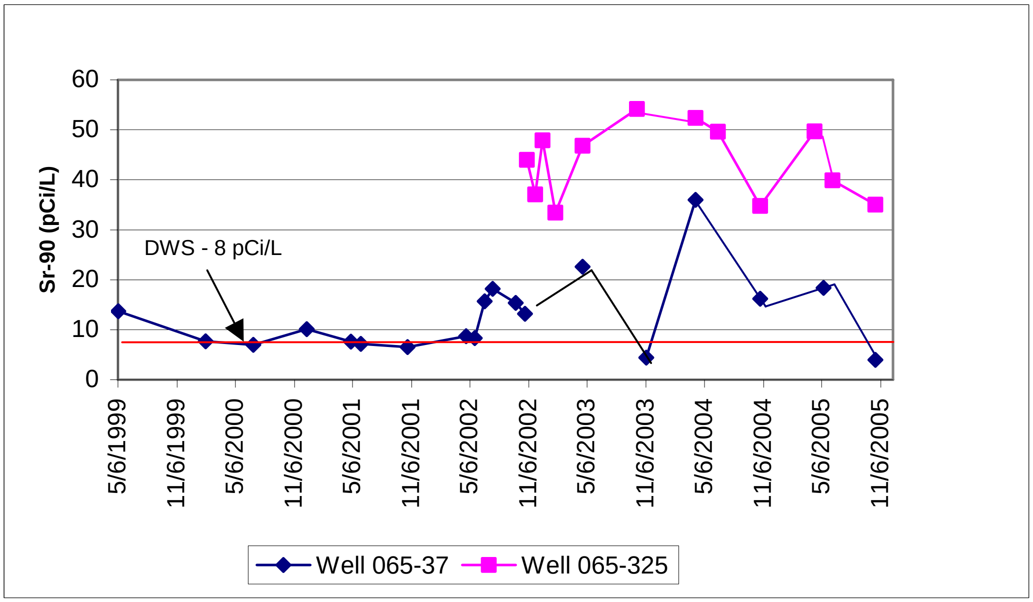
The April, June, and October 2005 samples from well 065-325 had Sr-90 concentrations of 49.7 pCi/L, 39.9 pCi/L, and 35 pCi/L, respectively (**Figure 4-29**). Cs-137 was not detected in any of the samples; however, a trace level of tritium was detected in the April sample, at a concentration of 456 pCi/L. Sr-90 concentrations in slightly deeper well 065-37 ranged from 18.4 pCi/L in May to 4 pCi/L in October 2005. Only low levels of Sr-90 were detected in deeper wells 065-169 and 065-170, with maximum concentrations of 2 and 1.9 pCi/L, respectively

4.10.3 Building 801 Monitoring Program Evaluation

Sr-90 concentrations in samples collected during 2005 from shallow groundwater wells located downgradient of Building 801 are consistent with pre-December 2001 values. Additionally, Cs-137 has not been detected in any of the groundwater samples. It is estimated that it could take approximately 3 to 8 years for Sr-90, and approximately 100 years for Cs-137, from the December 2001 Building 801 floodwater release to migrate to the closest downgradient well (065-325). Furthermore, detecting any new groundwater impacts from this release will be difficult to identify, as the local groundwater is already contaminated with radioactivity from legacy releases (see discussions related to nearby Pile Fan Sump in **Section 3.2.15**).

The monitoring frequency for well 065-325 for 2006 will be reduced to semiannual, and the monitoring will be conducted as close as possible with planned semiannual sampling of wells 065-37, 065-169, and 065-170 by the Environmental Restoration Program.

Figure 4-29.
Sr-90 Concentration Trends in Downgradient Wells 065-37 and 065-325 at Building 801.



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5.0 SUMMARY OF RECOMMENDATIONS

This section, a summary of all of the recommendations from Sections 3 and 4, is provided as a quick reference. The recommendations are sequenced as they appear in Sections 3 and 4.

5.1 OU I South Boundary Pump and Treat System

The following are recommendations for the OU I South Boundary Pump and Treat System and groundwater monitoring program:

- The routine operation and maintenance (O&M) monitoring frequency implemented in the fourth quarter of 2004 should be continued. Plume core and perimeter wells are monitored on a semiannual frequency. Sentinel and bypass wells are sampled at a quarterly frequency.
- Continue pulsing of the treatment system wells to optimize system performance.
- Install a monitoring well upgradient of EW-1 and EW-2 during June 2006 as recommended in the 2004 Groundwater Status Report.

5.2 Carbon Tetrachloride Pump and Treat System

The following are recommendations for the OU III Carbon Tetrachloride Groundwater Remediation System and monitoring program:

- Change the sampling of the extraction wells from a monthly to quarterly basis.
- The monitoring well network is adequate and no modifications are necessary at this time, with the exception of increasing the sampling frequency for well 095-90 to quarterly. This is due to the expected arrival of the leading edge of the plume in this area in the next year.
- If significant concentrations of carbon tetrachloride are detected, the system will be turned on.
- The increased VOC concentrations (TCA, DCE) in well 095-93 observed over the past several years will be evaluated including additional groundwater characterization in this area.

5.3 Building 96 Air Stripping System

The following are recommendations for the OU III Building 96 groundwater remediation system and monitoring program:

- Recirculation well RTW-1 is downgradient of the silty zone area, and pumps from 48 to 58 feet bls, below the silty zone. This well recharges its effluent to the shallower zone above the silty zone, 25 to 35 feet bls. It can be seen that the silty zone layer is between the lower extraction well screens and the upper discharge well screens for RTW-1(**Figure 3.2.2-3)**. From a review of the monitoring well data, influent data, and the cross section for the Building 96 area, the continued operation of extraction well RTW-1 is no longer providing capture of the plume. Therefore, it is recommended that extraction well RTW-1 be placed in standby mode and sampled quarterly.
- Downgradient monitoring will continue and, if needed, downgradient recirculation wells RTW-2, -3, and -4 can be restarted if elevated VOC concentrations are seen. These wells are 230 to 250 feet downgradient of RTW-1 and would be able to intercept and treat any contamination migrating downgradient past it.
- The influent for recirculation wells RTW-2, RTW-3, and RTW-4 will be sampled quarterly.

- Monitoring wells sampling frequencies will be changed from monthly to quarterly, effective the third quarter of 2006. No $KMnO_4$ injections are planned for 2006, and based on data observations over the past several years, a monthly frequency is no longer necessary for these wells.
- Monitoring will continue in 2006 and the results will continue to be evaluated. If VOC concentrations don't show a decline in the source area wells, alternative methods for remediating the contamination in the silty zone upgradient of extraction well RTW-1 will be evaluated including soil excavation and biodegradation enhancers such as molasses. The potential for creating breakdown products such as vinyl chloride will be addressed as part of the evaluation.

5.4 Middle Road Pump and Treat System

The following recommendations are made for the OU III Middle Road Pump and Treat System and groundwater monitoring program:

- Maintain the routine O&M monitoring frequency that began in 2003.
- Continue extraction wells RW-4 and RW-5 in standby mode during 2006. Restart the wells if extraction or monitoring well data indicate TVOC concentrations exceed the 50 µg/L capture goal.
- Shut down well RW-6 due to low VOC concentrations (below MCLs in 2005). Continue quarterly sampling of the well. Restart the well if TVOC concentrations in the vicinity of this well exceed the 50 µg/L capture goal.
- Install one or two temporary wells near HFBR tritium extraction wells EW-9, EW-10, and EW-11 (**Figure 3.2.3-1**) to characterize the high-concentration portion of the plume. Based on the results from the temporary wells, consider installing a monitoring well.

5.5 South Boundary Pump and Treat System

The following are recommendations for the OU III South Boundary Pump and Treat System and groundwater monitoring program:

- A routine O&M monitoring frequency was implemented in the fourth quarter of 2003. This frequency should be maintained during the O & M phase.
- Change monitoring of the OU III South Boundary Magothy wells (121-40, 121-44, 122-41, and 122-05) to a semiannual frequency in 2006.
- Extraction well EW-12 was placed in standby mode in 2003. This well will continue in standby mode during 2006. The well will be restarted if extraction or monitoring well data indicate TVOC concentrations exceed the 50 µg/L capture goal.
- Shut down extraction well EW-8, due to low VOC concentrations in this well. The highest concentration observed in this well in 2005 was 6.4 µg/L of tetrachloroethylene. Continue quarterly sampling of this well. The well will be restarted if extraction or monitoring well data indicate TVOC concentrations exceed the 50 µg/L capture goal.
- Install temporary and permanent wells in the Magothy aquifer downgradient of the Middle Road treatment system to enhance the monitoring well network. This will help determine the extent of VOCs in the Magothy aquifer between the Middle Road and South Boundary plume monitoring networks, as well as provide additional hydrogeologic data.

5.6 Western South Boundary Pump and Treat System

The following are recommendations for the OU III Western South Boundary Treatment System and groundwater monitoring program:

- Due to the low influent concentrations and because five out of seven plume core wells have reached the cleanup objective of 20 μg/L TVOCs, it is recommended that pulse pumping the extraction wells continue. The wells will be shut down for two months, then turned back on for one month. This process will continue to evaluate any changes to the VOC concentrations in the influent and the monitoring wells.
- The extraction wells sampling frequency will change from monthly to quarterly.

5.7 Industrial Park In-Well Air Stripping System

The following are recommendations for the Industrial Park In-Well Air Stripping System and groundwater monitoring program:

- The current routine operations and maintenance monitoring frequency should be maintained during 2006.
- The system should continue operations at 60 gpm per well except for well UVB-1, which is to remain in a standby mode. Monthly sampling will continue and if higher concentrations are observed, well UVB-1 will be restarted.
- Increase the operational time of the system in 2006, as 2005 had extended periods of downtime due to electrical and well fouling problems.

5.8 Industrial Park East Pump and Treat System

The following are recommendations for the Industrial Park East Pump and Treat System and groundwater monitoring program.

- As per the recommendation in the *2004 Groundwater Status Report*, BNL will install an additional Magothy monitoring well adjacent to well 000-495, but deeper.
- Install a temporary well near well 000-514 to evaluate concentrations of deeper contamination in this area. If concentrations exceed 50 μg/L in this area, consider installing an additional monitoring well at this location.
- Continue operations at 115 gpm for EWI-1 and 75 gpm for EWI-2.
- No changes are recommended at this time to the monitoring well network and sampling frequency.

5.9 North Street Pump and Treat System

The following is recommended for the North Street Pump and Treat System and groundwater monitoring program:

- Change the monitoring well sampling schedule from the startup to O&M phase (core and perimeter wells sampled semiannually and sentinel wells sampled quarterly).

5.10 North Street East Pump and Treat System

The following is recommended for the North Street East Pump and Treat System and groundwater monitoring program:

- Begin pulse pumping of both extraction wells, since the system influent concentrations have remained very low over the past year and 90% of the monitoring wells are already below the capture goal of 50 µg/L TVOC. The pulse pumping will consist of having the system on for one month then off in standby mode for the next. This will continue for approximately one year. The extraction wells will continue to be sampled on a monthly basis. If concentrations above the capture goal of 50 µg/L TVOCs are observed in either of the extraction wells, the well(s) will be put back into fulltime operation.

- Continue the startup sampling frequency for the monitoring wells.

5.11 LIPA/Airport Pump and Treat System

The following are recommendations for the LIPA/Airport Groundwater Treatment System and groundwater monitoring program:

- Quarterly sampling of the monitoring wells associated with this project should continue in 2006.
- The extraction well sampling should continue on a monthly schedule.
- The leading edge of the plume has not reached the airport extraction wells. Continue the airport extraction wells pulse pumping of one week per month. This will verify that the higher concentrations have not reached the airport system. If concentrations above the capture goal of 10 µg/L VOCs are observed in any of the extraction wells or the monitoring wells adjacent to them, the well(s) will be put back into fulltime operation.

5.12 Magothy Monitoring

No changes to the monitoring program are warranted at this time.

5.13 Central Monitoring

No changes to the monitoring program are warranted at this time.

5.14 Off-Site Monitoring

No changes to the monitoring program are warranted at this time.

5.15 South Boundary Radionuclide Monitoring Program

No changes to the monitoring program are warranted at this time.

5.16 BGRR/Waste Concentration Facility Strontium-90 Monitoring

The following are recommendations for the BGRR/WCF groundwater monitoring program:

- Maintain the southerly groundwater flow direction by managing the pumping of the BNL supply wells. This will be accomplished via the oversight of the BNL Water and Sanitary Planning Committee.

- Replace abandoned monitoring wells 085-299, 085-300, 085-302, 085-310, 085-311, and 085-312, which were abandoned due to the construction of the Center for Functional Nanomaterials. New wells will be installed to replace these abandoned wells once construction of the CFN is complete.
- Install an additional monitoring well downgradient of the leading edge of the WCF plume. The new well is to be located southwest from the front of the HFBR and downgradient from well 65-189.
- Install an additional monitoring well downgradient of the PFS plume. The new well is to be located in the 75-46 well cluster.

5.17 Chemical/Animal Holes Strontium-90 Pilot Study Treatment System

The following are the recommendations for the Chemical/Animal Holes Strontium-90 Treatment System and groundwater monitoring program:

- Continue operating the treatment system at 6 gpm.
- Continue the current monitoring well sampling frequency.
- Evaluate temporary well data collected in the spring of 2006 downgradient of the extraction well, in particular, monitoring well 106-49. Model this new data with new initial concentrations to compare against previous model predictions (2003 and 2004). The contamination downgradient of the extraction well may present a risk to achieving the cleanup goal of 40 years. New temporary well data and modeling will better define this potential risk.

5.18 HFBR Tritium Monitoring

The following are recommendations for the HFBR tritium plume.

- Up to eight temporary wells will be installed and sampled to the east of Weaver Drive and Chilled Water Facility Road on a semiannual basis beginning in October 2006. This data will be used to track the centerline of the tritium plume, to monitor for exceedance of the 20,000 pCi/L OU III ROD contingency trigger value at Weaver Drive, and to assess the trailing edge of the hot spot as it moves through the Chilled Water Facility Road area. It is anticipated that the semiannual installation and sampling of temporary wells will be necessary for up to a 2-year duration, at which time the nature and extent of the plume will be reevaluated with respect to monitoring frequency. The flexibility afforded by the installation of temporary wells over permanent wells is preferred, due to the narrow width of the plume and documented history of small flow changes resulting in monitoring well locations quickly being rendered less than optimal.
- Select monitoring wells along Cornell Avenue will continue to be monitored quarterly to track the centerline of residual tritium moving south from the HFBR. Several additional temporary wells will be installed along Temple Place if, based on the monitoring well data, it is determined that the plume has shifted outside of this line of monitoring wells.
- An evaluation will be performed utilizing the BNL groundwater model to determine whether the HFBR tritium pump and recharge wells (EW-10, -11, and -12) are located to intercept the tritium plume should the 20,000 pCi/L trigger value concentration be exceeded at Weaver Drive and the system reactivated. This evaluation will included a recommendation for modifications to this pump and recharge system, if necessary.
- The eastward shift of the HFBR plume since 1997 has resulted in much of the central and western portion of the monitoring well network being located outside of the plume. It is recommended that the focus of the groundwater monitoring program be shifted to key wells in the eastern

portion of the monitoring well network. As a result, the sampling of the western wells will be reduced to either an annual frequency or suspended indefinitely, and focus monitoring on optimally located wells (based on current plume position) to the east in conjunction with the sampling of temporary wells semi-annually.

There is now a sampling history of 6 to 9 years for most of the wells in the program. Given the current knowledge of the position of the plume, based on the recent characterization data and the extensive volume of historical data, it is recommended that the sampling frequencies be reduced in the following manner:

1. Reduce the sampling frequency for wells significantly west of the current plume to either annually or suspend sampling altogether. No monitoring wells will be abandoned at this time and the flexibility will remain for these sampling frequencies to increase should the plume shift back to the west.
2. Maintain quarterly sampling frequencies only for those wells immediately downgradient of the HFBR and in a position to intercept tritium as it is flushed from the vadose zone beneath the building. Also maintain quarterly frequencies for sentinel wells in the vicinity of Princeton Avenue.
3. Based on the large volume of historical data, reduce remaining monitoring to semiannual. Based on current knowledge of the plume position, the semiannual installation of temporary wells, and the rate of plume movement, this frequency will be sufficient to meet the goals of the OU III ROD.

- **Table 3.2.17-2** summarizes the last detection of tritium, the last detection above 1,000 pCi/L, and the last detection above the 20,000 pCi/L DWS for each monitoring well. The table also lists the current sampling frequency and the proposed modified frequency based on the above recommendations and analysis of historical data. The monitoring program will be assessed twice a year and the regulatory agencies will be briefed, based on an analysis of data collection efforts and changes to the plume. Recommendations for additional modifications to the monitoring program will then be addressed in the appropriate quarterly system operation reports.

5.19 Post Closure Monitoring (Former OU IV AS/SVE) System

The *Final CERCLA Five Year Review Report for OU IV* (BNL 2003e) required that wells 076-04 and 076-06 would continue to be monitored quarterly for VOCs and SVOCs. If concentrations remain below MCLs for a one-year period, the sampling frequency would be reduced to semiannual for up to five years. The VOC concentrations in each of these two wells remained below MCLs during 2005. Therefore, it is recommended that the 2006 sampling frequency for VOCs and SVOCs be reduced to semiannual. Well 076-185 will continue to be sampled for VOCs semiannually, and wells 076-18 and 076-19 will continue to be monitored under the BNL Facility Monitoring Program on a semiannual basis.

5.20 Building 650 (Sump Outfall) Strontium-90 Monitoring

The recommendation for the Building 650 Strontium-90 Groundwater Monitoring Program is to continue monitoring and reduce the frequency of sampling for monitoring wells 076-07, 076-09, 076-10, 076-22, 076-181, 076-182, 076-184, and 076-265 to annual.

5.21 Operable Unit V

The routine monitoring program will continue unchanged for 2006. In addition, it is recommended that eight OU V monitoring wells continue to be analyzed for perchlorate in 2006.

5.22 Operable Unit VI Pump and Treat System

Due to the detection of EDB in well 000-498, which is near the edge of the capture zone for extraction well EW-1E, increase the pumping rate at EW-1E to increase the capture zone. An evaluation will be performed to determine if the existing pump is adequate or whether a larger pump is required. Pumping at this rate will extend the capture zone sufficiently westward such that any EDB in this area will be captured and treated by the remediation system.

As of August 2006, the OU VI EDB system will have been in operation for two years. Beginning with the third quarter of 2006, the groundwater monitoring program will move into the O&M phase (**see Table 1-6**). The sampling frequency for plume core and perimeter wells (**Table 1-5**) will be reduced from quarterly to semiannually. The exception to this will be well 000-498, which will remain at a quarterly sampling frequency until further notice. Sentinel well sampling will remain at a quarterly frequency and the analytical parameters will remain unchanged.

Based on the absence of any tritium detections in OU VI monitoring wells dating back to 1997, this parameter will be dropped from the program. The exception will be wells 099-06, 099-10, 099-11, 100-12, and 100-13 (all located on the south boundary). These wells will be incorporated into the OU III South Boundary Radionuclide monitoring program and analyzed for tritium annually. The inclusion of these wells will allow for radionuclide monitoring across the entire downgradient site boundary.

Monitoring wells 800-24, -25, and -54 will be dropped from the program, as they are no longer deemed to be providing value. This is due both to the establishment of hydraulic control of the plume at EW-1E and EW-2E and the fact that these three wells are not positioned, either horizontally or vertically with respect to the plume, to intercept EDB should it reach these locations.

5.23 Site Background Monitoring

No modifications are recommended to the Site Background monitoring program.

5.24 Current Landfill Groundwater Monitoring

There were no recommendations to modify the sampling schedule.

5.25 Former Landfill Groundwater Monitoring

There were no recommendations to modify the sampling schedule presented.

5.26 Alternating Gradient Synchrotron (AGS) Complex

The following actions are recommended for 2005:

- For 2006, the monitoring frequency for the Building 912 wells not used to track the g-2 tritium plume will be reduced from semiannual to annual.
- Starting in 2006, the monitoring frequency for the Booster area monitoring wells will be reduced from semiannual to annual.

- Tritium levels in the E-20 Catcher area wells have been <1,500 pCi/L for the past two years, therefore well sampling frequency will be reduced from semiannual to annual.
- Tritium levels in the J-10 Beam Stop area wells are less than 1,000 pCi/L; therefore, the sampling frequency will be reduced from semiannual to annual.
- Tritium levels in the former U-line area wells have been less than 3,000 pCi/L for the past three years; therefore the sampling frequency will be reduced from semiannual to annual.

5.27 Brookhaven Linac Isotope Producer Facility

Until the tritium levels in groundwater routinely remain below the 20,000 pCi/L DWS, the Laboratory will continue to monitor the BLIP wells on a quarterly basis.

5.28 Relativistic Heavy Ion Collider Facility

For 2006, groundwater samples will continue to be collected on a semiannual basis. Additional samples will be collected from the wells downgradient of the southern 10 o'clock area beam stop to verify that tritium was not released by the rise in the water table following the October 2005 rain event.

5.29 Brookhaven Medical Research Reactor Facility

The BMRR structure is effectively reducing rainwater infiltration into the underlying soils, and therefore reducing the movement of residual tritium from the soil to the groundwater. The monitoring frequency will be reduced to annual starting in 2006, and reduced further to once every two years starting in 2007.

5.30 Sewage Treatment Plant

No changes to the STP groundwater monitoring program are proposed for 2006.

5.31 Motor Pool Maintenance Area

No changes to the Motor Pool groundwater monitoring program are proposed for 2006.

5.32 On-Site Service Station

No changes to the Service Station groundwater monitoring program are proposed for 2006.

5.33 Major Petroleum Facility Area

Groundwater monitoring at the MPF will continue in accordance with NYSDEC operating permit. The wells will continue to be tested monthly for floating product and semiannually for VOCs and SVOCs.

5.34 Waste Management Facility

Groundwater monitoring at the WMF will continue to be conducted on a semiannual basis, in accordance with the RCRA Part B Permit modifications approved by NYSDEC in 2003. Samples will be analyzed for gross alpha, gross beta, gamma, and VOCs semiannually, whereas samples will be analyzed annually for metals and anions.

5.35 Building 801

The monitoring frequency for well 065-325 for 2006 will be reduced to semiannual, and the monitoring will be conducted as close as possible with planned semiannual sampling of wells 065-37, 065-169, and 065-170 by the Environmental Restoration Program.

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