2006 Site Environmental Report

GROUNDWATER STATUS REPORT

BROOKHAVEN NATIONAL LABORATORY

Volume II

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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

2006 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 *2006 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 eleventh 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 is presented 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) by the Long Term Response Actions (LTRA) Group, 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 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.

Section 1 summarizes the regulatory drivers of the data collection work in 2006, the site's groundwater classification, and the objectives of the groundwater monitoring efforts. Section 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 2006. Section 3 summarizes the groundwater cleanup data, progress towards achieving the site's cleanup goal, and recommended modifications to the remediation systems or monitoring programs. Section 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 Section 5.

HYDROGEOLOGIC DATA

The following were important hydrogeologic findings in 2006:

- The desired flow conditions were maintained in the central portion of the site during 2006 with 89 percent of the total sitewide potable and process water pumpage being derived from the western supply well field. No shifting of contaminant plumes outside of the established monitoring networks was observed on-site in 2006.
- Total annual precipitation in 2006 was 61.6 inches, well above the yearly average of 48 inches. Four of the past five years have featured above normal annual average precipitation at BNL. In an average year, it is estimated that 24 inches of rainfall recharge the Upper Glacial aquifer. The recharge rate for 2006 was estimated at 31 inches. Based on data from both long and short-term hydrographs, water table elevations in the BNL vicinity in 2006 were the highest observed since 1997, and slightly less than some of the highest recorded water elevations observed since record keeping began in the 1940s.

GROUNDWATER RESTORATION PROGRESS AND ISSUES (CERCLA)

Table E-1 summarizes the status and progress of groundwater cleanup at BNL under the provisions of CERCLA. In 2006, 372 pounds of volatile organic compounds (VOCs) were removed from the aquifers by the treatment systems. To date, 5,680 pounds of VOCs in the aquifer have been removed. The Operable Unit (OU) III Chemical Holes Strontium-90 System removed 0.24 mCi of strontium-90 (Sr-90) from the Upper Glacial aquifer in 2006, for a total to date of 2.32 mCi. The OU III BGRR Sr-90 system was started up in early 2005 and removed 5.1 mCi of Sr-90 during the year, for with a total of 9.25 mCi since removal began.

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. One system (OU IV AS/SVE) has been decommissioned, three systems are in standby (OU III Carbon Tetrachloride, HFBR Tritium, and Bldg. 96) and a number of individual system extraction wells have been placed on standby. Groundwater remediation activities are expected to continue until approximately 2030 to meet the cleanup objectives for the plumes. The specific goals are as follows:

- Achieve maximum contaminant levels (MCLs) for VOCs in the Upper Glacial aquifer by 2030
- Achieve MCLs for VOCs in the Magothy aquifer by 2065
- Achieve MCLs for Sr-90 at the BGRR in Upper Glacial aquifer by 2070
- Achieve MCLs for Sr-90 at the Chemical Holes in the 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 measure the remediation progress.

The locations and extent of the primary VOC and radionuclide plumes at BNL as of December 2006 are summarized in Figures E-1 and E-2, respectively. Significant items of interest during 2006 were the following:

- 727 monitoring wells were sampled as part of the LTRA Groundwater Monitoring Program in 2006, comprising a total of 2,097 groundwater sampling events. Approximately 60 temporary wells were also installed in 2006, for a total of 947 sampling events. BNL continued to make significant progress in characterizing and restoring groundwater quality at the site. During 2006, ten VOC groundwater remediation systems were in operation, along with two Sr-90 treatment systems.
- During 2006, 1.5 billion gallons of groundwater were treated. Twelve of the 16 groundwater treatment systems were operational in 2006 (**Table E-1**).

Table E-1.
BNL Groundwater Remediation System Treatment Summary for 1997 – 2006.

	1997 – 2005		2006	
VOCs Remediation (start date)	Water Treated (gallons)	VOCs Removed (pounds)(c)	Water Treated (gallons)	VOCs Removed (pounds)(c)
OU III South Boundary (June 1997)	2,813,099,850	2,423	235,853,000	102
OU III Industrial Park (Sept. 1999)	1,083,298,330	901	151,180,000	66
OU III W. South Boundary (Sept. 2002)	477,163,000	39	54,484,000	6
OU III Carbon Tetrachloride (Oct. 1999)	153,538,075	349	0	0
OU I South Boundary (Dec. 1996)	2,893,249,000	323	154,065,000	8
OU III HFBR Tritium Plume (May 1997) (a)	241,528,000	180	0	0
OU IV AS/SVE (Nov. 1997) (b)	0	35	0	0
OU III Building 96 (Feb. 2001)	132,557,416	70	2,940,000	1
OU III Middle Road (Oct. 2001)	965,650,550	619	173,761,000	81
OU III Industrial Park East (May 2004)	143,598,000	24	82,574,000	5
OU III North Street (June 2004)	345,841,000	187	157,281,000	45
OU III North Street East (June 2004)	246,900,000	11	111,076,000	5
OU III LIPA/Airport (June 2004)	437,682,000	147	238,205,000	53
OU VI EDB (August 2004)	177,652,000	NA(d)	156,059,000	NA (d)
Total VOCs removed	10,099,373,220	5,308	1,517,478,000	372

	1997 – 2005		2006	
Sr-90 Remediation (start date)	Water Treated (gallons)	Sr-90 Removed (mCi)	Water Treated (gallons)	Sr-90 Removed (mCi)
OU III Chemical Holes (Feb 2003)	6,612,826	2.08	3,392,000	0.24
OU III BGRR (June 2005)	3,576,000	4.15	10,975,000	5.1
Total Sr-90 removed	10,188,826	6.23	14,367,000	5.34

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) EDB has been detected at trace levels in the system influent since operations began and well below the standard. Therefore, no removal of VOCs are reported.

- The OU III ROD contingency of 20,000 pCi/L tritium at Weaver Drive was triggered with a detection of 21,000 pCi/L in temporary well GP-297 on November 2, 2006. The design of a fourth HFBR extraction well will be prepared and submitted to the regulatory agencies. It is anticipated that the new extraction well, along with EW-11 (and possibly EW-10), will be operational during the third quarter of 2007. A complete discussion of the triggering of the OU III ROD contingency and plans for the restart of the system are included in **Section 3.2.17** of this report.
- Based on the results of monitoring well data collected since the last injection of potassium permanganate in the Building 96 source area in January 2006, it appears that additional remedial action will be required to reduce high VOC concentrations in the source area. An engineering evaluation will be completed by the end of 2007 to evaluate remedial alternatives.
- Additional characterization of the downgradient portion of the Chemical/Animal Holes Sr-90 plume was conducted in 2006. Two additional extraction wells will be needed to achieve the cleanup goal of meeting MCLs in the Upper Glacial aquifer by 2040.
- Elevated VOCs were observed in Airport perimeter well 800-96, which is outside the capture zone of the treatment system. Groundwater characterization was performed to determine the location of the plume in this area, and an additional extraction well will be installed to allow for capture of the plume. The new extraction well will be operational during the third quarter of 2007.

Other progress highlights include:

- The OU I South Boundary system continued pulse pumping, which began in September 2005, due to low VOC concentrations.
- The OU III Carbon Tetrachloride system remained on standby as per the petition for shutdown.
- OU III Middle Road extraction wells EW-4 and EW-5 remained on standby due to low VOC concentrations. Groundwater characterization was performed in the vicinity of the Princeton Avenue Firebreak Road in 2006 to determine the location of the OU III VOC plume in this area.
- OU III South Boundary extraction well EW-8 was placed in standby mode in 2006 and well EW-12 remained on standby due to low VOC concentrations. Groundwater characterization data showed that VOC contamination is not migrating below the Magothy Brown clay between the Middle Road and South Boundary systems.
- OU III Western South Boundary system continued pulse pumping, which began in September 2005, due to low VOC concentrations.
- OU III Industrial Park extraction well UVB-1 was placed on standby mode in 2006. The system continued to effectively remove VOCs from the Upper Glacial aquifer.

Progress of the groundwater restoration program is summarized in Table E-2.

INSTITUTIONAL CONTROLS

Institutional controls are in place at BNL to ensure effectiveness of all groundwater remedies. During 2006, 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 and east 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 the BNL property.

No breaches to the groundwater remediation program institutional controls were observed in 2006. The Land Use Controls Management Plan will be updated in 2007.

ENVIRONMENTAL SURVEILLANCE (FACILITY) MONITORING RESULTS

During 2006, the Environmental Surveillance (ES) Program monitored groundwater quality at 10 active research and support facilities. Groundwater samples were collected from 125 wells during 240 individual sampling events. Although no new impacts to groundwater quality were discovered during 2006, 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 10 of 12 quarterly monitoring periods being less than 100,000 pCi/L. In the last quarter of 2006, the maximum tritium concentration was 44,900 pCi/L. Although the engineered stormwater controls are effectively protecting the activated soil shielding at the source area, monitoring data indicates 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 2006, tritium concentrations exceeded the 20,000 pCi/L drinking water standard in one well immediately downgradient of BLIP, with a concentration of 31,400 pCi/L in January. Tritium concentrations for the remainder of the year were less than 20,000 pCi/L. Similar to the g-2/VQ-12 source area discussed above, the periodic release of tritium at the BLIP facility is 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 New York State Ambient Water Quality Standards (NYS AWQS) of 5 µg/L. TCA was detected at concentrations up to 18 µg/L, and DCA was detected at concentrations up to 6.6 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 1.8 µg/L in 2006. The NYS AWQS for MTBE is 10 µg/L. No floating petroleum or petroleum-related VOCs were 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 480 µg/L, o-xylene at 210 µg/L, 1,2,4-trimethylbenzene at 360 µg/L, and 1,3,5-trimethylbenzene at 110 µg/L. The solvent tetrachloroethylene (PCE) was detected in several wells at a maximum concentration of 25 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 0.3 µg/L in 2006, well below the NYS AWQS of 10 µg/L. 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 (additional details of which are provided in Chapter 5):

- **OU I South Boundary System** – Resume full-time pumping of EW-1 and EW-2 during the third quarter of 2007 in anticipation of the arrival of the leading edge of a higher concentration VOC slug migrating towards the extraction wells.
- **Carbon Tetrachloride System** – Change the monitoring well sampling frequency from shutdown phase to standby phase.
- **Building 96** – As an interim action to maintain hydraulic containment of the source area, modify recirculation well RTW-1 to work as a pumping well and discharge the treated water to the nearby surface drainage culvert. This will involve running a discharge line to the culvert about 300 feet away and will require a State Pollutant Discharge Elimination System (SPDES) equivalency permit. This will be implemented by January 2008. An engineering evaluation will be performed to evaluate remedial alternatives for the source area.
- **Middle Road System** – Install one additional temporary well 150 feet west of MRVP-104 to characterize the high-concentration portion of the plume in this area. Install two monitoring wells, one near MRVP-103 to monitor the high concentrations, and one on the western edge of the plume to use as a perimeter monitoring well.
- **OU III South Boundary** – Place extraction wells EW-6 and EW-7 in standby mode beginning in October 2007 due to the low VOC concentrations in these wells.
- **Industrial Park System** – It is recommended that well UVB-4 be placed in standby beginning in October 2007, since influent concentrations to this well are at or near the drinking water standard

and have been for over a year.

- **Industrial Park East** – Due to low VOC concentrations (all wells are less than the capture goal of 50 µg/L TVOC), in October 2007 begin pulse pumping of the extraction wells one month on and one month off for EWI-1 and EWI-2. Change the monitoring well network sampling frequency from the O&M phase (semi-annual sampling) to the shutdown phase (quarterly sampling) starting in the third quarter of 2007.
- **North Street East** – Since the system has been operating for over two years, change the sampling frequency for the monitoring wells from start-up to the O&M phase (core and perimeter wells sampled semi-annually, and sentinel wells sampled quarterly). However, plume core wells 000-481, 000-482, 000-483, and 000-484 should be maintained at the quarterly sampling frequency since they are immediately upgradient of extraction well NSE-2.
- **LIPA/Airport System** – As per a recent groundwater investigation, an additional extraction well (RW-6A) is being added to the west of Airport well RTW-1A. Five new monitoring wells are also planned. The plan is to have this well operational by September 2007. For LIPA, change the groundwater monitoring frequency from the startup phase to O&M phase. The extraction well sampling should change to quarterly, except for the Airport well RTW-1A, which should be maintained at the monthly schedule. Reduce system sampling and analysis from weekly to two times per month.
- **HFBR Tritium Plume –** In response to triggering the OU III ROD contingency, install a fourth extraction well (EW-16) approximately 400 feet south of Weaver Drive. Extraction well EW-11, and possibly EW-10, will be restarted in addition to the new well to provide for the capture of tritium located further west.
- **Chemical Holes Sr-90** – Based on low influent concentrations during 2006, begin pulse pumping in October 2007 (EW-1 cycle of one month on, and one month off). This will be performed to help evaluate rebounding of the Sr-90 influent concentrations. If concentrations in the extraction well increase significantly, then the extraction well will be put back into full-time operation. Change the monitoring well sampling frequency from startup (semi-annual and quarterly) to the O&M phase (semi-annual and annually).
- **OU V Plume Monitoring** – The monitoring well sampling frequency will be changed from semi-annual to annual for 2007.
- **Alternating Gradient Synchrotron (AGS) Complex –** During 2007, temporary Geoprobe wells will be used to track the leading edge of the g-2 plume.
- **Waste Management Facility** – In 2007, up to five new downgradient groundwater monitoring wells will be installed. These wells are needed because the predominant groundwater flow directions in the Waste Management Facility area have changed since the initial monitoring wells were installed in the mid 1990s.

Table E-2.
Groundwater Restoration Progress.

Project	Target	Mode	Treatment Type	Treatment Progress	Years of Operation	Highlights
OU I						
OU I South Boundary (RA V)	VOCs	Operational (pulse)	P&T with AS	331 lb of VOCs treated to date	10 of 14	Hot spot migrating toward the extraction wells based on monitoring well data.
Current Landfill	VOCs tritium	Long Term Monitoring & Maintenance	Landfill capping	Cap is maintained and stable	11 of 30	Groundwater quality slowly improving. VOCs and tritium stable or slightly decreasing.
Former Landfill	VOCs Sr-90 tritium	Long Term Monitoring & Maintenance	Landfill capping	Cap is maintained and stable.	10 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 8 pCi/L in well 088-26 in 2006, down from 21.6 in 2003.
OU III						
Chemical/Animal Holes	Sr-90	Operational	P&T with ion exchange (IE)	2.32 mCi Sr-90 removed to date	4 of 10	Additional characterization performed in 2006. Planning two new extraction wells in 2007 to meet cleanup goals.
Carbon Tetrachloride source control	VOCs (carbon tetra-chloride)	Standby	P&T with carbon treatment	349 lb of VOCs treated to date	Complete	Monitoring well concentrations continued slow decreasing trend in 2006.
Building 96 source control	VOCs	RTW-1,2,3,4 in standby	Recirculation wells with AS	71 lbs of VOCs treated to date	5 of 2 (planned)	Treatment well RTW-1 operational through May 2006 due to rebounding VOC concentrations in source area. Evaluating alternative remedies due to ineffectiveness of permanganate injections on reducing PCE concentrations in source area silt zone.
South Boundary	VOCs	Operational (EW-8 and EW-12 on standby)	P&T with AS	2,525 lbs of VOCs treated to date	9 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. Determined that VOCs are not migrating below the gray-brown Magothy clay in between the Middle Road and South Boundary.
Middle Road	VOCs	Operational (RW-4 and RW-5 on standby)	P&T with AS	700 lbs of VOCs treated to date	5 of 25	Extraction wells RW-1 and -2 continue to show moderate VOC levels. Eastern extraction wells showing low VOC concentrations.

continued

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

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	45 lbs of VOCs treated to date	4 of 11	System continued in pulse pumping mode due to low VOC concentrations. VOC concentrations in monitoring wells continued to decrease in 2006. Maximum TVOCs in monitoring well during 2006 was 25 µg/L.
Industrial Park	VOCs	Operational (UVB-1 on standby)	In-well stripping	967 lbs. of VOCs treated to date.	7 of 12	Generally decreasing VOC levels, particularly in the vicinity of UVB-4.
Industrial Park East	VOCs	Operational	P&T with carbon treatment	29 lbs. of VOCs treated to date.	3 of 5	Continued decrease in VOC concentrations. All wells currently below the capture goal of 50 µg/L.
North Street	VOCs	Operational	P&T with carbon treatment	232 lbs. of VOCs treated to date.	3 of 8	High concentration segment of plume continues to be located in the capture zone of NS-1 and NS-2. Lead edge of plume beyond the capture zone migrating towards the Airport system.
North Street East	VOCs	Operational	P&T with carbon	16 lbs. of VOCs treated to date.	3 of 10	Concentrations in plume core wells continued to decrease in 2006.
Long Island Power Authority (LIPA) Right of Way/ Airport	VOCs	Operational	P&T and recirculation wells with carbon treatment	200 lbs. of VOCs treated to date.	3 of 10	Airport wells continued pulse pumping in 2006. VOCs detected in Airport perimeter well 800-96. Performed groundwater characterization to determine location of plume and began design for additional extraction well.
Magothy	VOCs	Operational	P&T with carbon treatment	NA	NA	LIPA extraction well EW-4L capturing high VOC concentrations in Magothy.
HFBR Tritium	Tritium	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	Triggered OU III ROD contingency at Weaver Drive. Performed extensive downgradient plume characterization and began design for additional pump and recharge extraction well.
BGRR/Waste Concentration Facility (WCF)	Sr-90	Operational	P&T with IE	9.25 mCi to date	2 of 10	A total of 5.1 mCi Sr-90 was removed for the year.

Continued

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

Project	Target	Mode	Treatment Type	Treatment Progress	Years of Operation	Groundwater Quality Highlights
AS/SVE system	VOCs	Decommis-sioned	Air sparging/ soil vapor extraction	35 lb of VOCs removed.	Complete	VOC concentrations in monitoring wells remain low. System decommissioned in Dec. 2003.
OU V						
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 and attenuating.
OU V						
STP	VOCs, tritium	Long Term Response Action	MNA	NA	NA	Low-level VOC plume concentrations continued to slowly decline during 2006. Tritium continued to be detected in monitoring wells just above detection limits, and continued to slowly decline.
OU VI						
Ethylene Dibromide (EDB)	EDB	Operational	P&T with carbon treatment	NA (due to minimal EDB in influent, no VOC removal is reported).	3 of 10	The highest EDB concentration in a monitoring well in 2006 was 2.9 µg/L, which continues a slow and steadily decreasing trend. Very low detections of EDB were observed in the extraction wells due to the low plume concentrations and dilution during the extraction process.

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

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 2006 Groundwater Status Report* is a comprehensive summary of groundwater data collected in calendar year 2006 that provides an interpretation of information on the performance of the Groundwater Protection Program. This is the eleventh 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 Long Term Response Actions (LTRA) Group. This technical document is intended for internal users, regulators, and other technically oriented stakeholders. This document can also be obtained through BNL's website. Data are presented in four 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 2006, 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 2006. 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 BNLs active experimental and support facilities. Chapter 5 is a summary of the proposed recommendations to the Groundwater Protection Program identified in Chapters 3 and 4.

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 LTRA 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 2006 Environmental Monitoring Report for the Current and Former Landfill areas.

1.1 Groundwater Monitoring Program

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 includes a requirement for groundwater monitoring (USEPA 1992).

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 2001a).

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 maximum concentration levels (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 2006a). 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. BNLs LTRA 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.

<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.

<u>Standby Monitoring</u>
This is a period of reduced monitoring over a 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.

<u>Post Closure Monitoring</u>
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. LTRA Groundwater Monitoring Program – Well Sampling Frequency.

Project Activity Phase	Well Type	Phase Duration (yrs.)	Sampling Freq. (events/yr.)
Start-up Monitoring	Plume Core	2	4x
	Plume Perimeter	2	4x
	Sentinel/Bypass	2	4x
Operations & Maintenance (O&M) Monitoring	Plume Core	End Start-up to Shutdown*	2x
	Plume Perimeter	End Start-up to Shutdown*	2x
	Sentinel/Bypass	End Start-up to Shutdown*	4x
Shutdown Monitoring	Plume Core	2	4x
	Plume Perimeter	2	4x
	Sentinel/Bypass	2	4x
System Standby Monitoring	Key Plume Core	5	2x
	Plume Perimeter	5	1x
	Sentinel/Bypass	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: 2045
*** - Verification monitoring for achieving MCLs.

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
- Sentinel – An early warning well to detect the leading edge of a plume.

1.2 Private Well Sampling

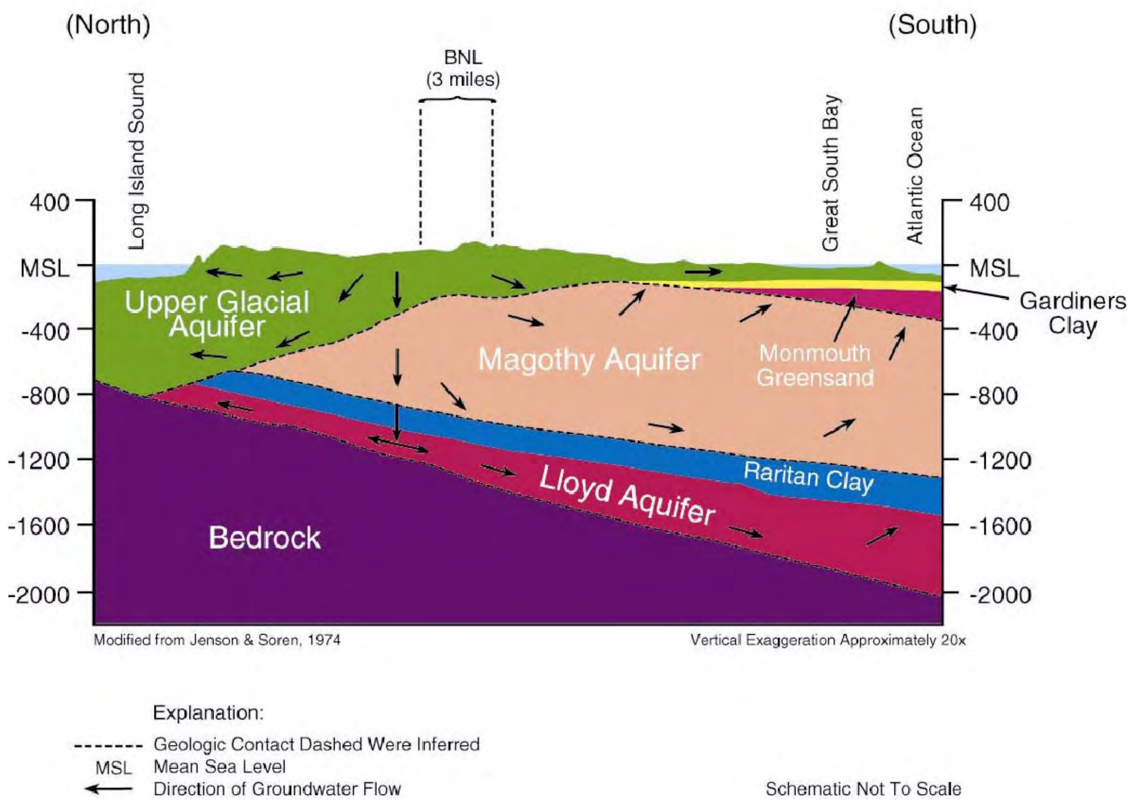
During 2006, there were eight known homeowners in the residential area overlying the plume who continue to use their private wells for drinking water purposes. In accordance with the OU III and VI RODs, annually DOE formally offers those homeowners free testing of their private drinking water wells. The response rate to the annual letters sent to the homeowners over the several years has been low, between one to two taking DOE up on the offer each year. During 2006, the eight homeowners were offered the free testing.

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 2006, 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 2006 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 the USGS.

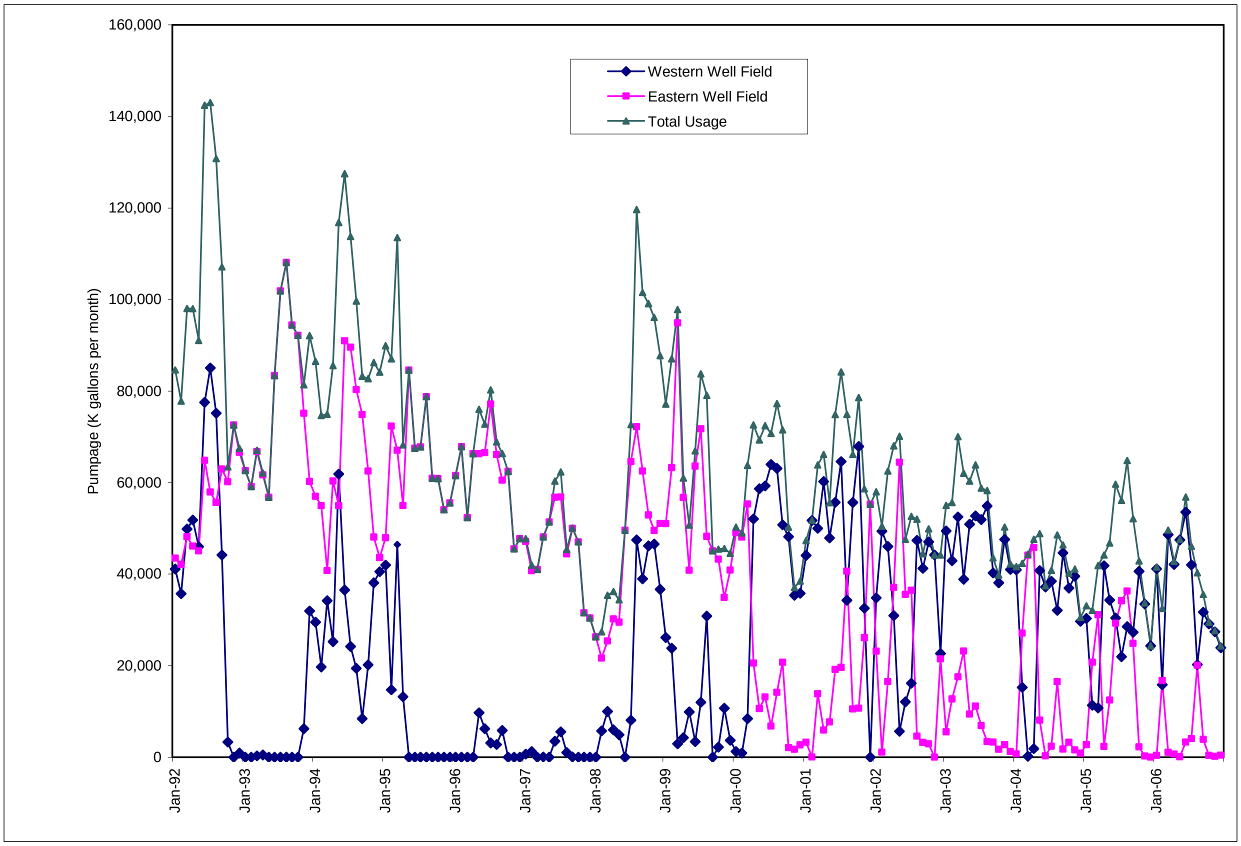
The quarterly synoptic water level measurement events comprising the complete network of on-site and off-site wells were reduced to a semi-annual event in 2006. This reduction was based on the fact that the groundwater remediation systems have all been operational for at least two years coupled with little overall change to pumping and recharge during that period. Synoptic rounds were conducted of the complete network from June 19 to 23, 2006 and December 11 to 15, 2006 with data collected from 756 and 785 wells, respectively. Reduced measurement efforts were conducted from March 29 to 31, 2006 and September 21 to 22, 2006 with data collected from approximately 100 shallow glacial wells during these events. The reduced measurement rounds were focused on the central portion of the BNL site in the vicinity of the plume source areas. These data are important for monitoring any changes to groundwater flow due to pumping and recharge and to collect data necessary for maintaining hydrographs for key wells. Water levels were measured with electronic water level indicators following BNL's Environmental Monitoring Standard Operating Procedure (EM-SOP-300). **Appendix A** has the depth-to-water (DTW) measurements and the calculated groundwater elevations for these 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 41 active treatment wells. There are 16 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 2006 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 currently requires that the western well field be used as the primary source of water, with a goal of 75 percent of sitewide potable and process water pumpage from that well field. 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 2006.



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.

The annual pumpage goal from the western well field is approximately 75 percent of total supply and process water pumpage. The western well field provided approximately 89 percent of the total water pumpage in 2006. The majority of the pumpage during 2006 was from Wells 6 and 7. Repairs to Well 4 allowed for it to be utilized to some degree in 2006. Eastern wells 11 and 12 were utilized significantly less than 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 2006. **Table 2-2** summarizes the 2006 BNL process water usage. **Table 2-3** summarizes the 2006 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 2006 is provided as **Figure 2-5.** In 2006, the William Floyd (Parr Village) and Country Club Drive Well Fields produced 406 and 436 million gallons for the year, respectively. Lambert Avenue produced 485 million gallons for the year. Total pumpage increased from 2005 values at the Lambert Avenue well fields in 2006 while slightly decreasing at the other two SCWA well fields.

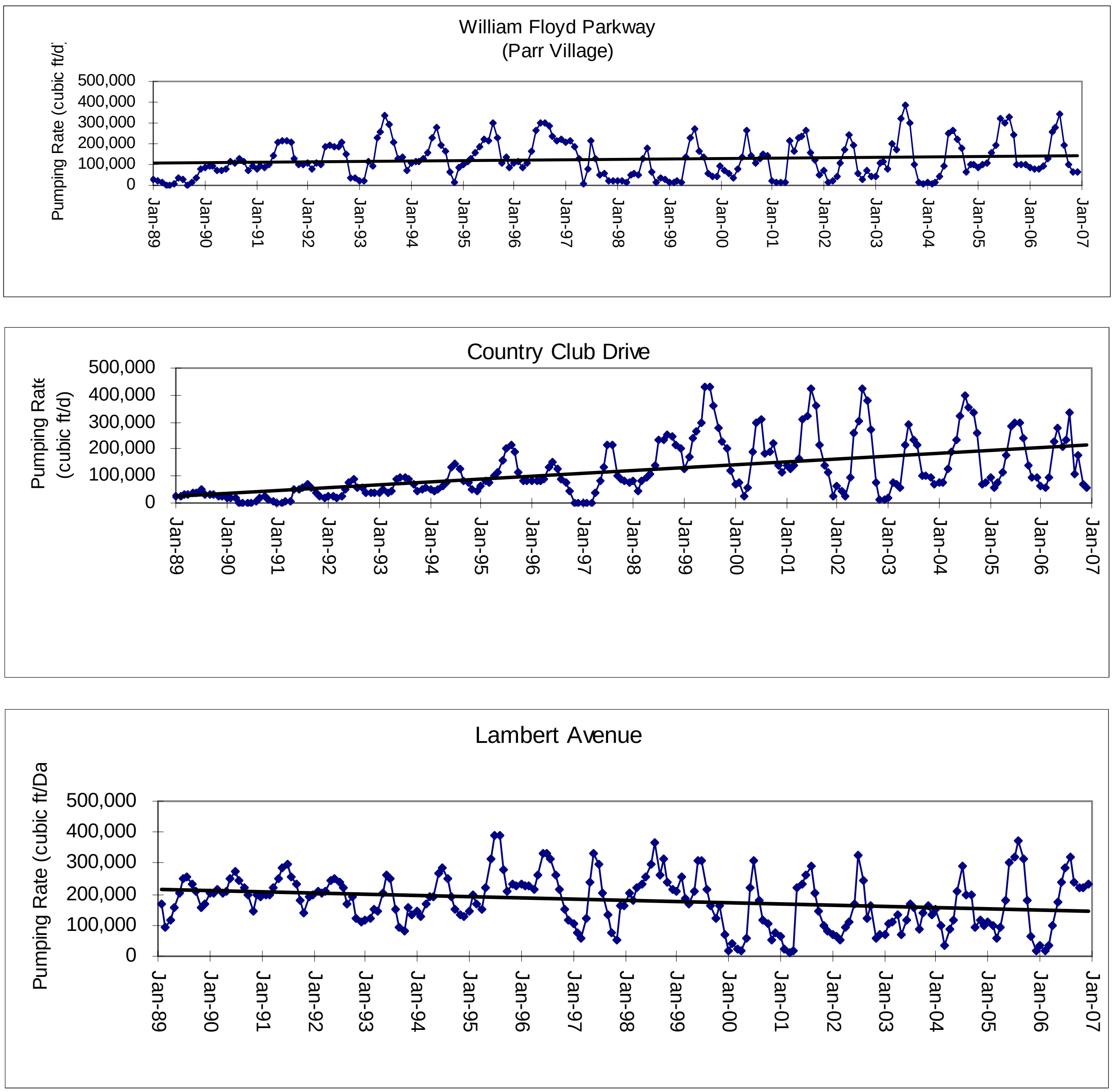
2.1.4 Summary of On-Site Recharge and Precipitation Data

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 10 on-site recharge basins during 2006. 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 permit requirements. Basin HP is no longer in use and as such will no longer be discussed in this report. Basin HP received secondary cooling water discharge from the Brookhaven Medical Research Reactor (BMRR), which is no longer in use. Generally, the amount of water recharging to the groundwater system to 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 2006 (17 and 29 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. Pulse pumping and the placement of several groundwater remediation extraction wells on standby in 2006 resulted in a slight overall decrease of discharge totals.

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 2005 and 2006.

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



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 2006, it is estimated that the recharge at BNL was approximately 31 inches. **Table 2-5** summarizes monthly and annual precipitation results from 1949 to 2006 collected on site by BNL Meteorology Services. Variations in the water table generally can be correlated with the amount of precipitation. As depicted in **Table 2-5**, total annual precipitation in 2006 was 61.6 inches, and is well above the yearly average of 48.76 inches. Four of the past five years have featured above normal annual average precipitation at BNL.

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 is a groundwater elevation contour map representing the configuration of the water table for December 2006. The contours were generated from the water level data collected during the December 2006 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 2006 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 (**Figure 2-2**). This pattern is consistent with comparable historical data published by SCDHS, USGS, and BNL. Compared to 2005, sitewide potable and process supply well pumping was re-established to the preferred western well field. This resulted in a shift back to a southeast to south groundwater flow direction in the central portion of the site from the temporary eastward component to flow observed in 2005. The target supply well pumping distribution resumed in late September 2005 and normal flow conditions were observed in 2006 as shown in **Figure 2-2**.

Localized hydrogeologic disturbances are evident on the groundwater contour maps. They result primarily from active on- and off-site SCWA supply 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 2006. 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 2006 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 present 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 1950–2006) and short-term (1997–2006) 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. In 2006, the USGS installed a real time continuous water level recorder in well S 5517 located adjacent to the southeast corner of the Brookhaven Center Building. Data from this monitoring station can be accessed on the world wide web at http://groundwaterwatch.usgs.gov/CRNSites.asp?S=405149072532201

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 2006 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. Based on data from both long and short-term hydrographs water table elevations in the BNL vicinity in 2006 were the highest observed since 1997 and just below some of the highest recorded water elevations observed since record keeping began in the 1940s (**Table 2-5)**.

2.3 New Geologic Data

In 2006 new geologic data were collected during the installation of temporary wells for the HFBR tritium plume, VOC contamination in Airport perimeter well 800-96 and TCA contamination in the vicinity of Weaver Drive and the Princeton Avenue firebreak road. These data did not significantly alter the BNL site conceptual model.

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3.0 ENVIRONMENTAL RESTORATION GROUNDWATER MONITORING AND REMEDIATION

Chapter 3 gives an overview of groundwater monitoring and remediation efforts at BNL during calendar year 2006. 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. Radionuclide plumes were contoured to their appropriate drinking water standard (DWS). **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

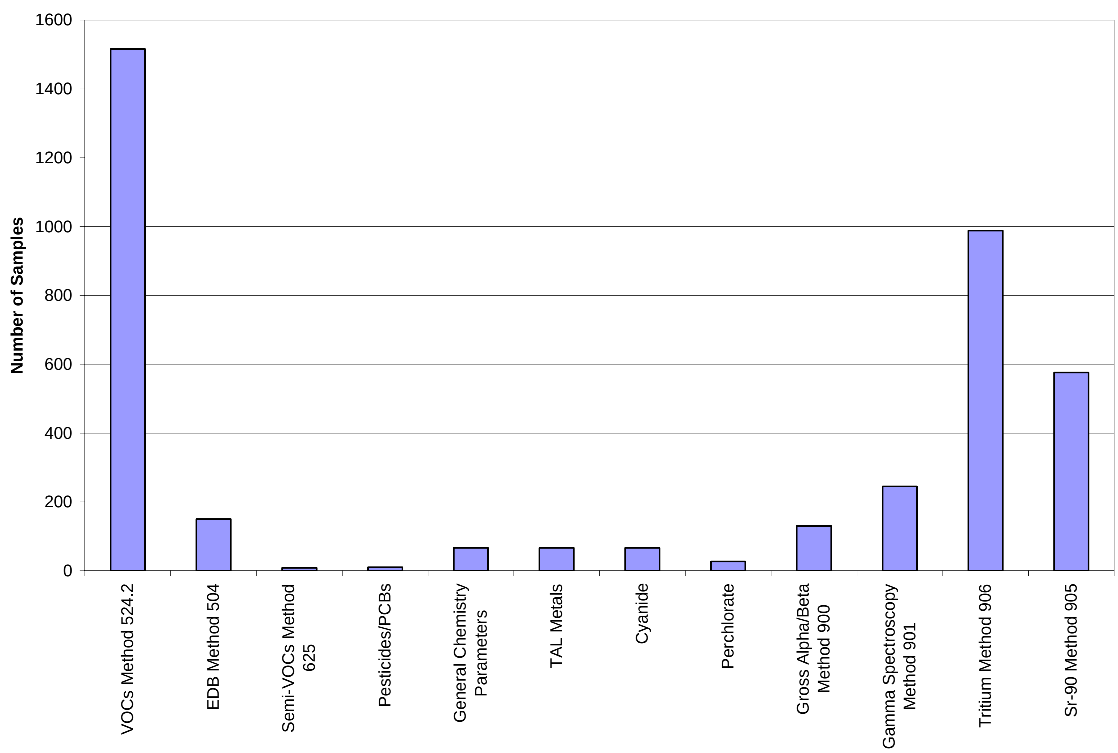
Additionally, BNL's ability to accurately depict these plumes has been enhanced over the years by:

- 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 2006, the contaminant plumes were tracked by collecting 2,097 groundwater samples obtained from 727 on-site and off-site monitoring wells. **Figure 3.0-2** below 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 2006 data from permanent monitoring wells. In several cases, data from early 2007 were utilized. Contaminant plumes associated with HFBR Tritium, Chemical/Animal Holes Sr-90, Airport, Middle Road, and Industrial Park East projects were further defined in 2006 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 2006.



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 (by 2030), 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 2005a) 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 70 years (by 2075) and 40 years (by 2045), respectively. In addition, cleanup of the Magothy aquifer VOC contamination must meet MCLs within 65 years (by 2070).

There are currently 12 groundwater remediation systems in operation, of which five off-site systems began operation in 2004. The last treatment system, for the on-site BGRR/WCF Sr-90 plume, began operations in 2005. Three systems are in standby mode (HFBR Tritium Pump and Recharge, the Carbon Tetrachloride Pump and Treat, and the Building 96 Treatment System) Another system has met its cleanup goals and has been decommissioned: 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.

Table 3.0-1. 2006 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	10	Basin	8 330
Operable Unit III						
South Boundary	P&T, (AS)	VOC	7	9	Basin	102 2525
HFBR Pump and Recharge	Pump and Recirculate	Tritium	3	Operate: 3 Standby: 6	Basin	NA 180
Industrial Park	Recirculation/ In-Well (AS/Carbon)	VOC	7	7	Recirculation Well	66 967
*Carbon Tet	P&T (Carbon)	VOC	3	Operate: 5 Standby: 2	Basin	NA 349
Building 96	Recirculation Well (AS/Carbon)	VOC	4	Operate: 4 Standby: 1	Recirculation Well	1 71
Middle Road	P&T (AS)	VOC	6	5	Basin	81 700
Western South Boundary	P&T (AS)	VOC	2	4	Basin	6 45
Chemical Holes	P&T, (IE)	Sr-90	1	4	Dry Well	0.24** 2.32
North Street	P&T (Carbon)	VOC	2	2.5	Wells	45 231
North Street East	P&T (Carbon)	VOC	2	2.5	Wells	5 16
LIPA/Airport	P&T and Recirc. Wells (Carbon)	VOC	9	2.5	Wells and Recirculation Well	53 200
Industrial Park East	P&T (Carbon)	VOC	2	2.5	Wells	5 29
BGRR/WCF	P&T (IE)	Sr-90	5	1.5	Dry Wells	5.1** 9.25
Operable Unit VI						
EDB	P&T (Carbon)	EDB	2	2.5	Wells	NA***

Notes:
AS = Air Stripping
AS/SVE = Air Sparging/Soil Vapor Extraction
EDB = ethylene dibromide
IE = Ion Exchange
LIPA = Long Island Power Authority
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.

NA = Not Applicable
* 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 twice in 2006, well below the standard. Therefore, no removal of VOCs are reported.

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 TVOC 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 the Operable Unit III Record of Decision (see **Section 3.2.9**).

Tritium is detected in several monitoring wells 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 2006, 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 2006 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.

Three quarterly reports were prepared with the operational data from January 1, 2006 through September 30, 2006. This Report also serves as a summary of the fourth quarter operational data. 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 TVOC contamination from the Current Landfill/former HWMF area based on the full round of samples collected in the third and fourth quarters of 2006. 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 plume (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 750 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 well 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 3.2.9,** the North Street East Pump and Treat System.

Figure 3.1-2 shows the vertical distribution of TVOCs. 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 2006 analytical results for the 57 wells. Significant findings for 2006 include:

- 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 2006 result indicated that TVOC concentrations have dropped to 5 µg/L. This well is screened in the Upton Unit immediately above the Gardiners Clay.
- Newly installed monitoring well 107-40 was sampled for the first time in 2006. TVOC concentrations were detected at levels up to 108 µg/L. The purpose of this well is to provide a monitoring point approximately 500 feet upgradient of extraction wells EW-1 and EW-2. The levels of VOCs detected in this well are indicative of the plume hot spot having reached this well and migrating towards the extraction wells.
- TVOC concentrations in well 115-13 increased from a maximum of 3 µg/L in 2005 to a high of 19 µg/L in 2006. This well is located in close proximity to EW-1 and EW-2 and the increasing TVOC concentrations indicate the arrival of the leading edge of the hot spot area migrating towards this area.
- There were no detections of VOCs above NYS AWQS in perimeter wells.
- TVOC concentrations in bypass wells 115-42 and 000-138 continued to decrease. This is evidence that the plume continues to be hydraulically contained at the site boundary.

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 wells 098-30 (immediately south of former HWMF) and 108-12 (located along the South Firebreak Road) from nondetectable levels up to 6,210 pCi/L and 5,050 pCi/L during 2006, most likely represent the attenuated remnants of elevated tritium concentrations originating from the former HWMF. A plot of historical tritium results for select OU I South Boundary program wells is shown on **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 on **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 8 pCi/L in September 2006. 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 slightly increased up to a high of 3.9 pCi/L in 2006. 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 Pollutant 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, and tritium quarterly.

The following is a summary of the OU I operations for 2006:

January–September 2006

The system operated normally during the first three quarters, with only minor shut downs due to various electrical problems. 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 2006

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

Table 3.1-1.
OU I South Boundary Pump and Treat System 2006 SPDES Equivalency Permit Levels

Parameters	Permit Level	Max. Measured Value
pH	6.0 – 9.0 SU	6.9 – 7.7 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:
SU = Standard Units
Required sampling frequency is monthly for VOCs and weekly for pH.

3.1.7 System Operational Data

Extraction Wells

During 2006, 154 million gallons of groundwater were pumped and treated by the OU I system, with an average flow rate of 582 gpm while operating. **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.

System Influent and Effluent

VOC and tritium concentrations in 2006 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 influent concentrations of TCA and DCA generally have decreased over the ten 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 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 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 rate of contaminants removed. The cumulative mass of VOCs removed by the treatment system vs. time was then plotted (**Figure 3.1-8**). During 2006, 7.5 pounds of VOCs were removed. Cumulatively, 330 pounds have been removed since 1997. Groundwater modeling estimated that the system would remove between 300 to 350 pounds by 2006–2007. 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 2006 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.

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***	0.00048
1,2-Dichloroethane	0.011	<0.0002
1,1-Dichloroethene	0.194	<0.0002
Chloroethane	10***	0.0004
1,1,1-Trichloroethane	10***	<0.0002
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.

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. The highest detection of tritium during 2006 was 540 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.

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 Groundwater Status 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 or extraction wells associated with the OU I South Boundary Pump and Treat System during 2006.

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 2006; 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 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 this 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 2006 and it appears that the trailing edge of this high concentration segment has migrated south of this area. Monitoring well 107-40 was installed in 2006 and will assist in tracking this high concentration segment as it migrates to the south boundary. 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 3.1.9**. Changes in the makeup of the plume are shown in **Figure 3.1-10**, which compares the TVOC plume from 1997 to 2006.

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 3.1-9**).

4c. How many individual plume core wells are above 50 µg/L?
Monitoring well 107-40, which was installed in 2006, is the only plume core well to have TVOC concentrations exceeding 50 µg/L.

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 to allow for the high concentration portion of the plume to migrate down to the extraction wells. 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:

- Based on TVOC concentration increases in well 115-13 and upgradient plume core well 107-40 the leading edge of the high concentration segment of the VOC plume is approaching the south boundary and should reach it during 2007. As a result, resume full-time operation of extraction wells EW-1 and EW-2 during the third quarter of 2007.
- 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.
- For consistency with previous changes made to the Current Landfill plume monitoring, delete monitoring of the system influent and effluent for metals (including iron and manganese), pesticides, PCBs, and gross alpha/beta.

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, the Warehouse area, various small sources in the north central developed portion of the site, 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. The eastern source areas no longer are contributing contamination to the plumes, based on the past several years of groundwater data. **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 Building 96 and Carbon Tetrachloride tanks area in the central part of the site, south to the vicinity of Flower Hill Drive off site (a distance of approximately 15,200 feet). The maximum width of its main body is about 2,200 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 25 μg/L. This contamination results from multiple small historical 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 the mid-1990s, in addition to more recent 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 2006 were south of Building 96, with TVOC concentrations up to 8,754 μg/L, continuing south to the Middle Road, with TVOC concentrations of 950 μg/L, and the south boundary, with TVOC concentrations up to 367 μg/L. TVOC levels range up to 375 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**) and C–C' (**Figure 3.2-3**), as well as 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-concentration segments of the plumes. Cross section N–N' was added to this report to provide an east-to-west view of the stratigraphy and groundwater quality data in the vicinity of the additional planned OU III Airport extraction well. A comparison of the OU III plumes in 1997 and 2006 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 data from the OU III Carbon Tetrachloride Pump and Treat System and offers conclusions and recommendations for 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, 2006 through December 31, 2006.

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 2000a).

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 (shutdown phase), 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. However, there are also low levels of chloroform (a breakdown compound of carbon tetrachloride) up to 39 µg/L. 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 carbon tetrachloride isocontour, is approximately 120 feet. The complete 2006 analytical results from the monitoring of wells in the carbon tetrachloride program are provided in **Appendix C**. A summary of key monitoring well data for 2006 follows:

- 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 21 µg/L in October 2006 (**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 24 µg/L in October 2006 **(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 2006, with a concentration of 20µg/L in October 2006.
- 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 <0.5 µg/L in October 2006 **(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 2004j). 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 <0.5 µg/L in October 2006, 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, they varied from 44 µg/l to 89 µg/L in 2006.

3.2.1.4 System Operations

Operating Parameters

In 2006, the extraction wells were sampled quarterly. All samples are analyzed for VOCs. The extraction well data is located in **Table F-6**. The parameters for sampling pH and VOCs adhere to the requirements of the SPDES equivalency permit. However, the system was in standby in 2006. The system operations are summarized below.

January – December 2006

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

None.

Cumulative Mass Removal

The system was shut down for the entire year so no mass removal is calculated.

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 one month in 2005. The system remained in stand-by mode for all of 2006. The groundwater extraction wells will remain on a quarterly sampling schedule to monitor for any significant rebound in concentrations of carbon tetrachloride.

The Carbon Tetrachloride Pump and Treat System performance can be evaluated based on the five major decision rules identified by applying the DQO process.

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

No. There were no detections of either carbon tetrachloride or any other contaminants in wells associated with this monitoring network during 2006 that would have triggered the BNL Groundwater Contingency Plan.

<u>*2. Were the cleanup goals met?*</u>

Yes. The groundwater cleanup goals for the system have been met. The system was shut down in August 2004.

<u>*3. Has the plume been controlled?*</u>

Yes. The plume has been controlled, and the system is in standby mode.

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 of meeting MCLs 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:

- If significant concentrations of carbon tetrachloride are detected in monitoring or extraction wells, the system will be turned on.
- Change the monitoring well sampling frequency from shutdown phase (quarterly) to standby (semi-annually).
- Move monitoring well 095-92 to the Middle Road Pump and Treat System well network.

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3.2.2 Building 96 Air Stripping System

This section summarizes the 2006 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 (RTW-2, -3, and -4) were placed in standby mode in July 2004 and the fourth recirculation well (RTW-1) was initially 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. As noted in **Section 3.2.2.4**, RTW-1 was placed back in standby mode in June 2006.

Due to the continuing source of VOC contamination in the silt zone, three injections of the oxidizer potassium permanganate ($KMnO_4$) were conducted from December 2004 through January 2006. Based on the monitoring well data in 2006, these injections were not successful with reducing the high VOC concentrations in the silt zone.

3.2.2.1 System Description

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 2002a). A modification to this manual was prepared and is titled, *Operations and Maintenance Manual Modification, Building 96* (BNL 2004c).

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**. Based on data observations over the past several years, a monthly sampling frequency is no longer necessary for the monitoring wells. The monthly frequency was initiated in December 2004 to help provide additional data points to evaluate the success of the KMnO4 injections. Since sufficient data has been collected following the injections, the monitoring well sampling frequency was changed from monthly to quarterly, effective the third quarter of 2006. The fourth-quarter 2006 plume is shown on **Figure 3.2.2-1**. The highest TVOC concentration seen in 2006 was 8,754 μg/L, from well 085-353, during the May sampling round. Historically, the highest concentration seen in this area was 18,000 μg/L TVOCs, in well 095-84 in October 1998. As shown in trend **Figure 3.2.2-2**, monitoring wells 085-347, 085-353, and 095-84 continue to show significant rebounding of contamination over the last few years. Based on this data, the $KMnO_4$ injections have not been effective in the silt zone.

Monitoring wells downgradient of extraction well RTW-1 showed TVOC concentrations ranging from 1.3 μg/L to 290 μg/L. Monitoring well 095-295, located on the west side of the plume area, maintained low TVOC concentrations throughout 2006 despite higher concentrations detected in 2005. The highest 2006 TVOCs in well 095-295 were 9.8 μg/L. The contamination seen on the west side of the plume area would not be treated by RTW-2, RTW-3, or RTW-4 but is expected to be captured by the OU III Middle Road System.

The monitoring wells immediately downgradient of extraction wells RTW-2, RTW-3, and RTW-4 detected TVOC concentrations up to 131 μg/L in the western portion of the plume, 34.5 μg/L in the center portion, and 87.2 μg/L in the eastern portion of the plume.

3.2.2.4 System Operations

Operating Parameters

Three of the four downgradient extraction wells (RTW-2, -3, and -4) remained in standby mode in 2006. The influent from these three extraction wells was only sampled in November 2006 due to a scheduling error and downtime due to repairs on the wells. The highest TVOC concentration from the influent of these wells was 44 µg/L in RTW-2. VOC's in RTW-3 and RTW-4 were less than the drinking water standard (**Table F-7** in **Appendix F**).

Recirculation well RTW-1 is downgradient of the silt zone area, and pumps from below the silt zone (48 to 58 feet bls). This well recharges its effluent to the shallower zone above the silt zone (25 to 35 feet bls). The silt zone layer is between the lower extraction well screen and the upper discharge well screen for RTW-1. From a review of the monitoring well data, influent data, and the cross section for the Building 96 area, the continued operation of RTW-1 as a recirculation well may be causing adverse impacts on the plume. This is because the depth of the injection screen now has elevated TVOC concentrations. Well RTW-1 was placed in standby mode in June 2006, and sampled quarterly, to allow the $KMnO_4$ to work unimpacted by the operation of this recirculation well.

January –May 2006

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

June –December 2006

Extraction well RTW-1 was placed in standby mode in June 2006 and was sampled in July and November 2006.

3.2.2.5 System Operational Data

Recirculation Well Influent and Effluent

Three of the four downgradient extraction wells (RTW-2, -3, and -4) remained in standby mode in 2006. Even though these wells were off, an influent sample was collected in November 2006. **Table F-7** lists the influent VOC concentrations for recirculation wells RTW-2, -3, and -4. The highest TVOC concentration from the influent of these wells was 43.5 µg/L in RTW-2. VOCs in RTW-3 and RTW-4 were less than the NYS AWQS. **Tables F-7 and F-8** also lists the influent and effluent VOC concentrations. The highest influent TVOC concentration from RTW-1 was 187 µg/L from July 2006. In November 2006, TVOC concentrations dropped to 38 µg/L. Effluent VOC concentrations for RTW-1 were less than the NYS AWQS 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 the five months of operation 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-9** in **Appendix F**. During 2006, the treatment system removed approximately one pound of VOCs during its limited operation. Since February 2001, the system has removed approximately 71 pounds of VOCs.

Air Treatment System

Due to a scheduling error no air samples were collected in during the first six months of 2006 while RTW-1 was operating. However, based on the influent groundwater concentrations and past operating history of this system, the carbon effluent during the operating year would be less than the New York State allowable emission rates (lbs/hr) (**Table 3.2.2-1**).

3.2.2.6 System Evaluation

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 silt soil zone of the aquifer upgradient of RTW-1. Therefore, in an attempt to reduce the high concentrations of VOC, primarily PCE, in the silt zone area upgradient of RTW-1, the injection of $KMnO_4$ was conducted (BNL 2004d). Three rounds of $KMnO_4$ injections have been conducted in the silt zone area upgradient of extraction well RTW-1. 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 percent 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 percent 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).

Table 3.2.2-1.
OU III Building 96
VOC Emission Rates, 2006 Average

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

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
NS = Not sampled

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 remained less than 380 µg/L to meet the OU III ROD cleanup objectives [Note: The value of 380 µg/L was developed based on the groundwater model as part of the Bldg. 96 Shutdown Petition.] 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. This round consisted of 330 gallons of a 2.0 percent 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 silt zone area upgradient of RTW-1 near wells 085-353 and 085-347. The highest TVOC concentrations in this area in 2006 were 8,754 µg/L and 2,442 µg/L in wells 085-353 and 085-347, respectively.

In the area upgradient of extraction well RTW-1, contamination is seen at two distinct depths that are separated by a low permeability zone (silt zone). A shallower area of contamination is located above and in this silt zone, approximately 20 to 27 feet bls. Also, a deeper zone of contamination is below the silt zone at approximately 30 to 55 feet bls. The focus of the $KMnO_4$ injections were the areas above, in, and below the silt zone. 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 well data, the $KMnO_4$ injections have not been effective in reducing the PCE concentrations in the shallow silt zone, thereby not meeting the remediation goals at this area. Specific wells where this is evident include 085-347, 085-353, and 095-84. A comparison of the plume from 2000 to 2006 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?
Yes. Potassium permanganate has not been effective in reducing the contamination in the silt zone. This has been communicated to the regulators via the Quarterly Operations Reports.

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 2002a), as updated by the *Operations and Maintenance Manual Modification Building 96* (BNL 2004c), the source control goals for this system have not been met. Based on monitoring data, the $KMnO_4$ injections have not been effective in remediating the PCE concentrations in the shallow silt zone. As a result, a continuing source of high VOC contamination still exists.

3.2.2.7 Recommendations

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

- As an interim action to maintain hydraulic containment of the source area, modify recirculation well RTW-1 to work as a pumping well and discharge to the nearby surface drainage culvert. This will involve running a discharge line to the culvert about 300 feet away and will require a SPDES equivalency permit. This will be implemented by January 2008. Effluent sampling frequency will be performed as per the SPDES equivalency permit.
- Downgradient monitoring will continue and, if needed, downgradient recirculation wells RTW-2, RTW-3, and RTW-4 can be restarted if elevated TVOC concentrations (> 50 μg/L) 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. Maintain a monthly sampling frequency of the influent and effluent when the system is operating.
- Maintain the current sampling frequency of quarterly for the extraction wells when they are not operating.
- Since VOC concentrations didn't show a consistent decline in the source area wells, alternative methods for remediating the contamination in the silt zone upgradient of extraction well RTW-1 will be evaluated. This evaluation will include excavation of the source area, adding an additional extraction well in the source area and evaluating other remedial technologies and will be prepared by the end of 2007.
- Monitoring well sampling will continue at the current frequency.

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 2006, and presents conclusions and recommendations for future operation. The analytical data from the monitoring wells are also 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. In September 2006, well RW-6 was also placed in standby mode due to low VOC concentrations. The system is currently operating at a pumping rate of approximately 300 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 2003a).

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 generally below 10 µg/L. VOC concentrations have generally continued to decline in 2006. Results for key monitoring wells are as follows.

- The highest TVOC concentration detected was in bypass detection well 113-17, at 950 µg/L in February 2006. 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.
- A vertical profile (SBMAG-VP-201) and a new monitoring well (OU III SBMW-01-2006) were installed in 2006 to determine the depth and location of the higher VOC concentrations seen at well 113-17. The VP and well are located between the Middle Road and South Boundary systems. The results showed TVOC concentrations as high as 474 µg/L at a depth of 190-195 feet **(See Figure 3.2-2)**. A monitoring well was subsequently installed at this location and depth. A significant clay layer over 50 feet thick was also observed from approximately 220 – 275 feet below grade. This clay layer is not present at the Middle Road location. Three samples obtained below the clay at 280, 290 and 300 feet below grade showed all VOC concentrations at less then 1.5 µg/L (toluene) and no chlorinated solvents were detected. This data confirms observations at the south boundary that the contaminants observed at the Middle Road area are not migrating into the Magothy aquifer in this area.
- 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 65 µg/L in the fourth quarter of 2006 (**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 2006. TVOC concentrations decreased in well 105-44, from 423 µg/L in 2001 to 7 µg/L in the fourth quarter of 2006 (**Figure 3.2.3-1)**.

- A total of four vertical profile wells (Figure 3.2-1 MRVP-101 through MRVP-104) were installed during 2006 and January 2007 along Princeton Avenue to further characterize the high VOC concentrations in this area. **Table 3.2.3-1** shows the results of the four temporary wells. The highest concentration was observed in MRVP-103 at 210 feet below grade at 432 µg/L TVOCs. The second highest concentration was observed in the most westerly VP MRVP-104 at 200 feet below grade and a concentration of 207 µg/L TVOC.

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.

Table 3.2.3-2.
Middle Road Air Stripping Tower
2006 SPDES Equivalency Permit Levels

Parameters	Permit Limit *	Max. Observed Value
pH range (SU)	6.5–8.5	6.1 – 7.8
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	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

Notes:
ND = Not detected above method detection limit of 0.50 µg/L.
SU = Standard Units
Required sampling frequency is monthly for VOCs and pH.

3.2.3.4 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 except for pH (**Table 3.2.3-2**).

Approximately 173 million gallons of water were pumped and treated in 2006 by the OU III Middle Road System. The following paragraphs summarize the Middle Road System operations for 2006.

January–September 2006

Recovery well RW-6 was offline from June–July, due to electrical repairs and replacement of the pump and motor. Well RW-6 was placed in standby mode in September 2006. The system was shut down for 3 days to remove sand buildup in the inlet screens and the tower spray nozzles. Approximately 126 million gallons of water were treated.

October – December 2006

The system operated normally and pumped and treated approximately 47 million gallons of water during this time.

3.2.3.5 System Operational Data

System Influent and Effluent

All parameters in the SPDES equivalency permit limits were within the specified ranges during 2006, except for pH, which was slightly lower than the permit limits during one sampling event in 2006, most likely due to natural groundwater fluctuations.

Results from samples collected from the extraction wells are found on **Table F-10 (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 2006 was 61 µg/L (see **Table F-11**). The results from sampling the influent and effluent are summarized in **Tables F-11** and **F-12**, 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 333 gpm during 2006 (**Table 2-3**, and **Table F-13**), and approximately 81 pounds of VOCs were removed. Approximately 700 pounds of VOCs have been removed since the system began startup testing on October 23, 2001. The cumulative total of VOCs removed vs. time is plotted in **Figure 3.2.3-3**.

Table 3.2.3-3.
Middle Road Air Stripper
VOC Emission Rates, 2006 Average

Parameter	Allowable ERP* (lb/hr)	Actual** (lb/hr)
carbon tetrachloride	0.022	0.0003
chloroform	0.0031	0.0001
1,1-dichloroethane	10***	0.000047
1,2-dichloroethane	0.008	0.000002
1,1-dichloroethylene	0.034	0.0003
cis-1,2-dichloroethylene	10***	0.0001
trans-1,2-dichloroethene	10***	0
tetrachloroethylene	0.387	0.0081
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.

Air Discharge

Table 3.2.3-3 shows the air emissions data from the system for the OU III Middle Road tower during 2006, 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-10**). The concentration of each constituent was averaged for 2006, and those values were used in determining the emissions rate. All air emissions were below permitted limits.

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. RW-6 was shut down in September 2006 due to low VOC concentrations in this well. Quarterly sampling of this well will continue.

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 2006.

2.Has the plume been controlled?

Yes. VOC concentrations in plume perimeter wells remained stable at low concentrations during 2006, 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.

Semiannual 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 2006.

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. 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. (**Figure 3.2.3-4**).

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, RW-5 and RW-6 in standby mode during 2007. Restart the wells if extraction or monitoring well data indicate that TVOC concentrations exceed the 50 µg/L capture goal.
- Install one additional temporary well 150 feet west of MRVP-104 (**Figure 3.2-1**) to characterize the high-concentration portion of the plume in this area. Install two monitoring wells, one near MRVP-103 to monitor the high concentrations and one on the western edge of this plume to use as a perimeter monitoring well.
- The increased VOC concentrations (TCA, DCE) in well 095-92 **(Figure 3.2-1)** observed over the past several years where characterized in January 2007 as a follow up to last years annual report recommendation. A vertical profile well (095-92 2007 VP-1) was installed adjacent to this well. The highest concentration detected at this location was at 130 feet below grade with a concentration of TCA at 64 µg/L. This is consistent with the depth of well 095-92. The profile

was sampled from a depth of 210 feet below grade to 70 feet below grade. Results are shown in **Table 3.2.3-4.** No further action is required at this time as these contaminants are expected to be captured by the Middle Road groundwater treatment system.

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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 2006, 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. It utilizes air-stripping technology for treatment of groundwater contaminated with chlorinated solvents. The water is pumped from seven extraction wells. The system is currently operating at a pumping rate of approximately 500 gpm, utilizing five extraction wells. Extraction well EW-12 was placed on standby during October 2003, and EW-8 in October 2006 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 2003a).

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 efficiency 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**. A number of OU III South Boundary wells are also analyzed for radionuclides as detailed in **Section 3.2.14**.

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. Individual VOC concentrations in the plume perimeter wells were less than 5 µg/L except for well 121-08, which had a concentration of TCA at 7.1 µg/L in October 2006 (TVOC at 22 µg/L) (**Figure 3.2.4-1**). This is still well below the capture goal of the system of 50 µg/L TVOC. VOCs were detected in the deep Upper Glacial aquifer in the vicinity of the site boundary, as depicted in **Figures 3.2-2, 3.2.4-1, and 3.2.4-2. Appendix C** (on CD-ROM) has the complete groundwater monitoring results for 2006.

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 2006 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. VOC concentrations remained below the NYS AWQS during 2006 except for a detection of TCA at 7.3 µg/L in October 2006.

- Plume core well 121-23 is immediately downgradient of EW-5. During 2006, the TVOC concentrations ranged between 116 and 131 µg/L. The primary contaminant observed is PCE. This is consistent with the contaminant and 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 recent PCE concentration in this well ranged from 780 µg/L in June 2005 to 5.3 µg/L in October 2006. PCE is the primary compound in wells 121-13, 121-23, EW-4, and EW-5. This rapid rise and then fall in concentrations of PCE represents a slug of contamination migrating into this area.
- Plume core well 121-11 is upgradient of EW-3. TVOC concentrations ranged from 34µg/L in May 2006 to approximately 25 µg/L in October 2006.
- 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, nearby 122-35, were below NYS AWQS in 2003 through 2006.
- Plume core well 122-05 is a Magothy monitoring well west of EW-8. TVOC concentrations have been showing a declining trend from recent levels of 50 µg/L in 2005 to 25 µg/L in October 2006.

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 in groundwater.

Table 3.2.4-1.
OU III South Boundary Air Stripping Tower
2006 SPDES Equivalency Permit Levels

Parameters	Permit Limit*	Max. Observed Value
pH range(SU)	6.5 – 8.5	6.3–7.8
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

Approximately 235 million gallons of water were pumped and treated in 2006 by the OU III South Boundary System. Well EW-8 was put in standby in October 2006 and EW-12 has remained in standby since 2003.

January–September 2006

Approximately 190 million gallons of water were pumped and treated. There were communications and electrical problems during this period.

October 2006-December 2006

The OU III South Boundary System pumped and treated approximately 44 million gallons of water. There were electrical problems with EW-3 during October.

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 declining trend of concentrations. The system was also sampled monthly for tritium, which was not detected above the reporting limit in any sample during 2006. System influent and effluent sampling results are summarized in **Tables F-15** and **F-16**, 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-17**). The cumulative total of TVOCs removed by the treatment system versus time is plotted in **Figure 3.2.4-4**. The 2006 total was approximately 102 pounds. Cumulatively, the system has removed approximately 2,525 pounds since it was started on June 17, 1997.

Table 3.2.4-2.
South Boundary Air Stripper
VOC Emission Rates, 2006 Average

Parameter	Allowable ERP*	Actual** ER
carbon tetrachloride	0.022	0.0016
chloroform	0.0031	0.0002
1,1-dichloroethane	10***	<0.0002
1,2-dichloroethane	0.008	0.0001
1,1-dichloroethylene	0.034	0.0004
cis-1,2-dichloroethylene	10***	0.0001
trans-1,2-dichloroethylene	10***	0
tetrachloroethylene	0.387	0.009
1,1,1-trichloroethane	10***	0.0012
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 2006, 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-15**). 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 2006 (**Figure 3.2.4-3**). **Table F-14** 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 plume 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 445 gpm during 2006. 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 during one sampling period. 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.

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

No. There were no unusual or unexpected VOC concentrations observed in the monitoring and extraction wells associated with the OU III South Boundary Pump and Treat System during 2006.

<u>*2. Has the plume been controlled?*</u>

Yes. An analysis of the plume perimeter and bypass wells indicates that there has been a declining TVOC trend in 2006.

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 this 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. 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 15 years; at the end of 2006 it had operated for approximately 9.5 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 effectiveness of the Middle Road Groundwater Treatment System, and the travel time from the Middle Road to the South Boundary. 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 approximately five to 10 years. Therefore, the high concentrations observed in the vicinity of well 113-17 (located just south of the Middle Road System) will likely determine the operating period of this system (**Figure 3.2-1 and 3.2-2**).

The trend in the mean of the TVOC concentrations in the core groundwater monitoring wells is declining. The target contamination in this area is the result of periodic historical releases, rather than continuous sources of contamination (**Figure 3.2.4-5**).

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 2006 (**Figure 3.2.4-5**).

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

Yes. Starting in late 2005 and continuing through 2006 **(Figure 3.2.4-5)**.

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

Two core wells, 121-23 and SBMW-01, have TVOC concentrations above 50 µg/L, as well as extraction well EW-4.

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:

- Maintain the routine operations and maintenance monitoring frequency that began in 2003.
- Extraction well EW-12 was placed in standby mode in 2003 and EW-8 in 2006. These wells will continue in standby mode during 2007. The wells will be restarted if extraction or monitoring well data indicate TVOC concentrations exceed the 50 µg/L capture goal.
- Place extraction wells EW-6 and -7 in standby mode in October 2007 due to low VOC concentrations in these wells. Therefore, four of the seven extraction wells will be in standby mode at the end of 2007. The highest VOC concentration observed in well EW-6 in 2006 was 6.5 µg/L in October 2006 and the maximum TVOC concentrations was 15.6 µg/L in October. This is well below the capture goal of 50 µg/L. Well EW-7 had a maximum VOC concentration of 8.1 µg/L of TCA in January 2006 and a TVOC maximum of 15 µg/L. Continue quarterly sampling of these wells. The wells will be restarted if extraction or monitoring well data indicate TVOC concentrations exceed the 50 µg/L capture goal.

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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 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 2002b).

3.2.5.2 Groundwater Monitoring

A network of 17 wells are 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 2006 monitoring well concentrations. A summary of key monitoring well data for 2006 follows:

- Plume core wells 121-42, 126-11, 126-13, 126-14, 127-04, and 127-06 have been generally 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. The highest TVOC detection of these seven plume core wells was 25 μg/L in well 126-14 in May 2006.
- Maximum TVOC concentrations during 2006 were found in bypass detection well 126-16, located south of extraction wells WSB-1 and WSB-2, at 57 μg/L during the fourth quarter, with dichlorodifluoromethane as the highest VOC, at 37 μg/L. The TVOC concentration for this well dropped-off to its lowest level in four years to 19 μg/L in the first quarter of 2007. Over time, similar to the plume core wells above, the concentrations are expected to drop off even though theses wells were installed prior to the system installation.
- TVOC concentrations in the other two bypass detection wells, 127-07 and 130-08, have also remained steady, between 20 μg/L to 51 μg/L, since the system started. If any of the three bypass detection wells starts showing increasing trends, the need to take further action will be evaluated.
- Plume perimeter well 130-03, located west of extraction well WSB-1, detected a maximum TVOC concentration in 2006 of 35 μg/L in May 2006. This is a decreasing trend from the historical high of 58 μg/L TVOCs in December 2004. The capture zones of the Western South Boundary extraction wells were not intended to include this area.
- 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 2006.

3.2.5.4 System Operations

During 2006, the extraction wells were sampled monthly through October, then the frequency was changed to quarterly per the recommendations in the 2005 Annual Report. 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 2006
The treatment system operated normally from January to September. The system is in a pulse pumping schedule set forth in the *2004 Groundwater Status Report* recommendations. The system is on a schedule of one month on and two months off.

October–December 2006
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.

Table 3.2.5-1.
Western South Boundary Pump & Treat System
2006 SPDES Equivalency Permit Levels

Parameter	Permit Level (µg/L)*	Max. Measured Value (µg/L)
pH range	6.5–8.5 SU	6.5–7.7 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

Required effluent sampling frequency is 2x/month for VOCs and monthly for pH.

3.2.5.5 System Operational Data

Extraction Wells
During 2006, approximately 54 million gallons of groundwater were pumped and treated by the OU III Western South Boundary System, with an average flow rate of approximately 299 gpm while in operation. **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-18** 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 7 to 25 µg/L for 2006, and the July value for WSB-2 was 25µg/L. Most of the individual VOC compounds were below the NYS AWQS. (**Figure 3.2.5-1)**.

System Influent and Effluent
All influent TVOC concentrations were less than 24 µg/L, and individual VOC concentrations were less than the NYS AWQS except for November 2006 data that detected freon and TCA at 10 µg/L and 5.1 µg/L, respectively. These levels are consistent with the historical influent concentrations. The influent consists primarily of freon, TCA, TCE, and chloroform (**Tables F-19** and **F-20**, **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-21, Appendix F**). The cumulative mass of VOCs removed by the treatment system is provided in **Figure 3.2.5-2**. During

2006, six pounds of TVOCs were removed; a total of 45 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 2006 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	0.0003
1,1-dichloroethane	10**	<0.0002
1,2-dichloroethane	0.011	<0.0002
1,1-dichloroethene	0.194	0.0003
chloroethane	10**	<0.0002
1,1,1-trichloroethane	10**	0.0004
trichloroethene	0.119	0.0002

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 2006.

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 2006, indicating that the plume is being controlled. In addition, perimeter well 130-03 has been slowly decreasing since late 2004. 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, 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. Extraction wells WSB-1 and WSB-2 have shown generally steady and low concentration trends since 2002 at approximately 10 µg/L and 20 µg/L TVOCs, respectively. However, there was an approximate doubling of TVOC concentrations in

extraction well WSB-2, to 25 µg/L, starting in late 2005 through 2006. Most of the extraction well and influent individual VOC data has been below the NYS AWQS.

4b. Is the mean TVOC concentration in core wells less than 20 µg/L?
No. Six out of seven core wells have been below 20 µg/L TVOCs for the past 18 months. Also, in 2006, four of seven plume core wells show individual VOCs below the NYS AWQS.

4c. How many individual plume core wells are above 20 µg/L TVOCs?
TVOC concentrations in one of seven core wells were above 20 µg/L. Well 126-14, just upgradient of extraction well WSB-1, showed TVOCs up to 25 µg/L in 2006. .

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. However, since then, there has been no significant variation in the TVOC concentration in core wells during the time the extraction wells were in standby mode. TVOC concentrations in the extraction wells typically averaged between 7 to 25 µg/L for 2006, consistent with previous years.

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:

- Maintain the routine O&M monitoring frequency that began in 2005.
- Due to the low influent concentrations, and because six out of seven plume core wells have reached the cleanup objective of 20 µg/L TVOCs, continue pulse pumping the extraction wells. The wells will be shut down for two months, then turned back on for one month. This process will continue and any changes to the VOC concentrations in the influent and the monitoring wells will be evaluated.

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 2006 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 3.2.4-1** 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 2000b).

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 3.2.4-1.** Screen depths are set 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

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**. VOC concentrations in the plume perimeter wells that monitor the width of the plume (000-245 and 000-272) remained below NYS AWQS during 2006. 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 2006 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 and 3.2.4-1**.

2006 Results for key monitoring wells are as follows.

Plume Core Wells

- 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 TVOC, have continued to show concentrations at or below NYS AWQS.
- Well 000-259, which was sampled in June and November 2006 (between UVB-2 and UVB-3) had elevated concentrations of 356 µg/L and 243 µg/L TVOCs, respectively. This is consistent with data observed in extraction wells UVB-2 and -3.
- A steady decline in TVOC concentrations was observed in well 000-112 (immediately upgradient of UVB-1 and UVB-2) since 1999. TVOC concentrations were at 5 µg/L in November 2006 (**Figure 3.2.6-2**).
- Well 000-262 (between UVB-4 and UVB-5) began showing decreasing TVOC concentrations in 2002 (**Figure 3.2.6-2**). TVOC concentrations in this well peaked at 2,175 µg/L in 2001 and dropped to 211 µg/L in November 2006. This is consistent with data observed in adjacent UVB wells 4 and 5.
- The TVOC concentration in well 000-268 (between UVB-6 and UVB-7) was 183 µg/L in November 2006 (**Figure 3.2.6-2**). These data are consistent with data observed in UVB wells 6 and 7.

Plume Bypass Wells

- TVOC concentrations in most of the wells located near Carleton Drive were stable or decreasing during 2006. Wells 000-431 and 000-432 serve as bypass monitoring points downgradient of UVB-2. Well 000-432 has shown TVOC concentrations between 3 µg/L and 25 µg/L during 2006. TVOC concentrations in 000-431 were below NYS AWQS during 2006. The low TVOC concentrations in these wells indicate that the system is effective in hydraulically controlling the plume.
- TVOC concentrations in wells 000-275, -276, -277, and -278 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 23 µg/L (March 2006), in well 000-278.
- Wells 000-273 and -274 have shown an increasing concentration trend. Well 000-273 went from 15 µg/L in March to 375 µg/L TVOC in November, and well 000-274 from 20 µg/L in March to 143 µg/L in November. These wells are located immediately downgradient of well UVB-1, which was shut down in October 2005. These TVOC concentrations being observed in the monitoring wells are from contamination that was in the "stagnation zone" downgradient of UVB-1 while it was operating. Now that it has been shut down, the contaminants have migrated downgradient of the extraction well. These contaminants could not be captured by the extraction well because they were too far downgradient but were held up by the pumping. These slugs should pass by the monitoring wells and then the concentrations should quickly decline. These contaminants will eventually be captured by the LIPA extraction wells.

Perimeter Wells:

- VOC concentrations for individual constituents remained below NYS AWQS (5 µg/L) in each of the shallow wells screened to monitor above the adjacent UVB effluent well screens.

3.2.6.4 System Operations

In 2006, approximately 148 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 2006:

Well UVB-1 remained in standby mode throughout the year.

January – September 2006

The system was off from February 16 to March 8 for repairs to the blower. Well UVB-2 was off for several months with electrical problems. UVB-3 ran intermittently from April through June with electrical problems. The system was shut down June 20 for a carbon change-out and re-started June 21. In August, wells UVB-5, -6 and -7 were off at various times during the month with electrical problems. Well UVB-3 was off most of August and September awaiting repairs.

October – December 2006

Well UVB-2 was off from October 3 to November 15, with electrical problems. Well UVB-7 was off from October 10 to November 11 for repairs. The entire system was off from November 13 to November 16 due to electrical problems. UVB-5 was off from December 5 to December 31 for repairs.

3.2.6.5 System Operational Data

Recirculation Well Influent and Effluent

During 2006, influent TVOC concentrations in all treatment system wells remained stable, except for a significant drop in the TVOC concentrations in UVB-2 in the fourth quarter. This is due to the extraction well undergoing electrical repairs. (**Figure 3.2.6-3**). The corresponding effluent well concentrations (**Figure 3.2.6-4**) showed decreasing or stable TVOC concentrations for the year. UVB-1 remained in stand-by mode for 2006. There was significant downtime in 2006 due to electrical problems and fouling of the recharge screens.

Overall for 2006, the average removal efficiency was 89 percent (**Table F-22**, **Appendix F**). Well UVB-1 was not used in this calculation because it was off and well UVB-4 was not utilized because all of the influent concentrations were very low.

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. **Table F-23** summarizes these data and they are included in **Appendix F**. Flow averaged approximately 42 gpm for the six operating wells during 2006. **Figure 3.2.6-5** plots the total pounds of TVOCs removed by the treatment system vs. time. During 2006, 66 pounds were removed from the aquifer, with a total of 966 pounds removed since 1999. 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 was 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 576 cfm for the seven wells during 2006 (**Table F-24, 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 or extraction wells associated with the OU III Industrial Park System during 2006.

2. Has the plume been controlled?
Yes. An analysis of the plume perimeter and bypass well data reveals that there were no significant VOC concentration increases in these wells during 2006, except for higher concentrations in wells 000-273 and -274, which is expected, as explained in **Section 3.2.6.3**. Therefore, it is concluded 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 2006. 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 trend in the mean of the TVOC concentrations in the core groundwater monitoring wells is declining (**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 2006, concentrations showed an overall slightly decreasing trend.

4b. Is the mean TVOC concentration in core wells less than 50 µg/L?
No, the mean TVOC concentration in the plume core wells was 76 µg/L in the fourth-quarter 2006.

4c. How many individual plume core wells are above 50 µg/L TVOC?
Three (000-259, -262, and -268) of the nine plume core wells have TVOC concentrations exceeding 50 µg/L, as of the fourth quarter 2006.

4d. During pulsed operation of the system, is there significant concentration rebound in the core wells?
No. The OU III Industrial Park In-Well Air Stripping 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 2007.
- The system should continue operations at 60 gpm per well except for well UVB-1, which is to remain in a standby mode. It is recommended that well UVB-4 be placed in standby beginning in October 2007, since influent concentrations to this well are at or near the drinking water standard and have been for over a year. Monthly sampling will continue, and if TVOC concentrations greater than 50 μg/L are observed, wells UVB-1 and -4 will be restarted.

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3.2.7 Industrial Park East Pump and Treat System

This section summarizes the 2006 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, 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 system.

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 2006 were found in upgradient plume core well 122-24, at 21 µg/L during the first quarter, with TCA as the highest VOC, at 8 µg/L.
- In plume core well 000-514, about 100 feet west of the extraction wells, TVOC concentrations were detected ranging from 2 µg/L to 9 µg/L during 2006.
- VOCs in plume bypass wells 000-493, -494, and -495 have remained below the MCL since they were installed in June 2004.
- A temporary well, IPEVP-01, near well 000-514 was installed to evaluate concentrations of deeper contamination in this area **(Table 3.2.7-1** and **Figure 3.2.6.1).** The results of this vertical profile showed no concentrations above 16 µg/L TVOC. Since no concentrations exceed 50 µg/L, no additional action is required at this location.
- The recommendation in the *2004 Groundwater Status Report* to install an additional Magothy monitoring well adjacent to well 000-495, but deeper, is no longer required based on the low concentrations observed in the vertical profile data from the recent vertical profile performed in this area.

3.2.7.4 System Operations

Operating Parameters

The influent, midpoint, and effluent of the carbon vessels are sampled twice a month. 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 3.2.7-2**).

Table 3.2.7-2.
Industrial Park East Pump & Treat System
2006 SPDES Equivalency Permit Levels

Parameters	Permit Limit (µg/L)	Max. Measured Value (µg/L)
pH (range)	5.5–8.5 SU	5.6–6.6 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

Required sampling frequency is monthly for VOCs and pH.

System Operations

The following information summarizes the system operations for 2006.

January –September 2006

The system was off from May 18 to May 23 for electrical repairs. EW-2 was off from July 24 to September 1 to replace the pump. Sixty-eight million gallons were pumped and treated during the first three quarters of 2006.

October–December 2006

The system was off from October 16 to October 18 for repairs. The system was also off from November 20 to December 18, for development of the diffusion well. The system pumped and treated 16 million gallons of groundwater this quarter.

Extraction Wells Operational Data

During 2006, approximately 84 million gallons were pumped and treated by the IPE system, with an average flow rate of 160 gpm. **Table F-25** shows the monthly pumping data for the system. VOC concentrations for the IPE extractions wells are provided in **Table F-26**. TVOC concentrations in EW I-1 ranged from 3.1 µg/L to 14.7 µg/L throughout 2006 and 3.4 µg/L to 15.8 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 were similar to levels that were recorded in 2005. **Tables F-27** and **F-28** 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-25 lists monthly pumpage rates for 2006 and gives total pounds of VOCs removed by the treatment system. **Figure 3.2.7-1** plots mass removal versus time. Approximately 5 pounds of VOCs were removed from the aquifer during 2006, and 29 pounds since system startup in 2004.

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 2006 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 or extraction wells associated with the Industrial Park East Groundwater Pump and Treat System during 2006.

2.Has the plume been controlled?
Yes. The downgradient monitoring shows all concentrations below MCLs.

3. Is the System operating as planned?
Yes. The system is operating as planned.

4. Can the groundwater treatment system be shut down?
Yes , the system has met all shutdown requirements.

4a. Have asymptotic VOC concentrations been reached in core wells?
No; however, all monitoring wells except well 122-24 are now below MCLs.

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

4c. How many individual plume core wells are above 50 µg/L?
None.

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.

- Due to low VOC concentrations (all wells are less then the capture goal of 50 µg/L TVOC), in October 2007 begin pulse pumping of the extraction wells one month on and one month off at 115 gpm for EWI-1 and 75 gpm for EWI-2. The extraction wells will be restarted if data indicate that capture goal of 50 µg/L TVOC is exceeded. If no rebound is seen (i.e., TVOC concentrations exceeding 50 µg/L) in extraction or monitoring wells after one year of pulse pumping, then petition for shutdown of this system.

- Change the monitoring well network sampling frequency from the O&M phase (semiannual sampling) to the shutdown phase (quarterly sampling) starting in the third quarter of 2007 (July through September).

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 (**Figure 3.2-1**).

Groundwater treatment consists of two extraction wells operating at a combined pumping rate of approximately 450 gpm. This pumping captures 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 into the Magothy aquifer.

The North Street plume has been divided into two segments for remediation purposes. The area to the north of extraction well NS-2 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 27 wells monitors the North Street VOC plume (**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) as well as the Former Landfill/Chemical/Animal Holes. Wells sampled under the OU III South Boundary and Industrial Park Programs are also utilized for mapping this plume.

Sampling Frequency and Analysis

The 27 wells are sampled and analyzed for VOCs according to the schedule in **Table 1-5**. Twenty-four 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, TCA, and chloroform. **Figure 3.2-1** and **Figure 3.2.8-5** depicts the TVOC plume distribution and includes data from the monitoring wells. The complete groundwater monitoring well data for 2006 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 less than 11 µg/L in 2005 and 2006. Plots of the VOC concentration trends in this area are shown in **Figure 3.2.8-2**.

High concentrations of VOCs continue to be observed in wells 000-463, -464, and -465 immediately upgradient of extraction well NS-1. Concentrations of TVOCs ranged from a low of 46 µg/L in well 000-464 in the fourth quarter of 2006, to a high of 603 µg/L in well 000-465 in the first quarter of 2006.

Values at bypass detection well 800-63, located about 2,500 feet upgradient of the Airport System, ranged from 34 µg/L in the second quarter of 2006 to 73 µg/L in the fourth quarter. This suggests that the leading edge of the higher concentration segment has reached this location. This contamination should be captured by the Airport system.

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 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 2006, the tritium concentration in this well was 610 pCi/L, consistent with 2005 data. The highest tritium detection in the North Street plume in 2006 was 1,020 pCi/L in well 000-469, located downgradient of well 000-153.

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
2006 SPDES Equivalency Permit Levels

Parameters	Permit Limit (µg/L)	Max. Observed Value (µg/L)
pH (range)	5.5 – 8.5 SU	5.5 - 7.6 SU
carbon tetrachloride	5	ND
chloroform	5	0.9
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

ND = Not detected above method detection limit of 0.50 µg/L.
Required effluent sampling frequency is monthly for VOCs and pH.

January–September 2006

Routine operations continued from January through September, with approximately 100 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. In addition the system was off for two weeks in January to clean and replace float switches in the injection wells. Various power surges due to lightning strikes were experienced during the first three quarters, all of which required system restarts and repair.

October–December

Routine operations continued from October through December. The system was off approximately two days per month to allow for scheduled carbon changeouts. Approximately 57 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 2006, with only minor shutdowns due to electrical outages, programmable logic controller (PLC) issues, scheduled maintenance, and GAC changeouts.

Extraction Wells

Table F-29 contains the monthly pumping data and mass removal data for the system. VOC concentrations for the extraction wells are provided in **Table F-30** in **Appendix F** (on the CD-ROM). TVOC values in well NS-1 declined from 68 to 31 µg/L over the year, and well NS-2 remained unchanged, with TVOC values ranging from 15 to 26 µg/L. In January 2006, extraction well NS-2 showed 1,830 pCi/L of tritium; however, the value is questionable since there were no detections the month prior to or following the detection.

System Influent and Effluent

VOC concentrations in 2006 for the NS carbon influent and effluent are summarized in **Tables F-31** and **F-32** in **Appendix F**. The combined influent declined from 75 µg/L in December 2004, to 26 µg/L in December 2006.

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 except for chloroform at 0.9 µg/L, 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 is plotted on **Figure 3.2.8-3**. During 2006, approximately 157 million gallons of groundwater were pumped and treated by the North Street system, and approximately 45 pounds of VOCs were removed. Since May 2004, the system has removed 231 pounds of VOCs. The mass removal data are summarized in **Table F-29.**

3.2.8.6 System Evaluation

Figure 3.2.8-4 compares the TVOC plume from 1997 to 2006. 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 TVOC) 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 segment of the plume 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 or extraction well associated with the North Street Pump and Treat System during 2006.

2. Has the plume been controlled?

Yes. The cleanup goals have not been met; however, 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 2006; thus, it can be concluded that that plume has not grown and continues to be controlled. It should be noted that bypass detection well 800-63 (just north of Moriches Middle Island Road) has shown TVOC concentrations up to 126 µg/L since 2004, and is clearly beyond the capture zone of the North Street extraction wells. This portion of the plume will be addressed by the Airport extraction wells directly downgradient.

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 eight homes in the residential area overlying the plume have been connected to public water. These eight 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. After two years of operation, the system influent VOC concentrations have been slightly higher than originally projected in the final design.

4. Are there off-site radionuclides that would trigger additional actions?
No. Based on monitoring and extraction well data, radionuclide contamination appears to be limited to isolated occurrences of tritium, primarily in the deep Upper Glacial aquifer, at concentrations well 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 ?
Currently five of twelve plume core wells are showing concentrations greater than 50 μg/L TVOC.

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 and current system performance, 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:

- Maintain the O&M sampling frequency for monitoring wells initiated in 2006.
- Change monthly sampling of the extraction wells to quarterly.
- Change system influent, midpoint, and effluent sampling frequency from weekly to twice per month.

3.2.9 North Street East Pump and Treat System

This section summarizes the 2006 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 are located in the same building and 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 15 wells. The monitoring program 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 (the 50 µg/L contour) 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/former HWMF/NSE plume. **Appendix C** contains a complete set of 2006 analytical results for the 15 NSE program wells. Significant findings for 2006 include:

- The plume continues to be bounded by the current network of wells.
- VOC concentrations in plume perimeter 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 core well 000-138 have dropped from 253 µg/L in 1999 to 8 µg/L during the fourth quarter of 2006.
- The maximum TVOC concentration in plume core well 000-124 was 10 µg/L in 2006, down from a high of 487 µg/L in 1998.
- TVOC concentrations in core well 000-478 were as high as 205 µg/L in 2004, but had dropped to 17 µg/L by December 2005, then increased to 49 µg/L in the fourth quarter of 2006. This well is upgradient of NSE-1.
- Plume core well 000-481, located between NSE-1 and NSE-2, has been increasing over the past couple of years, from a low of 5 µg/L TVOCs in 2004 to 46 µg/L in 2006.

- All monitoring wells in the plume have remained below the treatment system capture goal of 50 µg/L TVOCs in 2005 and 2006.
- The highest tritium concentration in the plume in 2006 was barely detectable at 660 pCi/L in well 000-215.

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
2006 SPDES Equivalency Permit Levels

Parameters	Permit Limit (µg/L)*	Max. Observed Value (µg/L)
pH range	5.5–8.5 SU	5.5– 7.6 SU
carbon tetrachloride	5	ND
chloroform	5	0.9
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 freq. is monthly for VOCs and pH.

3.2.9.5 System Operational Data

The NSE system operated from January through December 2006. The system was operational throughout 2006 with only minor shutdowns due to electrical outages, programmable logic controller (PLC) issues, and scheduled maintenance. During 2006, approximately 5.4 pounds of VOCs were removed. In October 2006 the system was placed in pulse pumping mode with the system on one month and off the next.

January through September

The system operated normally for the first three quarters of 2006. The system was down for three weeks in April due to electrical surges and their associated repair. The system pumped and treated approximately 100 million gallons of water.

October through December

The system operated normally for the last quarter of 2006. The system was off in October and December for normal pulse pumping operations. In this quarter, the system pumped and treated approximately 11 million gallons of water.

Extraction Wells

During 2006, 111 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-33** in **Appendix F**. Declining TVOC trends are noted for both wells during 2006, with concentrations below 10 µg/L reported in both wells during the fourth quarter.

System Influent and Effluent

VOC concentrations for 2006 for the carbon treatment influent and effluent are summarized in **Tables F-34** and **F-35** 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 the rate of contaminant removal (**Table F-36**). The cumulative mass of VOCs removed by the treatment system versus time was then plotted (**Figure 3.2.9-1**). It shows that 5.4 pounds of VOCs were removed during 2006, with a cumulative total of 16 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.

The North Street East Pump and Treat System performance can be evaluated based on the four 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 concentrations of contaminants observed in monitoring or extraction wells associated with the NSE Treatment System.

2. Has the plume been controlled?

Yes. The system has been in operation for two years, and an analysis of the plume perimeter and bypass wells shows that there have been no significant increases in VOC concentrations in 2006, 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. Even though shutdown criteria of reaching less than 50 μg/L TVOCs for at least four consecutive sampling rounds has been met in the core monitoring and extraction wells, two wells are just under the 50 μg/L criteria and should be captured by the system.

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

No. Since the system has only been operating for just over two years, sufficient time has not yet been realized to reach an asymptotic condition. These conditions may be achieved in the next few years.

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

No. All core wells were below 50 μg/L TVOCs; however, wells 000-478 and -481 detected 48 μg/L and 46 μg/L, respectively.

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

Since the system was first shut down starting October 2006, there was only one sampling event since then, in November. This is not sufficient time to evaluate if rebound is occurring.

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 Recommendations

The following recommendations are made for the NSE Pump and Treat System and groundwater monitoring program:

- Continue pulse pumping of both extraction wells, since the system influent concentrations have remained very low over the past year and all of the monitoring wells are already below the capture goal of 50 µg/L TVOC. The pulse pumping consists of having the system on for one month, then off in standby mode for the next month. 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 the core monitoring wells or the extraction wells, the well(s) will be put back into full-time operation.
- Since the system has been operating for over two years, change the sampling frequency for the monitoring wells from start-up to the O&M phase (core and perimeter wells sampled semi-annually, and sentinel wells sampled quarterly). However, plume core wells 000-481, -482, -483, and -484 should be maintained at the quarterly sampling frequency since they are immediately upgradient of extraction well NSE-2.
- Lower the pump location four feet in monitor wells 000-482, -483, and -484 to obtain representative data from a slightly deeper portion of the aquifer.

3.2.10 LIPA/Airport Pump and Treat System

3.2.10.1 System Description

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

1. The Magothy extraction well (EW-4L) 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, -2L, and -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. The Airport system wells were installed to prevent further migration of the plumes. They have a capture goal of 10 µg/L TVOC.

The water from the four LIPA 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 portion of the plume and was designed to monitor the VOC plume off site, south of the OU III Industrial Park System. 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 components of the system. **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 for VOCs.

3.2.10.3 Monitoring 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 2006 well data is posted on **Figures 3.2-1** and **3.2.10-1**. The complete results are in **Appendix C** and **Table F-38** in Appendix F summarizes the data for the extraction wells. Results for key monitoring wells and extraction wells are as follows.

- Maximum TVOC concentrations during 2006 for the Magothy extraction well EW-4L on Stratler Drive were detected in April 2006 at 106 µg/L. The lowest TVOC concentration observed was 38 µg/L in February 2006. The concentration was 82 µg/L in December 2006. 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 TVOC, with well 000-130 showing the highest concentration, at 22 µg/L in the fourth quarter of 2006.

- The three Upper Glacial LIPA extraction wells all showed the following TVOC concentrations during 2006. Well EW-1L had 10 µg/L in January and 8µg/L in December. Well EW-2L had 22 µg/L in January and 38 µg/L in December. Well EW-3L had 10 µg/L in January and 8 µg/L in December 2006.
- All monitoring wells near the extraction wells for the airport system are below MCLs except for well 800-96. However, upgradient monitoring wells 800-94 and -95, approximately 1,500 feet north of wells RTW-1A and -2A, have historically shown TVOC concentrations primarily composed of carbon tetrachloride ranging up to 100 µg/L. This is an indication that higher concentrations should be expected at the extraction wells. The five airport extraction wells had VOC concentrations below MCLs throughout 2006.
- Well 800-96 is screened from 180 to 200 feet below grade. The well was installed as a western perimeter monitoring well for extraction well RTW-1A. Sampling of this well began in March 2004. No detections of carbon tetrachloride were found in this well until December 2005, when it was detected at 1.6 µg/L. In June 2006 a concentration of carbon tetrachloride of 10 µg/L was detected in this well, and on August 31, 2006 the concentration increased to 40 µg/L. Due to these recent VOC increases, the monitoring frequency for this well was changed from quarterly to monthly beginning in December 2006. Subsequent sampling showed concentrations of 100 µg/L in November 2006, 60 µg/L in December, and 51 µg/L in January 2007. When the August data were received, a work plan was developed for a groundwater investigation to evaluate the extent of this contamination and determine if any additional extraction and monitoring wells would be required to capture and monitor this contamination. This work was completed with a total of five vertical profiles in this area. **Figure 3.2.10-2** and **Table 3.2.10-2** show the results of this investigation.

3.2.10.4 System Operations

The extraction wells were sampled once per month in 2006. 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 2006.

January–September

The system operated normally during this period, with some down time other then for routine maintenance and repairs. The Airport System was down in June and July due to high pressure across the carbon vessels. The scheduled carbon changeout in July corrected the problem by changing out the vessel with the high differential pressure. The Airport wells continued a pulse pumping schedule of one week of operation per month except for well RTW-1A, which was put back into full-time operations in September 2006.

October–December

The five airport extraction wells were operated one week per month beginning in 2006, except for well RTW-1A, which began full-time operation in September 2006. Several carbon changeouts were performed during this time frame. The LIPA wells continued full-time operations.

Extraction Wells Operational Data

During 2006, approximately 244 million gallons were pumped and treated by the OU III Airport/LIPA System, with an average flow rate of 462 gpm. **Table F-37** shows the weekly pumping data. VOC concentrations for the airport and LIPA extractions wells are provided in **Table F-38**.

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.

3.2.10.5 System Operational Data

System Influent and Effluent

VOC concentrations in 2006 for the carbon influent and effluent are summarized in **Tables F-39** and **F-40** (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, except for pH.

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-37**) 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 3.2.10-3**) shows that 53 pounds of VOCs were removed during 2006, with a total of 200 pounds removed since startup.

Extraction Wells Data Evaluation

Table F-38 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 performed for the design of this system.

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

1. Was the BNL Groundwater Contingency Plan triggered?

Yes, the Plan was triggered. This was due to the concentrations of TVOCs observed in well 800-96, which is outside the capture zone of the treatment system. No other unexpected VOC concentrations were observed in the monitoring wells of the LIPA/Airport Treatment System during 2006.

2. Has the plume been controlled?

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 Upper Glacial and Magothy wells is being met. The leading edge of the plume has reached the airport extraction wells and, based

Table 3.2.10-1
OU III LIPA/Airport Pump & Treat System
2006 SPDES Equivalency Permit Levels

Parameters	Permit Level (µg/L)	Max. Measured Value (µg/L)
pH	5.5–7.5 SU	5.8-8.0 SU
carbon tetrachloride	5	ND
chloroform	7	ND
1,1-dichloroethane	5	ND
1,1-dichloroethylene	5	ND
methylene chloride	5	ND
1,1,1-trichloroethane	5	ND
trichloroethylene	10	ND

ND = Not detected above method detection limit of 0.50 µg/L.

on the recent characterization work, an additional extraction well is required to achieve capture of this portion of the plume. The regulators were notified and kept informed of follow-up actions.

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, for the Airport, an additional planned extraction well will capture the western-most portion of the plume. 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?
No, asymptotic concentrations have not been met.

4b. Is the TVOC concentration in the LIPA core wells less than 50 µg/L)?
Yes; however, extraction well EW-4L still shows concentrations greater then 50 µg/L.

4c. Are the TVOC concentrations in the Airport core wells less than 10 µg/L ?
No, five airport core wells (800-63, -94, -95, -96, and -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 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?
No, the cleanup goals have not been met. 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 recommendations are made for the LIPA/Airport Pump and Treat System and groundwater monitoring program:

- As per the recent groundwater investigation, an additional extraction well (RW-6A) is being added west of Airport well RTW-1A. Five new monitoring wells are also planned. See **Figure 3.2.10-2** for the proposed location and depth of the extraction and monitoring wells. A detailed report and design for this work will be sent out under separate cover. The plan is to have this well operational by September 2007.
- For LIPA, change the groundwater monitoring frequency from the startup phase to O&M phase (core and perimeter wells sampled semi-annually, and sentinel wells sampled quarterly).
- For the Airport, since the plume has not reached at the treatment system recovery wells, maintain the startup monitoring frequency of quarterly sampling of the monitoring wells.
- The extraction well sampling should change to quarterly, except for the Airport well RTW-1A, which should be maintained at the monthly schedule.
- Reduce system sampling and analysis from weekly to two times per month.

- Continue the airport extraction wells pulse-pumping of one week per month except for well RTW-1A, which should continue with full-time operations. This will verify that the higher concentrations have not reached the Airport System. If concentrations above the capture goal of 10 µg/L TVOCs 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.
- Shut down and place in standby mode LIPA wells EW-1L and -3L, as both of these wells have had TVOC concentrations well below the 50 µg/L capture goal throughout 2006. In addition, all of the monitoring wells in this area have concentrations less then 50 µg/L TVOC. The extraction wells will be restarted if TVOC concentrations rebound in either the plume core monitoring wells or the extraction wells, greater than the 50 µg/L capture goal.

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3.2.11 Magothy Aquifer

This section provides a brief summary of the Magothy Aquifer Groundwater Monitoring Program and the remedial approach for addressing the VOC contamination. The 41 monitoring 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 about these characterization results are in the *Final Magothy Aquifer Characterization Report* (Arcadis Geraghty & Miller 2003).

Table 3.2.11-1. Magothy Aquifer Contamination (Historical and 2006).

	Max. TVOC(a) in µg/L			
Location	2006	Historical	Primary VOCs	Results
Western boundary on site	<5.0	<5.0	None	Magothy not impacted. Two monitoring wells serve as adequate outpost/sentinel wells for Suffolk County Water Authority William Floyd well field.
Middle Road and south boundary on site	92	340	PCE, CCl4	VOCs identified in upper 20 to 40 feet of Magothy at Middle Road area where brown clay is absent. A temporary well installed in 2006 did not detect Magothy contamination between the Middle Road and South Boundary. VOCs not detected at south boundary beneath the clay.
North Street off site	30	50	TCE	Low VOC 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	7	30	1,1-DCA; 1,1-DCE	Low VOC 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	91	570	TCA, CCl4	Less than 50 µg/L TVOCs and higher (more than 500 µg/L) 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	138	7,200	CCl4	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

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	Selected Remedy
Western boundary onsite area	Continue monitoring and evaluate data.
Middle Road and s. 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.
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.
North Street East off-site area	Continue monitoring and evaluate data.
Industrial Park East off-site area and s. boundary	Continue operation of the Industrial Park East Magothy extraction well until cleanup objectives are achieved. Continue monitoring and evaluate data.
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 20 to 25 µg/L in 2006. 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 -250: These wells are in the industrial park near well UVB-1. Well 000-249 had VOC concentrations ranging from 138 µg/L in March 2006 to a low of 44 µg/L in November. Well 000-250 had VOC concentrations below MCLs in 2006. 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 -460: These wells are adjacent to the LIPA Stratler Drive Magothy extraction well. Well 000-425 had concentrations of VOCs ranging from 11 to 17 µg/L during 2006. 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 of <1 µg/l in 2006.

Well 122-05, located at the eastern edge of the OU III South Boundary System, showed concentrations of VOCs ranging from 25 to 35 µg/L in 2006.

Well 000-343, south of the OU I South Boundary system, had VOC concentrations between 5 and 7 µg/L in 2006.

Well 115-50, located near the OU I south Boundary extraction wells, had concentrations between 3 and 4 µg/L in 2006.

Wells 000-427 and -429 are just south of the industrial Park East system on Carleton Drive. Well 000-427 had concentrations ranging from 3 to 9 µg/L in 2006. Well 00-429 had concentrations ranging from 1 µg/L in June, to 91 µg/L in August. The concentrations observed are consistent with concentrations observed in the industrial park east system prior to system operations.

Well 800-92, (not a Magothy well) located about 2,500 feet north of the airport system, had VOC concentrations ranging from 42 to 33µg/L in 2006. This is indicative of contamination that was already past the North Street extraction wells prior to operation and will eventually be captured by the Airport extraction wells.

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) TVOC 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 eastern site boundary. They were installed by the Suffolk County Department of Health Services (SCDHS) to serve as sentinel wells for the Suffolk County Water Authority (SCWA) William Floyd Parkway well field.

3.2.12.1 Groundwater Monitoring

Well Network

The monitoring well network is comprised of 20 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 wells 109-03 and -04 are analyzed quarterly for 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 from 2005 or were otherwise noteworthy:

- Wells 083-01 and -02 are near the intersection of Brookhaven Avenue and Upton Road, and are screened in the Upper Glacial aquifer. These wells consistently have contained 1 to 8 µg/L and 10 to 25 µg/L of chloroform since 1997, respectively. In December 2006, well 083-01 had a detection of chloroform of 7.1 µg/L, barely exceeding the NYS AWQS of 7.0 µg/L. Potential sources of this contamination may be in the AGS area of the site.
- SCDHS wells 109-03 and -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 and methylene chloride at concentrations less than 1 µg/L (the detection limit is 0.5 µg/L). No radionuclides were detected in either well in 2006.
- Well 054-66, an AGS monitoring well, identified TVOC concentrations as high as 20 µg/L in 2006.

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 2006?

No. There were no unusual or unexpected VOC or radionuclide concentrations in the monitoring wells associated with this program during 2006.

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 2006, with the exception of low-level chloroform detections (below NYS AWQS).

3. Are the performance objectives met?
No. Since 1997 the VOC concentrations in the central portion of the site have significantly decreased as noted in TVOC plume comparison **Figure 3.2-4**. However, several individual wells continued to contain VOC concentrations exceeding the NYS AWQS during 2006; therefore, the OU III ROD objective of meeting MCLs by 2030 has not been met.

4. If not, are observed conditions consistent with the attenuation model?
Yes. The observed VOC concentrations generally agree with the model-predicted concentrations, with respect to both the plume extent and contaminant concentrations.

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

3.2.13 Off-Site Monitoring

The OU III Off-site Groundwater Monitoring Program consists of 12 wells. They were installed to monitor contamination for the southwest portion of the OU III plume.

3.2.13.1 Groundwater Monitoring

Well Network

The network has 12 wells that monitor the off-site, southwest 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.

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 extent of the off-site segment of the OU III VOC plume is shown in **Figure 3.2-1**.

The monitoring wells in the OU III Off-Site Program are perimeter and sentinel wells, continue to have VOC concentrations below the NYS AWQS.

3.2.13.3 Groundwater Monitoring Program Evaluation

There were no unexpected results during 2006 that would have triggered the BNL Groundwater Contingency Plan. All VOC detections were below NYS AWQS.

3.2.13.4 Recommendations

The following recommendation is made for the Off-Site Groundwater Monitoring program:

- Change the frequency of monitoring from semi-annual to annual.

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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 south section of the BNL site. The sampling was conducted in conjunction with the OU III South Boundary and Western South Boundary Programs. The eastern portions of the site south boundary are monitored for radionuclides as part of the OU I South Boundary, OU VI, and OU V STP groundwater monitoring programs.

3.2.14.1 Groundwater Monitoring

A network of 59 monitoring wells is used to monitor radionuclides from the OU III South Boundary, OU III Western South Boundary, and OU VI 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 2006. In June 2006 there was one reported detection of a radionuclide within the South Boundary Radionuclide Monitoring Program. This was a very low detection of cesium-137 (10.2 pCi/L) in well 114-06 (the DOE Groundwater Screening Level is 120 pCi/L). A data usability review indicates that this result is most likely a false positive. Therefore, the value has 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 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 2006 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 Treatment System

The OU III Brookhaven Graphite Research Reactor (BGRR)/Waste Concentration Facility (WCF) Treatment System addresses the Sr-90 plumes in groundwater downgradient of these facilities. Some of the wells included in the OU III BGRR/WCF network are also 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 consists of:

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 (by 2075)
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**).

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 -2) south of the WCF and three extraction wells (SR-3, -4, and -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

In 2005, a network of 85 monitoring wells monitored the Sr-90 plumes associated with the BGRR, WCF, and PFS areas. In late 2005, six monitoring wells (085-299, -300, -302, -310, -311, and -312) in the network were abandoned due to construction of the new Center for Functional Nanomaterials (CFN). New wells will be installed to replace the abandoned wells once construction of the CFN is complete. Two new monitoring wells (065-384 and -385), located just south of the WCF and downgradient of the g-2 area (**Figures 1-2 and 3.2.15-1**) were installed in January 2006 after tritium from the g-2 plume was captured by extraction well SR-2. This brings the total number of wells in the monitoring network for 2006 to 81.

Sampling Frequency and Analysis

The wells are monitored semiannually and the samples are analyzed for Sr-90. As noted in **Table 1-5,** several wells are also analyzed by the HFBR monitoring program for tritium, and several of the BGRR wells are analyzed for VOCs.

3.2.15.3 Monitoring 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 the fourth-quarter 2006 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 701 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 six former underground storage tanks (USTs A/B), approximately 25 feet north of the WCF (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 former PFS area (566 pCi/L) was collected in March 1997 from a temporary well installed downgradient of the PFS.

The following is a summary of the 2006 monitoring well data for the three Sr-90 plumes:

WCF Plume:

- In 2006, the highest Sr-90 concentration from all three plumes was 801 pCi/L during May from plume core well 065-175, which is immediately south of the WCF yard. This is an increase from the 2005 high of 574 pCi/L in the same well. The historical high for this well was 821 pCi/L in 2000. See **Figure 3.2.15-5** for the historical trend in this well since 1999. This contamination will be captured by extraction well SR-2.
- Plume core well 065-174, located west of well 065-175 has been increasing since 2000 from 20 pCi/L to a high of 148 pCi/L in May 2006. This contamination will also be captured by the treatment system.
- Downgradient plume core well 065-39, located approximately 300 feet northwest of the HFBR, detected 143 pCi/L and 88 pCi/L of Sr-90 in April and October 2006, respectively. Even though this portion of the plume (>100 pCi/L) will not be captured by an extraction well, it is expected to naturally attenuate to below the drinking water standards within the required timeframe of 70 years.
- Plume perimeter well 075-189, located on the southwest portion of the HFBR lawn identifies the leading edge of the WCF plume. This well detected Sr-90 at 9 pCi/L, just above the DWS of 8 pCi/L. This is the highest historical value for this well.
- Sentinel wells 075-47, -48, and -87, located on Temple Place, are ahead of the plume. In well 075-47, the maximum Sr-90 concentration was 1 pCi/L for 2006.
- Sentinel wells 065-384 and -385 were installed in January 2006 to monitor the g-2 tritium plume concentrations immediately upgradient of SR-2 (see Section 3.2.15.4 below). The highest tritium concentrations in these wells in 2006 was 61,000 pCi/L in September from well 065-384, and 51,500 pCi/L from well 065-385 in July. This is a reduction in tritium concentrations, since the 150,0000 pCi/L was identified in a temporary well in January 2006.

BGRR Plume:

- The highest Sr-90 concentration downgradient of the BGRR in 2006 was from extraction well SR-3, reaching a peak of 670 pCi/L in February 2006.
- Plume core well 075-664 is the closest upgradient well to SR-3, approximately 45 feet away. The highest concentration of Sr-90 detected in this well was 131 pCi/L in March 2005. The high in 2006 was 63 pCi/L. As depicted on **Figure 3.2.15-2**, this well appears to be screened a few feet below the high area of Sr-90 contamination seen in SR-3.

- The highest Sr-90 concentration in a monitoring well downgradient of the BGRR in 2006 was 234 pCi/L in plume core well 075-669. 2005 values in this well ranged from 43 pCi/L in February to 272 pCi/L in October. This well, located south of Cornell Avenue, is approximately 200 feet downgradient of the southernmost extraction well SR-4. Even though this portion of the plume was not planned to be actively remediated, it is expected to naturally attenuate to below the drinking water standards within 70 years.
- Plume core wells 075-666 and -673 are immediately upgradient of extraction well SR-5. The concentrations in these wells (up to 68 pCi/L and 16 pCi/L in 2005 and 2006, respectively) are somewhat lower than that seen in SR-5 during the same period.
- Plume perimeter wells 075-195, -196, -197, and -200, located west of the downgradient portion of the plume, are all less than the DWS.
- Sentinel wells, 075-670 and -671 are north of Brookhaven Avenue on the National Synchrotron Light Source (NSLS) lawn, just downgradient of the leading edge of the 8 pCi/L Sr-90 contour. The highest 2006 Sr-90 concentrations in these wells were 5.4 pCi/L and 2.4 pCi/L, respectively.

Pile Fan Sump Plume:

- The highest Sr-90 contamination in the PFS plume is in well 065-325, located approximately 20 feet south of Bldg. 801 and just north of the former PFS. Sr-90 concentrations in this well reached a high of 60 pCi/L in April 2006.
- Plume core wells 075-193, -194, -674, and -675 are located on the south side of Cornell Avenue and monitor the leading edge of the plume. The highest 2006 Sr-90 concentration in these wells was 29 pCi/L in well 075-93 in May. This plume is not addressed by active pumping, but will naturally attenuate to below the DWS.
- Plume perimeter wells 075-46, 075-86, 075-672, and core well 075-85 are located just downgradient of the leading edge of the 8 pCi/L Sr-90 contour. The highest 2006 Sr-90 concentrations in these wells was 7.5 pCi/L in well 075-85, in April.

The following cross-sectional views are also provided:

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

In accordance with the SPDES equivalency permit, since there have been no exceedances of the effluent limits after six months of weekly sampling, in April 2006 the required frequency for Sr-90 and VOC sampling was reduced to monthly. The pH is still required weekly. However, samples from the influent, effluent, and midpoint locations of the treatment system were still collected once a week in 2006 in order to develop a history of resin usage. All samples were analyzed for Sr-90 and VOCs. The influent was analyzed for tritium, and both the influent and effluent were analyzed weekly for pH. Sr-90 concentrations in 2006 for the extraction wells are summarized in **Table F-41** in **Appendix F**. System influent and effluent concentrations are summarized in **Tables F-42** and **F-43**. **Table F-44** contains the monthly Sr-90 removal totals for the system.

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 -2) were subsequently turned off. A series of 14 temporary and two new sentinel monitoring wells (065-384 and -385) were subsequently installed to determine tritium concentrations upgradient of extraction well SR-2 and to better define the g-2 tritium plume in this vicinity. 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. After the collection of samples from the temporary wells, the new monitoring wells, and the extraction wells, SR-1 and SR-2 were gradually brought back into full operation. Extraction well SR-1 was offline from October 12 through October 19, 2005. Extraction well SR-2 was offline from October 12, 2005 through March 9, 2006. The regulators were kept informed of the situation. 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 percent split. During 2006, the western wellfield provided approximately 89 percent of the total water pumpage.

Operations details are given in the O & M manual for this system. Below is a summary of the system operations for 2006:

January–September 2006

The treatment system was off from January 1 through January 9 for resin vessel change-out. Well SR-2 was off from January 1 to March 1 for repairs. The treatment system was off from March 31 through April 11 for resin vessel change out. The system was shut down September 7 to monitor for resin break-through and was re-started September 26.

October–December 2006

The treatment system was off from October 23 to November 8 for change-out of the resin vessels. The system was off from November 9 to November 21 for repairs to the computer program controlling the system. The system was off from December 1 through December 4 for a carbon vessel change-out.

3.2.15.5 System Operational Data

The analytical data for the period January 1 through December 31, 2006 showed a Sr-90 influent range from 52 to 386 pCi/L, with the highest sample collected in January. The highest tritium concentration in the influent during 2006 was 1,670 pCi/L, in July. Sr-90 was detected three times in the effluent samples during 2006, with the highest at 1.1 pCi/L in October, below the limit of 8.0 pCi/L. The highest VOCs detected in the system influent and effluent were TCA at 4.9 µg/L and methylene chloride at 0.31 µg/L, respectively. During 2006, approximately 11 million gallons of groundwater were processed through the system.

Table 3.2.15-1.
Sr-90 BGRR Treatment System
2006 SPDES Equivalency Permit Levels

Parameter	Permit Level	Max. Measured Value
pH range	5.5–8.5 SU	6.6–6.9 SU
Sr-90	8.0 pCi/L	1.1
chloroform	7.0 µg/L	<0.5
1,1,1-trichloroethane	5.0 µg/L	<0.5

ND = Not detected above minimum detectable activity.
SU = Standard Units
Required sampling frequency was originally weekly for Sr-90, VOCs, and pH. In April 2006, the frequency changed to monthly for Sr-90 and VOCs after 6 months of non-exceedances. pH is still weekly.

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 24 gpm from January 1 through December 31, 2006. Approximately 5.1 mCi of Sr-90 was removed during 2006, for a total removed since system startup in 2005 of 9.25 mCi (**Figure 3.2.15-6**).

Extraction Wells

Extraction well SR-1 was offline from October 10–19, 2005 and SR-2 was offline from October 12, 2005 to March 9, 2006, due to the detection of tritium in late 2005.

Maximum Sr-90 concentrations in each of the extraction wells during 2006 are as follows:

- SR-1 94 pCi/L in December
- SR-2 49 pCi/L in March
- SR-3 670 pCi/L in February
- SR-4 140 pCi/L in March
- SR-5 140 pCi/L in February

Tritium concentrations in extraction well SR-2 have been increasing throughout 2006, from a low of 662 pCi/L in March to a high of 7,550 pCi/L in September.

The treatment system influent and extraction wells SR-1 and -2 continue to be monitored for Sr-90 and tritium.

3.2.15.6 Groundwater Monitoring Program Evaluation

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

1. Was the BNL Groundwater Contingency Plan triggered?

For WCF Plume: No. However, it was triggered in late 2005 due to an unexpected tritium detection (less than the DWS) in the influent to the treatment system. The issue was resolved through additional characterization, and by maintaining optimum pumping ratios between the western and eastern supply well fields via the oversight of the BNL Water and Sanitary Planning Committee.

For BGRR Plume: No.

For PFS Plume: No.

2. Has the plume been controlled?

For WCF Plume: Yes. Based on the monitoring well data, the high concentration portion of the plume is being captured by the extraction wells SR-1 and SR-2.

For BGRR Plume: Yes. Based on the monitoring well data, the high concentration portion of the plume is being captured by the extraction wells SR-3, SR-4 and SR-5. However, well 075-669 should continued to be monitored to ensure that the Sr-90 concentrations in this well do not continue to climb higher than the 272 pCi/L identified in October 2006. This portion of the plume is outside the extraction well's capture zone.

For PFS: Yes. Based on the monitoring well data, the high concentration portion of the plume is expected to attenuate to below DWS.

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

For WCF Plume: The hydraulic capture performance of the system is operating as modeled in the system design. The system has been removing Sr-90 from the aquifer and the resin is effectively treating the Sr-90 to below MCLs. The system is operating as planned except for the temporary shutdown of extraction wells SR-1 and -2 in late 2005 through early 2006 as a result of the impacts from the g-2 tritium plume.

For BGRR Plume: The hydraulic capture performance of the system is operating as modeled in the system design, and the system has been removing Sr-90 from the aquifer. The system has been removing Sr-90 from the aquifer and the resin is effectively treating the Sr-90 to below MCLs.

For PFS Plume: Based on the Sr-90 concentrations detected this year in this plume, it is expected that the requirements of the ESD to meet DWS within 70 years will be met.

4. *Have the cleanup goals been met? Can the groundwater treatment system be shut down?*
For WCF Plume: No. The cleanup goal of meeting the DWS in the aquifer has not yet been met; however, the system is preventing and minimizing plume growth of the higher concentrations of Sr-90. In addition, the system has only been operating just under two of the projected 10 years. As stated in the Sr-90 BGRR/WCF/PFS O&M Manual, preliminary criteria for turning off the extraction wells includes reaching 175 pCi/L of Sr-90 in the plume. Since plume core well 065-175 and at times the system influent exceeded this value, and high levels of Sr-90 are immediately upgradient, extraction wells SR-1 or -2 cannot be shut off at this time.

For BGRR Plume: No. The cleanup goal of meeting the DWS in the aquifer has not yet been met; however, the system is preventing and minimizing plume growth of the higher concentrations of Sr-90. Since plume core and extraction well SR-3 exceed the preliminary criteria and high levels of Sr-90 are immediately upgradient, extraction wells SR-3, -4, or -5 cannot be shut off at this time.

For PFS Plume: No. The cleanup goal of meeting the DWS in the aquifer has not yet been met.

3.2.15.7 Recommendations

The following are recommendations for the BGRR/WCF Groundwater Treatment System and monitoring program:

- Maintain the southerly groundwater flow direction by managing the pumping of the BNL supply wells, via the oversight of the BNL Water and Sanitary Planning Committee.
- Install new monitoring wells in 2007 to replace those previously abandoned.
- Install an additional perimeter 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 (and slightly deeper than) well 075-189.
- Install an additional monitoring well (sentinel well) downgradient of the PFS plume. The new well is to be located in the 75-46 well cluster.
- Change the treatment system monitoring frequency from weekly to two times per month.
- Remove gross beta from the analyte list for the treatment system sampling, since this sampling is no longer needed. It was previously used as a means to confirm any rapid breakthrough of the resin. However, based on operations data, breakthrough is a slow and gradual process. Thus, the two-week turnaround on Sr-90 analyses is now adequate for continued verification.
- Analyze select wells for Sr-90 during the installation of temporary wells just northwest of the HFBR in the spring 2007 for the g-2 Tritium Plume. This will help enhance the monitoring of the WCF Sr-90 plume.
- Change the monitoring well sampling frequency from startup (semi-annual and quarterly) to the O&M phase (semi-annual and annually).

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 2006, 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 1-1 and 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 650 feet long and 65 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 (>100 pCi/L) appears to be a very narrow band approximately 350 feet long and 25 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 and supplemented with 17 temporary wells installed between April 2006 through February 2007 (see **Table 3.2.16-2**). These temporary wells were installed to collect additional data as a result of increasing Sr-90 concentrations downgradient of EW-1;, in particular, up to 1,530 pCi/L in monitoring well 106-49 in the fourth quarter of 2005. The Sr-90 detections for the seven temporary wells installed through July 2006 were provided to the regulators via the 3rd Quarterly Operations Report. The highest Sr-90 concentration observed in 2006 was 566 pCi/L, in well 106-49. This well is approximately 170 feet downgradient of extraction well EW-1. (Note: This value is not identified on the plume figure, since it was detected in the second quarter). The next highest Sr-90 concentration in 2006 was 356 pCi/L, in temporary well GVPB-110 in May 2006. This temporary well is approximately 320 feet downgradient of EW-1.

As noted on plume **Figure 3.2.16-1,** there are two distinct portions of the plume greater than 50 pCi/L. The smaller area extends approximately 85 feet upgradient from EW-1. There is then a break in the 50 pCi/L contour from EW-1 and downgradient approximately 65 feet. Based on the data from the temporary wells, the higher concentrations (>50 pCi/L) then continue for approximately 400 feet.

The leading edge of the plume, as defined by the DWS of 8 pCi/L, is approximately 500 feet south of well EW-1.

As shown in **Figure 3.2.16-2**, the concentrations of Sr-90 in monitoring well 106-99, immediately upgradient of EW-1, has significantly dropped off in 2006 compared to 2005. However, after hitting a historic low of 41 pCi/L in 2005 in well 106-16 (also upgradient of EW-1), the Sr-90 concentrations began increasing again in 2006, to 352 pCi/L.

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 106-102, with a TVOC concentration of 5.3 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 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 2006. 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 became effective in May 2006. Since then, there have been no exceedances of the pH limits. The treatment system consists of one extraction well and Sr-90 concentrations in 2006 for the system influent and effluent are summarized in **Tables F-45** and **F-46** in **Appendix F**. **Table F-47** contains a summary of the monthly Sr-90 mass removal for the system.

Summarized below are the system operations data for 2006. Details for this system are given in the operation and maintenance manual.

Table 3.2.16-1.
Sr-90 Chemical Holes Treatment System
2006 SPDES Equivalency Permit Levels

Parameter	Permit Level	Max. Measured Value
pH* range (SU)	5.0–8.5	5.3–6.5
Sr-90 (pCi/L)	8.0	2.90

* In May 2006, the permitted pH lower limit changed from 6.5 to 5.0 SU
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 2006

The system was off from January 1 to February 9 for a resin vessel change-out. Due to naturally occurring groundwater conditions, the effluent pH was lower than the equivalency permit level. In April 2006, DOE requested a NYSDEC modification to the permit, which was approved and became effective in May 2006. The system was off from July 14 to July 20 to repair a high water level alarm indicator in the diffusion well.

October–December 2006
The system operated normally this entire period.

3.2.16.5 System Operational Data

The analytical data for the period January 1–December 31, 2006 show that Sr-90 in the influent ranged from 16 to 40 pCi/L. The maximum Sr-90 influent concentration in 2006 was significantly reduced from the 2005 level of 566 pCi/L. All effluent samples were well below the SPDES equivalency permit level of 8 pCi/L for Sr-90, and are normally not detected. However, there were three detections in the effluent samples during the later part of the year, up to a high concentration of 2.9 pCi/L, but below the discharge limits. During 2006, approximately 2.7 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, 2006. The cumulative total was approximately 0.24 mCi of Sr-90 removed during 2006, and a total since 2003 of approximately 2.32 mCi (**Figure 3.2.16-2**).

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 triggered?
Yes. As noted above, based on the increasing Sr-90 concentrations in monitoring well 106-49 during the later portion of 2005 and early 2006, 17 temporary wells were installed in 2006 and early 2007 to further characterize the extent of the downgradient portion of the plume.

2. Has the plume been controlled?
The monitoring data 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 4th Quarter 2005 showed significant Sr-90 concentrations (up to 1,530 pCi/L). Elevated Sr-90 concentrations, up to 356 pCi/L, were documented from the additional temporary wells installed between April 2006 and February 2007. This Sr-90 was already downgradient of the pilot study extraction well when the well went into operation (**Figure 3.2.16-1**).

3. *Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate identified in the Explanation of Significant Differences to the OU III Record of Decision?*
The groundwater extraction well is removing contamination at the expected rate. The original design groundwater modeling was based on initial Sr-90 concentrations of less than approximately 350 pCi/L in order to meet the ROD cleanup goal of reaching maximum contaminant levels (MCLs). Based on more recent higher Sr-90 concentrations from monitoring well 106-49 as well as from the 17 temporary wells, it was determined that the higher Sr-90 concentrations are projected to present a significant risk in meeting the cleanup goals. As a result, planning is underway for the addition of two extraction wells to ensure that the cleanup goal, as stated in the OU III Explanation of Significant Differences, will be met. The regulators were briefed on this information starting with the November 2, 2006 IAG weekly teleconference, and they continue to be kept informed. A design report currently being prepared will be submitted to the regulators under separate cover.

4*. Have the cleanup goals been met? Can the groundwater treatment system be shut down?*
No. Significant contamination remains upgradient of the extraction well as evidenced by two of the monitoring wells. Left untreated, this contamination would threaten achieving the cleanup goal of meeting the MCL 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:

- Submit the design for the two additional downgradient extraction wells to the regulators, and implement by the end of 2007.
- Based on low influent concentrations over 2006 and to help evaluate improving the effectiveness of removing Sr-90 from the aquifer, beginning in October 2007, implement pulse pumping (EW-1 cycle of one month on, and one month off). This will be performed to help evaluate rebounding of the Sr-90 influent concentrations. If concentrations in the extraction well increase significantly, the extraction well will be put back into full-time operation.

- Change the monitoring well sampling frequency from startup (semi-annual and quarterly) to the O&M phase (semi-annual and annually). However, maintain the new monitoring wells to be installed as part of the semi-annual frequency for approximately two years.
- Remove gross beta from the analyte list for the treatment system sampling, since this sampling is no longer needed. It was previously used as a means to confirm that there was not rapid breakthrough of the resin. However, based on the three years of operations data, breakthrough is a slow and gradual process. Thus, the two-week turnaround on Sr-90 analyses is now adequate for continued verification.

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 firebreak road 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 OU III ROD contingencies are defined as either a detection of tritium above 25,000 pCi/L in monitoring wells at the Chilled Water Facility Road, or above 20,000 pCi/L in monitoring wells along Weaver Drive. The OU III ROD contingency of exceeding 20,000 pCi/L at Weaver Drive was triggered with a detection of 21,000 pCi/L in GP-297 on November 2, 2006. Further discussion is presented in **Section 3.2.17.3**.

Groundwater flow in the vicinity of the HFBR is primarily to the south (**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.

3.2.17.1 Groundwater Monitoring

Well Network

A monitoring well network of 111 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**). The permanent monitoring well network is being supplemented with a semi-annual temporary well characterization. A total of 35 temporary wells were installed and sampled during the fourth quarter of 2006 (**Figure 3.2.17-1**).

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. Seven wells immediately downgradient of the HFBR were upgraded to a monthly frequency during the second half of 2006 to monitor for any potential impacts to the groundwater from a water leak detected inside the facility in September 2006. The leak identified tritium concentrations in the water inside the building slightly above the drinking water standard of 20,000 pCi/L.

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 from monitoring wells during the fourth quarter of 2006 supplemented with data obtained from 35 temporary wells installed from September 2006 through early January 2007. 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. 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, east of Weaver Drive, south of Weaver Drive, and along the Princeton Avenue firebreak road, as shown in **Figure 3.2.17-1**. **Appendix C** has the complete set of monitoring well data. Data from temporary wells installed from September 2006 through January 2007 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**. Tritium concentration trends for key monitoring wells are shown in **Figure 3.2.17-3**.

Background

Samples are collected from a network of seven monitoring wells located to the north of the HFBR. These wells serve as early detection points should groundwater flow shift to a more northerly direction and towards supply well numbers 10, 11, and 12. Groundwater flow during 2006 was consistently to the south. Supply well 10 remained in a standby mode the entire year, while wells 11 and 12 operated minimally. As a result there was no northward migration of tritium in groundwater. It should be noted that tritium was detected in well 065-39 at concentrations up to 8,560 pCi/L in 2006. This well is located approximately 400 feet northwest of the HFBR. The tritium observed in this well originates from the g-2 source area and is at the downgradient end of that tritium plume.

HFBR to Brookhaven Avenue

Tritium concentrations directly downgradient from the HFBR had remained low from the first quarter of 2004 through 2005. In 2006, a general increase in tritium concentrations was observed in the monitoring wells immediately south of the HFBR. The highest tritium concentration observed was in well 075-240, at 34,000 pCi/L in January. A gradual tritium increase was also observed during the fourth quarter of 2006 in several of the wells immediately downgradient of the HFBR that were sampled on a monthly basis. This correlates closely with the increasing water table level during 2006. In fact, the water table was higher in 2006 than at any other time since late 1997, when a historical high water table was observed at BNL (**Figure 3.2.17-4**). Based on the timing of past tritium increases in response to water table flushing of the unsaturated zone beneath the HFBR, concentrations in this area are expected to peak during the first quarter of 2007 **(Figure 3.2.17-4)**. The tritium concentrations detected in monitoring wells located immediately downgradient of the HFBR and associated with the periodic water table rises mobilizing tritium beneath the source area are trended in **Figure 3.2.17-5**. A steady decrease is observed with respect to these peak tritium concentrations over time. Based on the trend, it is anticipated that peak tritium concentrations immediately downgradient of the HFBR associated with water table rises and resulting mobilization of tritium will be less than the 20,000 pCi/L DWS within the next several years.

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. Monitoring data from the latter part of 2006 indicate that the plume is shifting back to the west along Cornell Avenue.

Brookhaven Avenue to Weaver Drive

The monitoring well network in this area was supplemented with five temporary wells during the fourth quarter 2006 characterization effort. These supplemental data points confirmed the location of the plume in this area that was previously characterized in 2005.

In late 2006, the highest concentration segment of the HFBR tritium plume appears to be located at or just south of Chilled Water Facility Road. The highest tritium concentration detected was 97,000 pCi/L, in temporary well GP-282. This was an increase over the high concentration in this area in 2005 of 80,000 pCi/L.

Weaver Drive to Princeton Avenue firebreak road

An extensive temporary well characterization effort was conducted in this area during the fourth quarter of 2006 into early 2007. The focus of this effort was to determine whether the ROD contingency of 20,000 pCi/L tritium at Weaver Drive had been attained. The contingency was triggered with a detection of 21,000 pCi/L in GP-297 on November 2, 2006 **(**see **Figure 3.2.17-1)**. The highest detection observed along Weaver Drive was 37,200 pCi/L in GP-299. Additional characterization was performed along two separate east–west transects south of Weaver Drive. The temporary well transect along the Princeton Avenue firebreak road did not detect tritium greater than 2,900 pCi/L. A temporary well transect was also installed along an east-west line approximately 400 feet south of Weaver Drive (near the railroad tracks). The maximum tritium concentration detected along this transect was 22,800 pCi/L in GP-341. Based on these characterization data, the leading edge of the plume as defined by the 20,000 pCi/L isocontour is several hundred feet south of Weaver Drive. Even though the pump and recharge system remained in standby mode in 2006, the three extraction wells were still sampled quarterly. **Table F-48** in Appendix F presents the VOC and tritium 2006 detections in these extraction wells.

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 November 2006 with the detection of tritium at a concentration of 21,000 pCi/L in temporary well GP-297 located along the Weaver Drive transect. This detection triggered the ROD contingency requiring the restart of the Princeton Avenue pump and recharge wells. Since the leading edge of the 20,000 pCi/L isocontour is not anticipated to reach the Princeton Avenue firebreak road for another one to two years, there is no advantage to restarting the existing extraction wells at the present time. The regulatory agencies were appropriately notified and have been updated on this issue on an ongoing basis.

2. Is the tritium plume growing?

Based on the position of the 20,000 pCi/L isocontour line, the high concentration segment of the plume has migrated to approximately 300 feet south of Weaver Drive. See **Figure 3.2.17-6** for the plume distribution comparison between 1997 and 2006.

Tritium detections exceeding 20,000 pCi/L at Weaver Drive have necessitated the restart of the Princeton Avenue Pump and Recharge wells. Based on current groundwater flow direction and velocity, the leading edge of the high concentration area (>20,000 pCi/L), which reached Weaver Drive during 2006, is not anticipated to arrive at the Princeton Avenue firebreak road until 2008. In addition, the projected location of the high concentration area on its arrival at Princeton Avenue firebreak road could range up to 200 feet east of the capture zone of the existing pump and recharge wells. Since the pump and recharge wells were installed in 1997, the path of the HFBR tritium plume has shifted several hundred feet to the east (see previous **Section 3.2.17)**.

BNL recommends installing a fourth extraction well approximately 400 feet south of Weaver Drive, as shown on **Figure 3.2.17-1**. A detailed design report will be submitted to the regulatory agencies under separate cover. This well will be installed and operating by late 2007, rather than waiting another one to two years for the plume to reach the Princeton Avenue firebreak road. Extraction well EW-11, and possibly EW-10, would also be restarted to provide for the capture of tritium located further west (migrating south from the GP-341 vicinity). The pump and recharge well(s) would be operated until the tritium concentrations from Weaver Drive to the new extraction well drop below 20,000 pCi/L (a duration of approximately two years), based on monitoring well and/or temporary well data. The estimated duration is based on the length of the high concentration area slug and the time it would take to be completely captured by the new pump and recharge well. The decision to shut the well off will be supported with data from additional permanent and temporary wells, as needed. The monitoring program will continue as defined in the 2005 BNL Groundwater Status Report.

Temporary wells will be installed twice per year over the next several years to characterize the location of the high concentration area and results will be communicated to the regulators via the IAG conference call and quarterly/annual reports. See **Section 3.2.17.4** below for specific 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. Observed conditions with respect to both tritium concentrations and hot-spot position match the model predictions reasonably well. The observed concentration of 37,200 pCi/L at Weaver Drive in November 2006 is within the model predicted range.

4. Is the tritium plume migrating toward the zone of influence of water supply wells 10, 11, and 12?
No. Groundwater flow from this area was to the south during 2006 (**Figure 2-2**).

5. Has any segment of the plume migrated beyond the current monitoring network?
No. The plume is monitored by a combination of permanent wells supplemented with temporary wells where necessary to ensure that the plume extent is characterized.

3.2.17.4 Recommendations

The following are recommendations for the HFBR Tritium Plume:

- Continue monitoring well sampling initiated in 2006, including semi-annual supplemental temporary well sampling.
- Install a fourth extraction well (EW-16) approximately 400 feet south of Weaver Drive, as shown on **Figure 3.2.17-1**. This well will be installed and operating by late 2007, rather than waiting another one to two years for the plume to reach the Princeton Avenue firebreak. Extraction well EW-11, and possibly EW-10, will be restarted in addition to the new well to provide for the capture of tritium located further west (migrating south from the GP-341 vicinity). The pump and recharge well(s) would be operated until the tritium concentrations from Weaver Drive to the new extraction well drop below 20,000 pCi/L. The estimated operational duration of two years is based on the length of the high concentration area slug and the time it would take to be completely captured by the new extraction well. The decision to turn the wells back to standby will be based on; 1) concentrations of tritium being less than 20,000 pCi/L in the monitoring wells at Weaver Drive as well as the extraction wells, and 2) verification that the new extraction well has captured concentrations of tritium in this area greater than 20,000 pCi/L. This decision to turn the wells back to standby will be supported with data from additional permanent and temporary wells as needed.
- Temporary wells will be installed twice per year over the next several years to characterize the location of the high concentration area, and results will be communicated to the regulators via the IAG conference call and quarterly/annual reports.
- Install up to five permanent monitoring wells to monitor the effects of the new extraction well on the tritium plume. A design report providing further details on the planned extraction well and additional monitoring wells will be provided under separate cover.

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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 in August 2001, and further monitoring was continued as per *OU IV Remediation Area 1 Proposed Supplemental Remedial Effort – Work Plan* (BNL 2001b). The *Petition for Closure and Termination of Formal Post Closure Monitoring of OU IV Air Sparge/Soil Vapor Extraction Remediation System* (BNL 2002c) 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 2003b) stated that monitoring under this program should continue for three monitoring wells: 076-04, 076-06, and 076-185.

Monitoring wells 076-18 and -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) **(Figure 1-2).**

Sampling Frequency and Analysis

- Recommendations for changes to the sampling frequency of wells 076-04 and -06 made in the *2005 BNL Groundwater Status Report* were implemented during the fourth quarter of 2006. The sampling frequency for these wells was changed from quarterly to semi-annually for VOCs and SVOCs. The sampling frequency for wells 076-185, 076-18, and 076-19 remained semi-annual for the analysis of VOCs.

3.3.1.2 Monitoring Well Results

- Post-closure sampling of monitoring wells was conducted for 2006. The complete groundwater data are given in **Appendix C**. There were no detections of SVOCs in any of the samples collected. No samples exceeded the NYS AWQS for VOCs during 2006.

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 2006.

3.3.1.4 Recommendations

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

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3.3.2 Building 650 Strontium-90 Monitoring Program

The Building 650 Strontium-90 Monitoring Program monitors a Sr-90 plume emanating from a former source area known as the former Building 650 Sump Outfall Area. This former source consisted of a depression at the terminus of a discharge pipe from the building. The pipe conveyed discharges from a concrete pad located approximately 1,200 feet to the west, 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 2006, the wells were monitored either annually or semi-annually 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 leading edge of the plume is now just to the southwest of well 076-24. The highest Sr-90 concentrations were detected in well 076-28, at 18 pCi/L, in September 2006. In general, the concentrations in wells associated with the Building 650 sump and sump outfall plume displayed stable to declining trends during 2006 (**Figure 3.3.2-2**), with the exception of well 076-24. Increasing concentrations in this well indicated the relatively recent arrival of the leading edge of the plume at this location.

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 the 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 in the vicinity of the pad/building. This water table flushing process has been observed in several former source areas across the site, including the HFBR, 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 2006.

2. Were performance objectives met?

No. The performance objective for this project is to achieve Sr-90 concentrations below the 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 addressed the predominate source of groundwater contamination. The groundwater plume continues to degrade due to natural attenuation (i.e., radioactive decay).

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 Recommendations

The following recommendations are made for the Building 650 Strontium-90 Groundwater Monitoring Program:

- Reduce the sampling frequency for monitoring wells 076-07, -09, -10, -22, -181, -182, -184, and -265 to annual.
- Since the primary contaminant for this plume is Sr-90, delete further monitoring of gross alpha/beta, gamma spectroscopy, and tritium.

3.4 OPERABLE UNIT V

3.4.1 Sewage Treatment Plant Monitoring Program

The Sewage Treatment Plant (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. 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 network of 34 monitoring wells was designed to track groundwater contamination downgradient of the STP, at the boundary, and off site (**Figure 1-2**). BNL's Groundwater Model was used to aid in placing these wells.

Sampling Frequency and Analysis

Wells are sampled semi-annually 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 2006. **Appendix C** contains the complete data. The VOC plume consists of an area of less than 15 μg/L TVOCs that extends from south and east of the STP southeast to the vicinity of the Long Island Expressway (**Figure 3.4-1**). During 2006, the highest TVOC concentration was 13 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 have shown a decreasing trend since early 2005 (**Figure 3.4-2)**. The only individual VOCs detected at levels exceeding NYS AWQS were TCE and 1,2-dichloropropane. Since 1998, 1,2-dichloropropane has been detected in shallow off-site sentinel well 600-25. During 2006 1,2-dichloropropane was detected at concentrations of 1.2 and 0.6 μg/L, exceeding the NYS AWQS of 1 μg/L in the March sampling round. 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 other than the gradual decline in concentrations(**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. The US EPA published a new Drinking Water Equivalent Level for perchlorate of 24.5 μg/L in January 2006.

In 2006, 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, 061-05, and 000-123, all of which monitor the deep portion of the Upper Glacial aquifer. Well 049-06 is near the eastern firebreak road, well 061-05 is at the eastern site boundary and well 000-123 is located immediately north of the LIE. The maximum perchlorate concentration, from well 000-123, was 15 μg/L, again, below the NYSDOH action level. Concentrations in wells 049-06 and 061-05 have been slowly declining over the past several years. The detection in well 000-123 during the March 2006 sampling round is the first for this well; perchlorate was not detected in the

September 2006 sampling event for this well. The same eight OU V wells will be sampled for perchlorate again in 2007.

Tritium has historically been detected at low concentrations in monitoring wells 049-06, 050-02, and 061-05. The maximum tritium concentration during 2006 was 1,200 pCi/L, in well 061-05; this is approximately one-twentieth 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 2006.

2. Were the performance objectives met?
No. The performance objective for this program is to attain NYS AWQS 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 following recommendations are made for the OU V plume groundwater monitoring program:

- The monitoring program sampling frequency will change from semi-annual to annual for 2007.
- Continue to analyze eight OU V monitoring wells for perchlorate in 2007.

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 30 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**). As recommended in the 2005 Annual Groundwater Status Report, three wells, 800-24, 800-25, and 800-54, were dropped from the program as they are not positioned, either horizontally or vertically with respect to the plume, to intercept EDB should it reach these locations.

Sampling Frequency and Analysis

Beginning with the third quarter of 2006, the OU VI plume monitoring program moved into the O&M phase (see **Table 1-7**). The sampling frequency for plume core and perimeter wells (**Table 1-5**) were reduced from quarterly to semi-annually. The exception to this was well 000-498, which remain at a quarterly sampling frequency for the year. Sentinel well sampling remained at a quarterly frequency and the analytical parameters will remain unchanged. The wells are analyzed for EDB by EPA Method 504. Samples are also analyzed annually for VOCs. As recommended in the 2005 Annual Groundwater Status Report, based on the absence of any tritium detections in OU VI monitoring wells dating back to 1997, this parameter was dropped from the program. The exceptions were wells 099-06, 099-10, 099-11, 100-12, and 100-13 (all located on the south boundary). These wells were 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. (**Table 1-5**).

3.5.3 Monitoring Well Results

Appendix C contains the complete results of the sampling program. The distribution of the EDB plume is shown for the fourth quarter of 2006 (**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 2006 was 2.9 µg/L during the third quarter, in well 000-283. This is less than the maximum EDB concentration reported in 2004 and 2005 of 4.1 µg/L and 3.4 µg/L, respectively, 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**. Over the past two years, 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, as well as the EDB concentrations in monitoring wells just south of North Street**,** also helps illustrates the southward movement of the plume.

There were no detections of VOCs besides EDB above MCLs in any of the wells in 2006 (**Appendix C**).

3.5.4 System Operational Data

The extraction wells are currently sampled every month. In conformance with the SPDES equivalency permit, since no exceedances of the discharge limits were shown for at least 24 consecutive weekly sampling events, the sampling frequency for the influent and effluent was changed to monthly starting in December 2005. 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
2006 SPDES Equivalency Permit Levels

Parameters	Permit Limit	Max. Measured Value
pH (range)	5.0 – 8.5 SU	5.7 – 8.2 SU
ethylene dibromide	5.0 µg/L	<0.50 µg/L
chloroform	7.0 µg/L	1.1 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

Required sampling frequency is monthly for VOCs and pH.

January through September
The system operated with EW-1E and EW-2E running at 150 gpm each for almost this entire period. The system was off from September 25 to September 30 to redevelop the injection wells. During this period approximately 121 million gallons of water was pumped and treated.

October through December
The system operated normally for the entire period.

Extraction Wells
During 2006, 156 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 low level detections of EDB in the extraction wells during 2006, with a maximum of 0.022 µg/L in EW-1E.

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-50 and F-51**, respectively. There were two detections of EDB in the influent in the last quarter of 2006 at 0.0098 µg/L and 0.013 µg/L. These detections were below the DWS of 0.05 µg/L.

Cumulative Mass Removal
EDB was only detected in extraction wells during eight of 24 sampling events in 2006. All detections were in EW-1E. No cumulative mass calculations were performed, based on the very low detections of EDB 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 four 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 above the DWS in 2006 except in perimeter well 000-174, located just south of the LIPA right-of-way along the centerline of the plume. It should also be noted that there was a detection of EDB in western perimeter well 000-179 in June 2006 at 2.1 µg/L. However, since this well was installed in 1998, there have been historically only two additional detections of EDB in this well, both below the DWS. The 2.1 µg/L detection appears to be an anomaly since it was not reproduced in the three sampling rounds prior and the two rounds since then.

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 twice in 2006 in the system influent at concentrations below the DWS. As the system has been operating just over two 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 two 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 six of 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? Are MCLs expected to be 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

The following recommendations are made for the OU VI EDB Pump and Treat System and groundwater monitoring program:

- Maintain the routine operation and maintenance monitoring frequency that began in third quarter 2006.
- Since there were no detections above the DWS for EDB in well 000-498 for 2006, change the sampling frequency for this well from quarterly (system start-up phase) to semi-annually (O&M phase). This will allow for consistency with the remainder of the wells in this monitoring program.

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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 2006 program included 10 wells located in the northwestern portion of the BNL property (**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 2006 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 chloroform at 0.68 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 2006. 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 2006 Environmental Monitoring Report, Current and Former Landfill Areas* (BNL 2007a). 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 2006 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 2006:

- VOCs, such as benzene and chloroethane, continue to be detected in downgradient wells 087-11, 087-23, 088-109, and 088-110 at concentrations above NYS AWQS. The maximum VOC concentration (chloroethane) in 2006 was 53 µg/L, in well 088-109. TVOC concentrations in these four wells ranged between 0.5 µg/L to 57.4 µg/L during 2006, indicating that low-level VOCs continue to emanate from the landfill. The continued presence of these compounds 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 the drinking water standards. These concentrations, up to 860 pCi/L and 1.95 pCi/L of tritium and Sr-90, respectively, were consistent with those observed in 2005.
- Since 1998, there have been no detections of VOCs, metals, water chemistry parameters, or radionuclides exceeding NYS AWQS 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.

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 2006:

- The Former Landfill is not a significant source of VOC contamination. No VOCs were detected above NYS AWQS in 2006. VOC concentrations in the downgradient wells were at or near the minimum detection limits.
- The Former Landfill no longer appears to be a source of Sr-90 contamination to groundwater. The approximated 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.

- Landfill-leachate indicators such as sulfate, nitrite, nitrate, chloride, alkalinity 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 it is capped.
- The implemented landfill controls are effective, as evidenced by the improving quality of groundwater downgradient of the landfill.

3.7.4 Former Landfill Recommendation

There are no recommended changes to the sampling schedule.

4.0 ENVIRONMENTAL SURVEILLANCE PROGRAM SUMMARY

During 2006, 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 2006, 125 groundwater surveillance wells were monitored during approximately 240 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. Complete analytical results from groundwater samples collected in 2006 can be found in **Appendix D**.

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. Of the radionuclides formed in the soil, only tritium (half-life = 12.3 years) and sodium-22 (half-life = 2.6 years) are detected in groundwater. Of these 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 2006, 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 (DWS) in the Former U-Line and E-20 Catcher areas. As discussed below, tritium concentrations greater 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 Long

Term Response Actions (LTRA) program's Operable Unit III Central groundwater monitoring program (see **Section 3.2.12**).

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. Although these beam lines stopped operations in 2002, 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 2006, Building 912 wells that were used to help track the g-2 tritium plume were sampled quarterly, whereas the remaining wells were sampled semiannually to annually. 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 2006 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 (570 pCi/L) and one sample from well 055-31 (260 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 (Building 811) (**Figure 4-1**). Tritium from this plume was detected in eight wells downgradient of Building 912, with a maximum concentration of 89,800 pCi/L in the April 2006 sample from well 065-123. As described in Section 4.1.6, remedial actions for the g-2 source area and tritium plume are described in the Record of Decision signed in May 2007 (BNL 2007b).

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 2007, the Building 912 wells used to track the g-2 tritium plume will be sampled semiannually, whereas the remainder of the Building 912 wells will be sampled annually.

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 -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 (BLIP) facility (well 054-61) is also used to provide data on background tritium concentrations.

Sampling Frequency and Analysis

The booster area wells were monitored one time during 2006 (**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 during 2003 through 2006 (**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 NASA Space Radiation Laboratory. 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. No changes to the monitoring frequency for these wells are proposed for 2007.

[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).

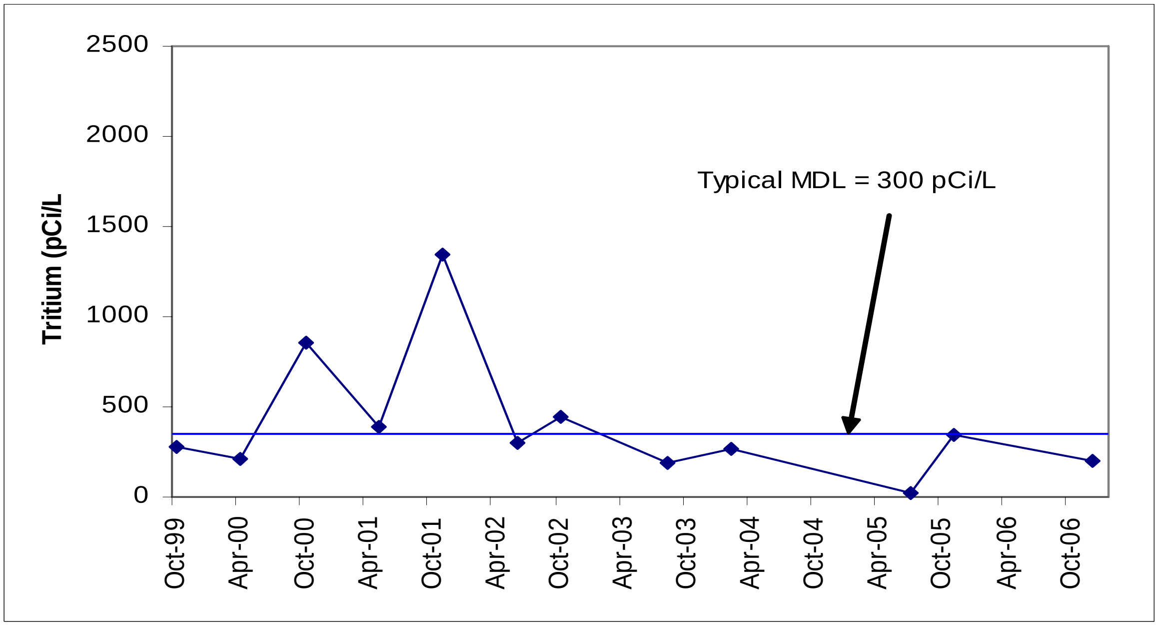
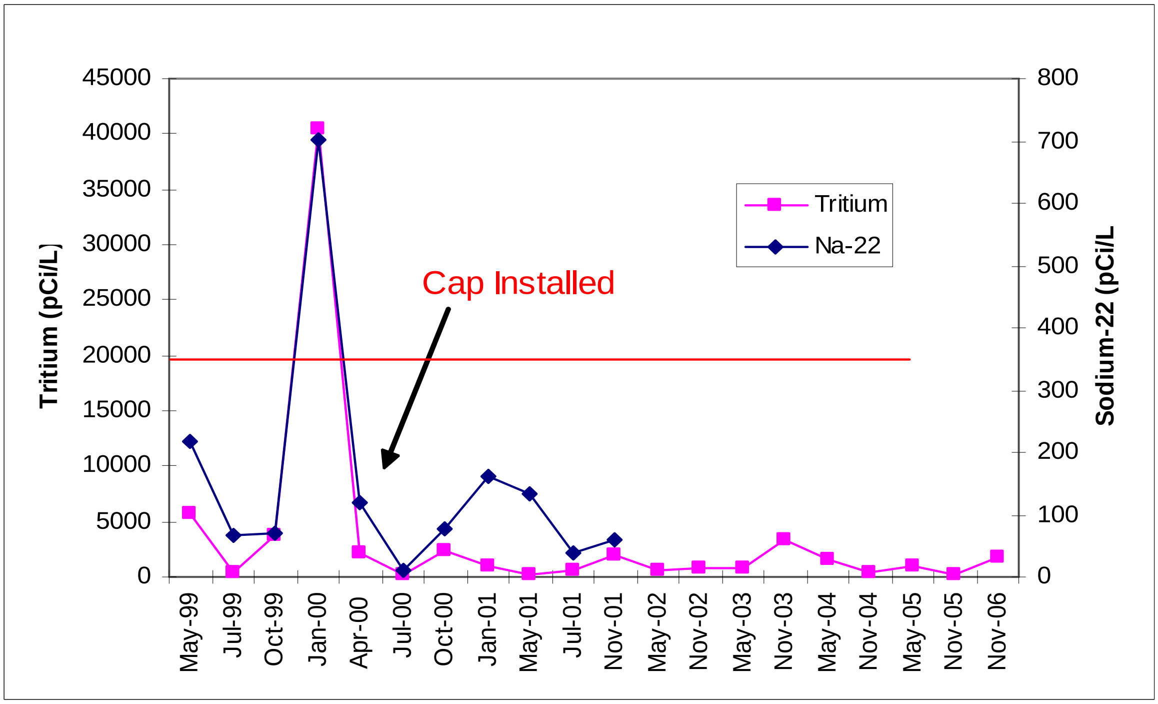


Figure 4-3.
Maximum Tritium and Sodium-22 Concentrations in Temporary and Permanent Monitoring Wells Downgradient of the Former E-20 Catcher.



4.1.3 NASA Space Radiation Laboratory Facility

The NSRL facility is jointly managed by the U.S. Department of Energy's Office of Science and NASA's Johnson Space Center. The NSRL facility employs beams of heavy ions extracted from Brookhaven's Booster accelerator for radiobiology studies. NSRL facility also features state-of-the-art specimen-preparation areas. NSRL became operational during summer 2003. The NSRL beam stop is an area where the interaction of secondary particles (primarily neutrons) and soil surrounding the stop can result in the activation of that soil. Some minor line losses may also occur along the beam line leading from the Booster. Although the secondary particle interactions with the soil are expected to result in only a minor level of soil activation, geomembrane caps were constructed over the entire length of the beam line and the beam stop region to prevent stormwater infiltration into potentially activated soil.

4.1.3.1 NSRL Facility Groundwater Monitoring

Well Network

Two shallow Upper Glacial aquifer monitoring wells (054-08 and 054-191) are located immediately downgradient of the NSRL facility (**Figure 4-1**).

Sampling Frequency and Analysis

The NSRL area wells were monitored one time during 2006 (**Table 1-6**). All of the groundwater samples were analyzed for tritium.

4.1.3.2 NSRL Facility Monitoring Well Results

Groundwater monitoring at the NSRL facility began in late 2002. Since that time, tritium has not been detected in any of the groundwater samples.

4.1.3.3 NSRL Groundwater Monitoring Program Evaluation

Based on monitoring conducted to date, NSRL beam line operations have not impacted groundwater quality.

4.1.4 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.

4.1.4.1 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 2006, the E-20 Catcher wells were monitored one time, and the samples were analyzed for tritium (**Table 1-6**).

4.1.4.2 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 DWS (**Figure 4-3**). During 2006, the maximum observed tritium concentration was 1,790 pCi/L, detected in well 064-80.

4.1.4.3 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. For 2007, the monitoring frequency for the E-20 Catcher wells will continue to be annually.

4.1.5 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.

4.1.5.1 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 2006, the Building 914 area wells were monitored one time and samples were analyzed for tritium (**Table 1-6**).

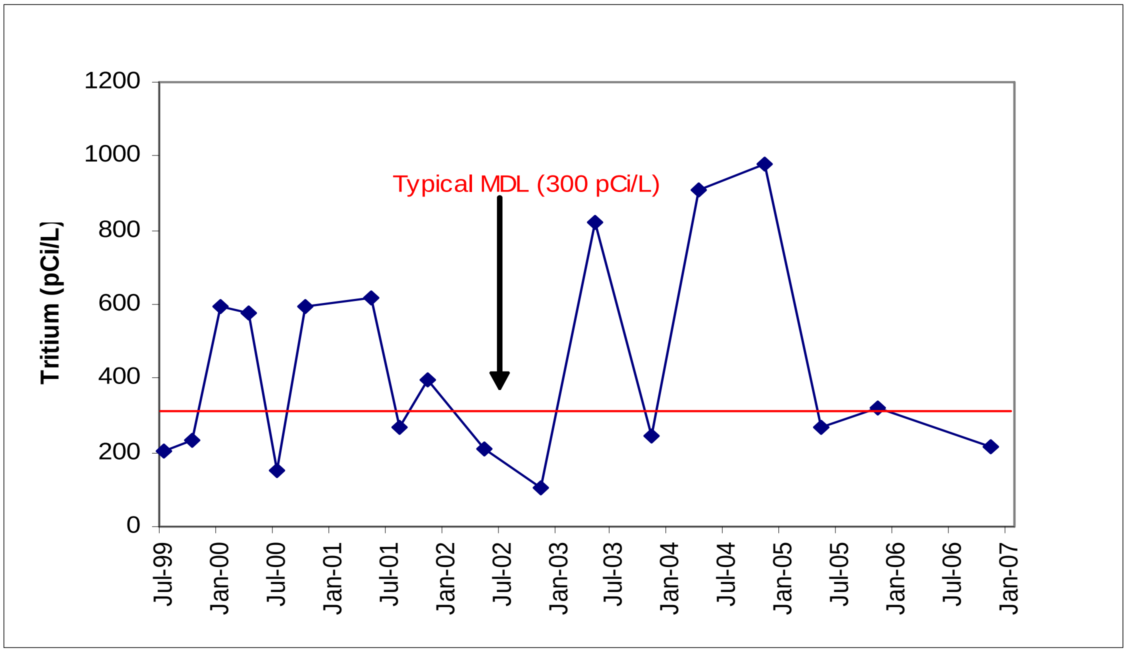
4.1.5.2 AGS Building 914 Monitoring Well Results

Low levels of tritium were detected intermittently in groundwater downgradient of the Building 914 transfer tunnel during 2000 – 2005 (**Figure 4-4**). During 2006, tritium was not detected in any of the groundwater samples.

4.1.5.3 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 periodic detection of trace levels of tritium since 2000 suggests that some rainwater may be infiltrating the activated soil. Continued monitoring is required. For 2007, the annual monitoring frequency for the Building 912 area wells will be annually.

Figure 4-4.
Maximum Tritium Concentrations Downgradient of 914 Transfer Tunnel (Wells 064-03, -53, and -54).



4.1.6 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. During 2006, a Focused Feasibility Study for the g-2 tritium source area and plume was prepared, followed by a Proposed Remedial Action Plan (BNL 2006b, c). The selected remedial actions for the g-2 tritium source area and plume are documented in a Record of Decision, which was signed in May 2007 (BNL 2007b).

4.1.6.1 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 2006, the g-2 beam stop wells were monitored annually, and g-2 tritium plume wells were monitored quarterly. All samples were analyzed for tritium, and several g-2 source area wells were also analyzed for sodium-22 (**Table 1-6**).

4.1.6.2 g-2 Beam Stop and VQ-12 Magnet Area Monitoring Well Results

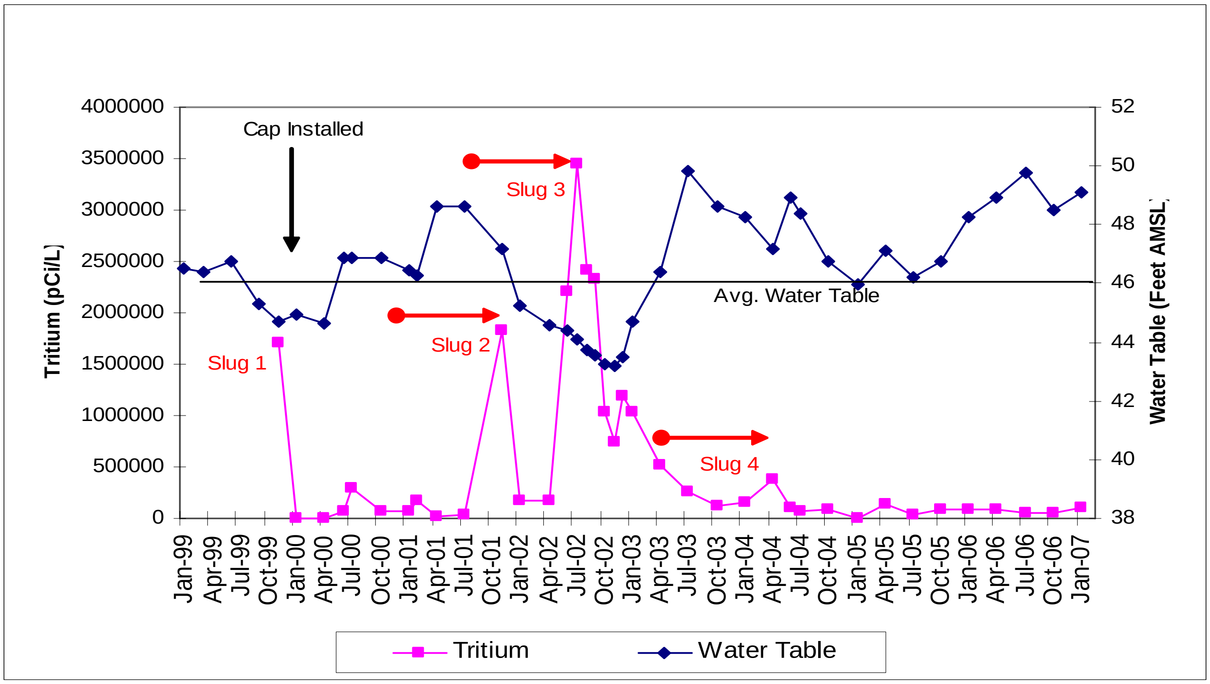
g-2 Tritium Plume

Samples collected during 2006 from wells approximately 150 to 200 feet downgradient of the VQ-12 source 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. Since June 2004, tritium concentrations in wells directly downgradient of the source area have been less than 150,000 pCi/L, with samples from 10 of 12 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 2006 was 89,800 pCi/L, in well 065-123 (**Figure 4-6**). In the AGS parking lot area, just to the south of the Waste Concentration Facility, tritium was detected up to 61,000 pCi/L in monitoring well 065-384. During 2006, a portion of the g-2 tritium plume was also detected in HFBR background well 065-39, at a concentration of 8,560 pCi/L. **Figure 4-1** shows the projected position of the g-2 tritium plume in the fourth quarter of 2006. As noted below, in the summer of 2007, BNL is planning to install a series of temporary wells to characterize and track the downgradient sections of the g-2 plume. 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 2006, tritium was not detected in any samples from the three monitoring wells located downgradient of the g-2 beam stop.

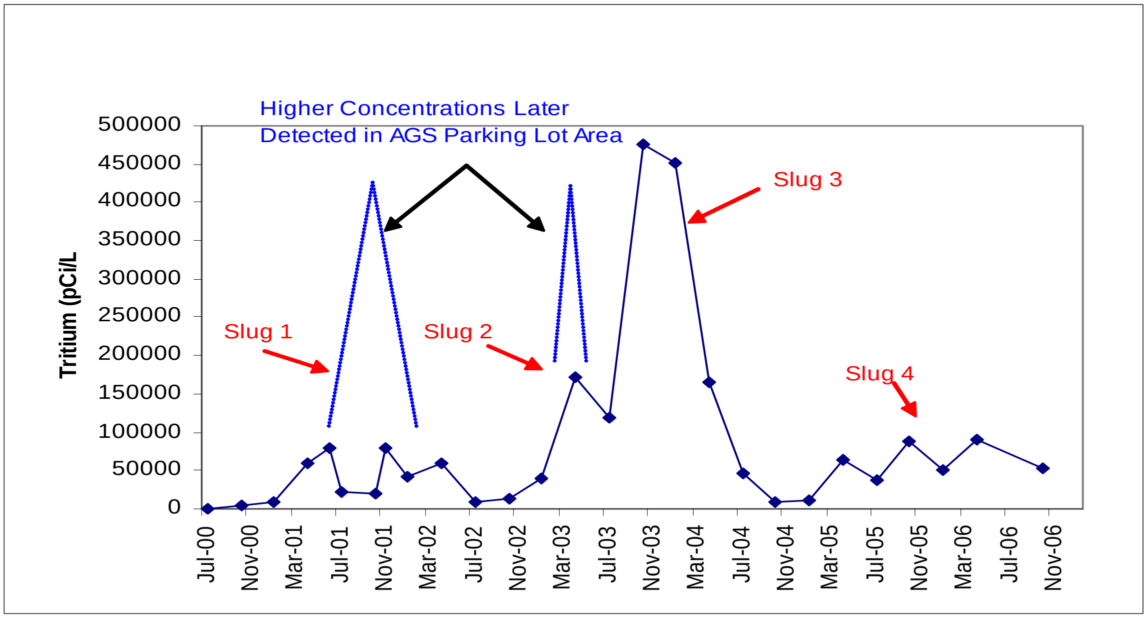
Figure 4-5.
Maximum Tritium Concentrations in Permanent and Temporary Wells Downgradient of the g-2/VQ-12 Source Area (West Side of Building 912A).



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).

4.1.6.3 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. Although the cap is effectively preventing rainwater infiltration into the activated soil-shielding zone, some tritium is being periodically released to the aquifer. 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 one year before the sampling (**Figure 4-5**). The groundwater travel time from beneath the source to the monitoring wells is about one year. Water levels in the central BNL area in mid 2000, mid 2001, July 2003 and July 2006, were near the highest observed in 49 years of record by the USGS. Additional details on the vadose zone release mechanism and possible remedial actions for the g-2 tritium plume is provided in the Focused Feasibility Study (BNL 2006b) and Proposed Remedial Action Plan (BNL 2006c). The selected remedial actions for the g-2 tritium source area and plume are documented in a Record of Decision, which was signed in May 2007 (BNL 2007b). During 2007, wells used to monitor the VQ12 source area and to track the g-2 tritium plume will continue to be sampled on a quarterly basis, and temporary Geoprobe wells will be used to track the leading edge of the plume. Wells used to monitor the g-2 beam stop will continue to be monitored on an annual basis.

4.1.7 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.

4.1.7.1 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 -64) (**Figure 4-1**).

Sampling Frequency and Analysis

During 2006, the three J-10 beam stop wells were monitored one time and the samples were analyzed for tritium (**Table 1-6**).

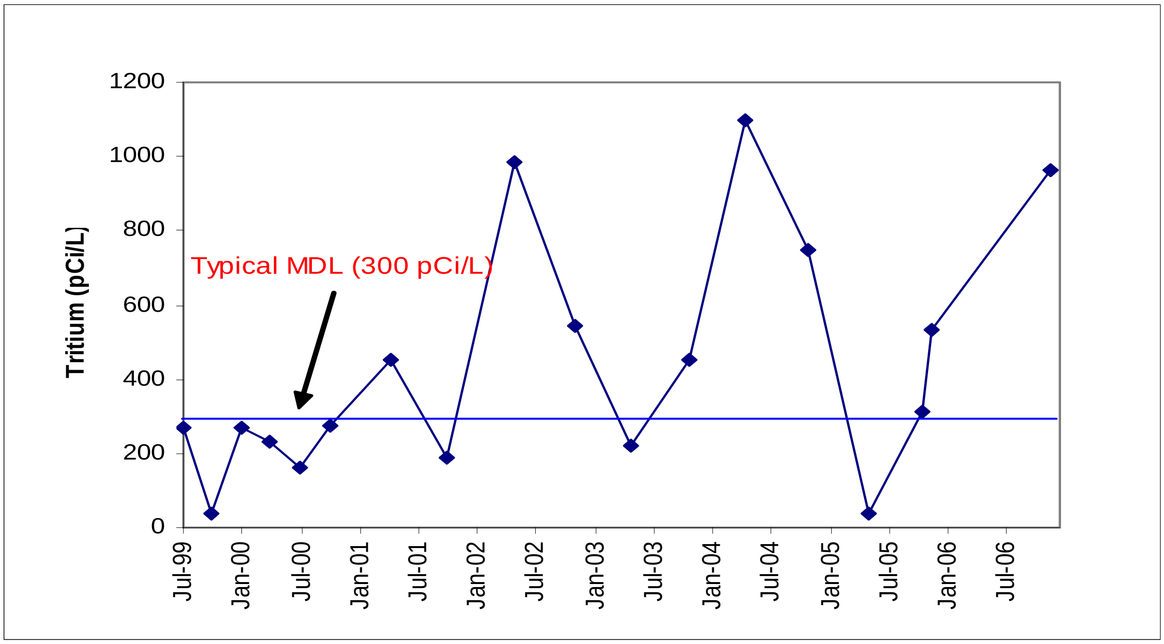
4.1.7.2 AGS J-10 Beam Stop Monitoring Well Results

Since 2001, low levels of tritium have been routinely detected in groundwater downgradient of the J-10 beam stop (**Figure 4-7**). During 2006, the maximum tritium concentration was 964 pCi/L in well 054-64.

4.1.7.3 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 occasional detection of low levels of tritium (up to 1,000 pCi/L), suggests that some rainwater may be infiltrating the activated soil. During 2007, the monitoring frequency for the J-10 Beam Stop area wells will continue to be annually.

Figure 4-7.
Maximum Tritium Concentrations in Wells 054-63 and 054-64, Downgradient of the J-10 Beam Stop.



4.1.8 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 rainwater infiltration and the continued leaching of radionuclides out of the soil and into groundwater. By October 2000, a permanent geotextile 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.

4.1.8.1 Former AGS U-Line 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 2006, the former U-Line area wells were monitored one time, and the samples were analyzed for tritium (**Table 1-6**).

4.1.8.2 Former AGS U-Line 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 2006 was 3,670 pCi/L, in well 054-129 located 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 2006, the maximum observed tritium concentration in wells downgradient of the U-Line target area was 704 pCi/L, in well 054-168.

4.1.8.3 Former U-Line 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. For 2007, the monitoring frequency for the U-line area wells will continue to be annually.

Figure 4-8:
Maximum Tritium Concentrations in Well 054-129, Downgradient of the Former U-Line Beam Target.

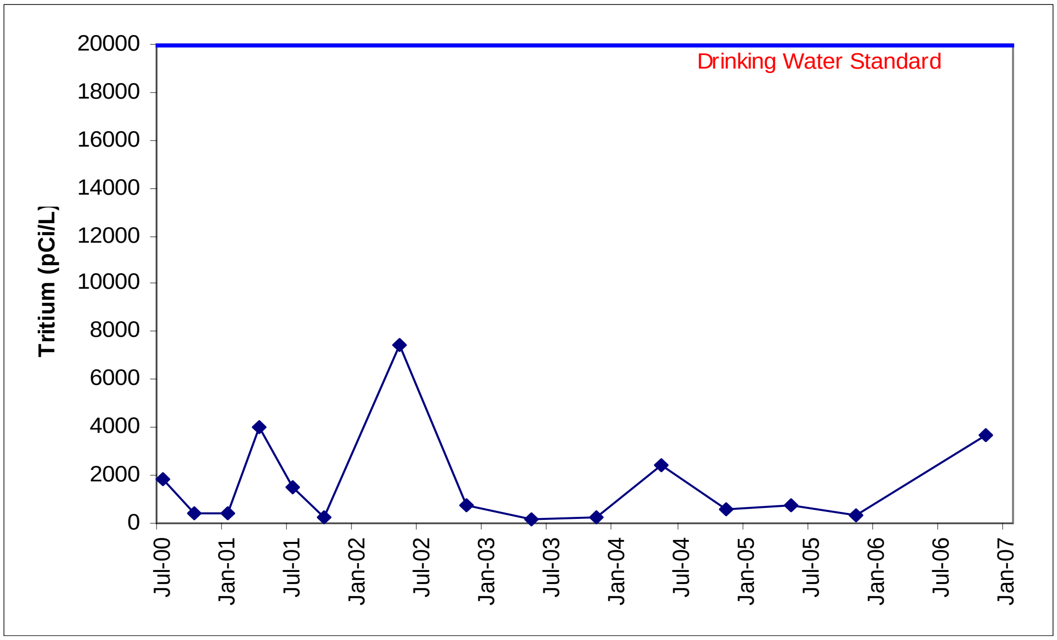
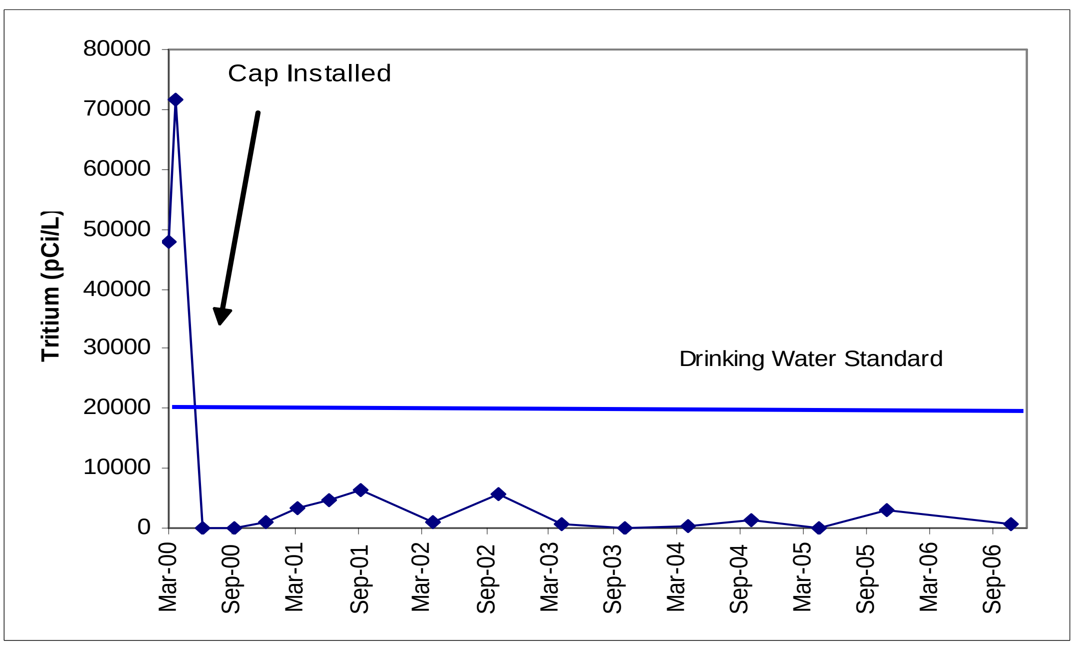


Figure 4-9.
Maximum Tritium Concentrations in Temporary & Permanent Wells Downgradient of U-Line Beam Stop.



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 the Suffolk County Department of Health Services (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 sub-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 (Standards 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 2006, the three wells located immediately downgradient of BLIP were monitored quarterly (wells 064-47,-48, and -67). The two upgradient wells and remaining two downgradient wells were

[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).

sampled semiannually. All samples were analyzed for tritium, and one set of samples from the three immediately downgradient 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 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 2006, 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, 46,500 pCi/L in July 2005, and 31,400 pCi/L in January 2006 (**Figure 4-10**).

Figure 4-10.
Maximum Tritium Concentrations in Wells ~ 40 feet Downgradient of BLIP Target Vessel.

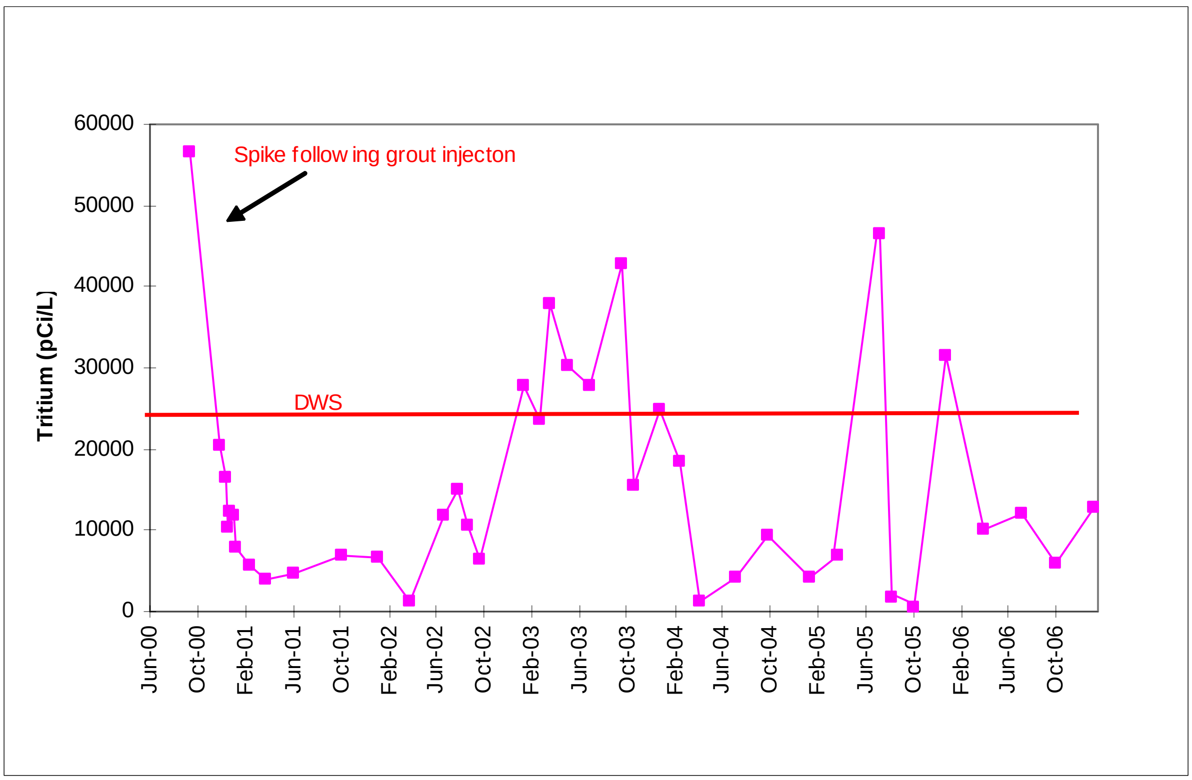
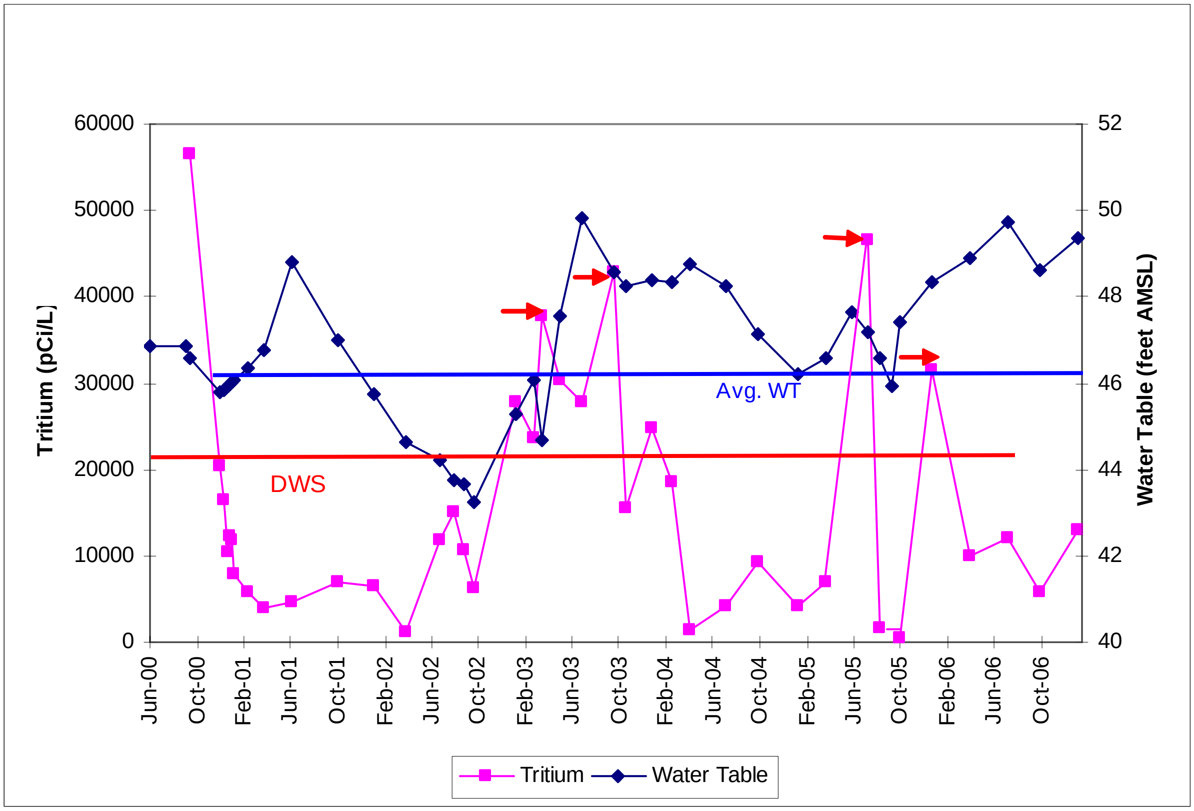


Figure 4-11.
Tritium Concentrations vs. Water Table Position, 40 Feet Downgradient of the BLIP Target Vessel.



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. The short-term concentration increases observed in 2005 and 2006, also appear to be correlated to increases in the position of the water table. 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. The selected remedial actions for the BLIP source area are documented in a Record of Decision, which was signed in May 2007 (BNL 2007b). The selected remedies include continued maintenance of the cap and groundwater monitoring.

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 2006, 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 025-05 and 025-06, located downgradient of the 10 o'clock beam stop area 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. During 2007, groundwater samples will continue to be collected on a semiannual basis.

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 the primary cooling water system has been drained. BNL is preparing plans to permanently decommission the facility.

The BMRR's primary cooling water system consisted of a recirculation piping system that contained 2,550 gallons of water. The cooling water contained 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 contained radioactive liquids. Historically, fuel elements that required storage were either stored within the reactor vessel, or they 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 2006, the BMRR wells were monitored one time, and the samples were analyzed for tritium, gamma emitting radionuclides, gross alpha, and gross beta (**Table 1-6**).

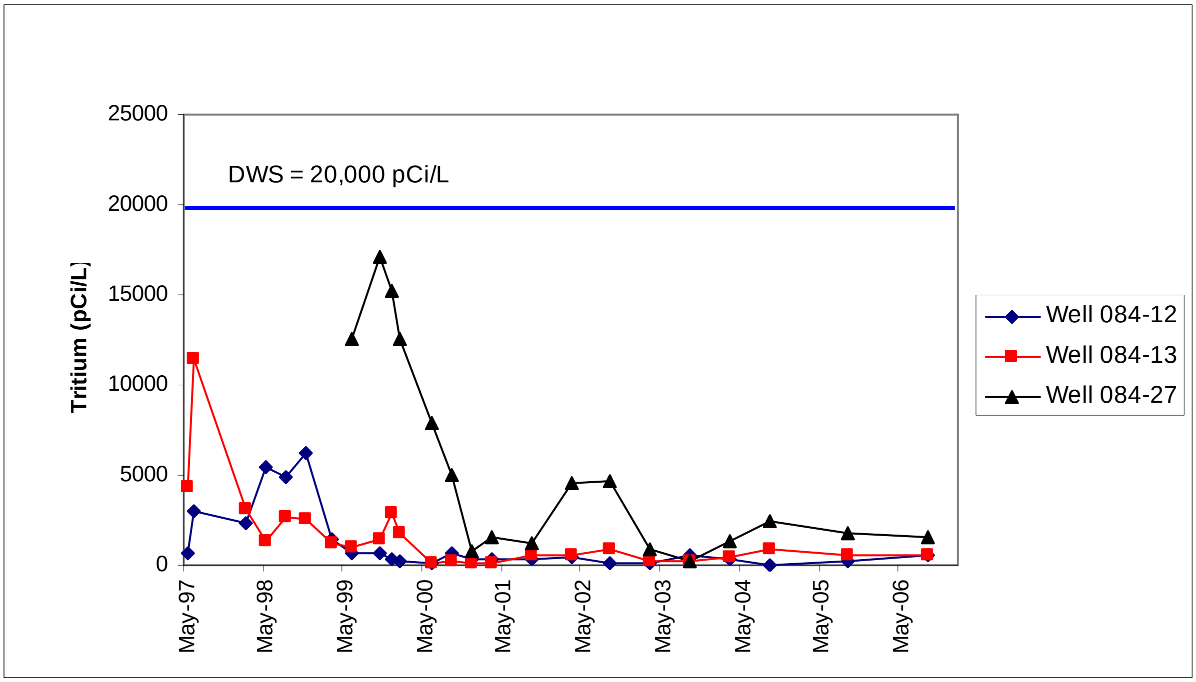
4.4.2 BMRR Monitoring Well Results

Monitoring results for sampling conducted during 2006 indicate that tritium concentrations continued to be well below the 20,000 pCi/L DWS. Detectable levels of tritium were observed in all three downgradient wells, with the maximum value of 1,570 pCi/L detected in well 084-27 (**Figure 4-14**). Gamma, gross alpha and gross beta results did not indicate the presence of any other reactor-related radionuclides.

4.4.3 BMRR Groundwater Monitoring Program Evaluation

Tritium concentrations in groundwater have never exceeded the 20,000 pCi/L DWS, 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 once every two years starting in 2007, with the next set of samples being collected in 2008.

Figure 4-14.
Tritium Concentrations Downgradient of the BMRR from 1997–2006.



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 an additional 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 2006, 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 2006 were generally typical of ambient (background) levels. Higher than normal gross alpha and gross beta levels were detected in the samples from filter bed area monitoring well 038-02, at maximum concentrations of 13 pCi/L and 21 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 BNL-related gamma emitting radionuclides or tritium was detected in any of the STP groundwater monitoring wells.

Nonradiological Analyses

During 2006, all water quality and most metals concentrations were below the applicable NYS AWQS or DWS. In filter bed area well 039-86 sodium was detected at a concentration of 27 mg/L, slightly above the 20 mg/L NYS AWQS. In filter bed area well 039-03 iron was detected at a concentration of 6.4 mg/L, well above the 0.3 mg/L NYS AWQS. Low levels of nitrates continue to be detected in many of the STP filter bed area wells, with a maximum concentration of 6.7 mg/L detected in filter bed area monitoring well 039-86. The NYS AWQS for nitrate is 10 mg/L. No VOCs were detected above the NYS AWQS in any of the STP monitoring wells.

4.5.3 STP Groundwater Monitoring Program Evaluation

Monitoring results for 2006 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 2007.

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 an old 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 -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, -11, -12, and -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 2006, the UST area wells were monitored semiannually, and the samples were analyzed for VOCs (**Table 1-6**). The wells were also checked for the presence of floating petroleum hydrocarbons on a semiannual basis. The Building 423/326 area wells were monitored annually, and the samples were analyzed for VOCs.

4.6.2 Motor Pool Monitoring Well Results

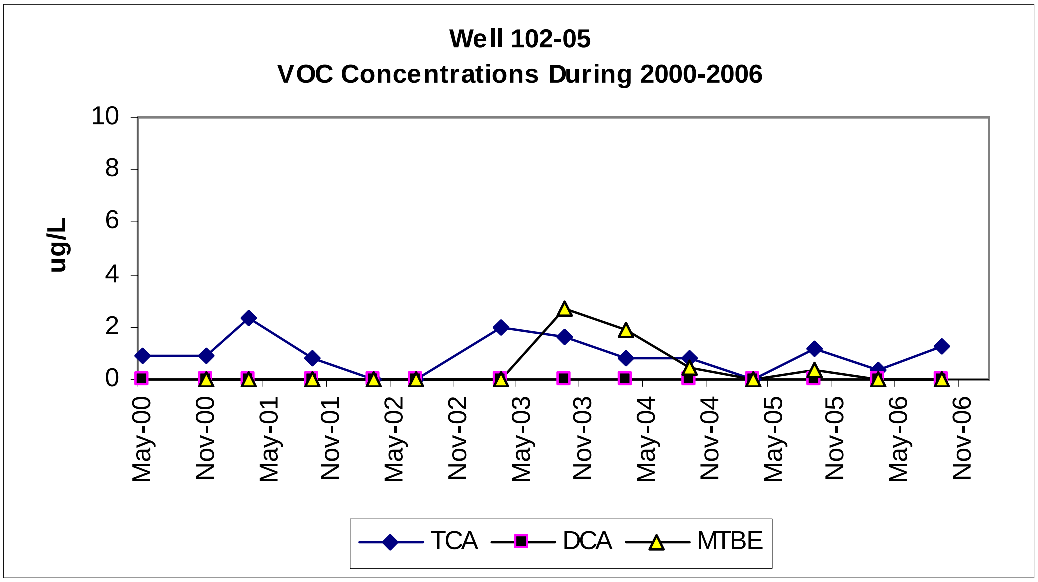
Underground Storage Tank Area

During 2006, 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 non-detectable levels by 2006. 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 2006, TCA continued to be detected in all four wells, at a maximum concentration of 18 μg/L in well 102-12 (**Figure 4-18**). DCA was detected in wells 102-11, 102-12 and 102-13 at concentrations up to 11.9 μg/L. The gasoline additive MTBE was detected in all four wells, at concentrations up to 1.8 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.



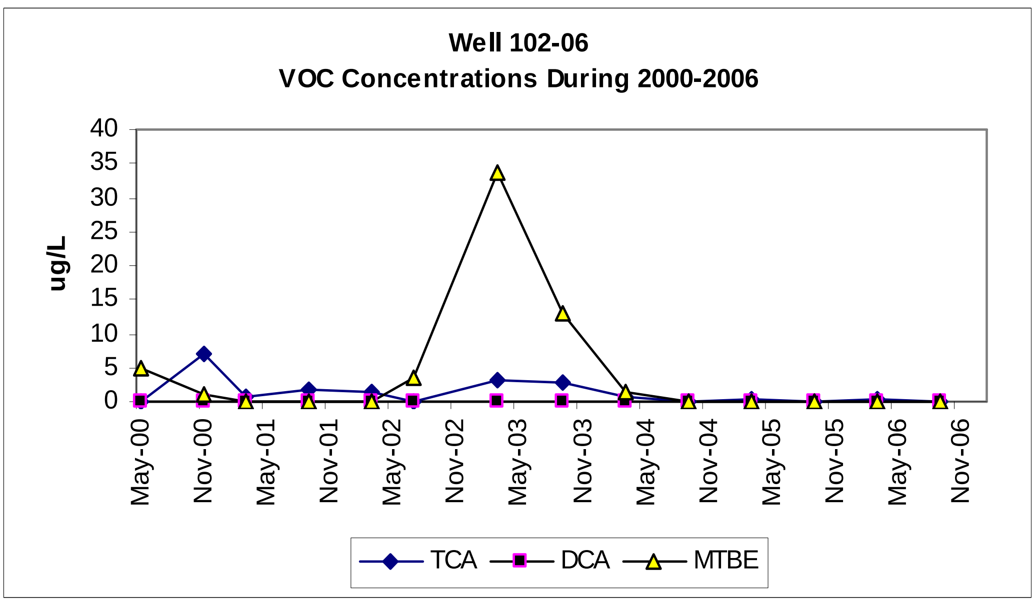
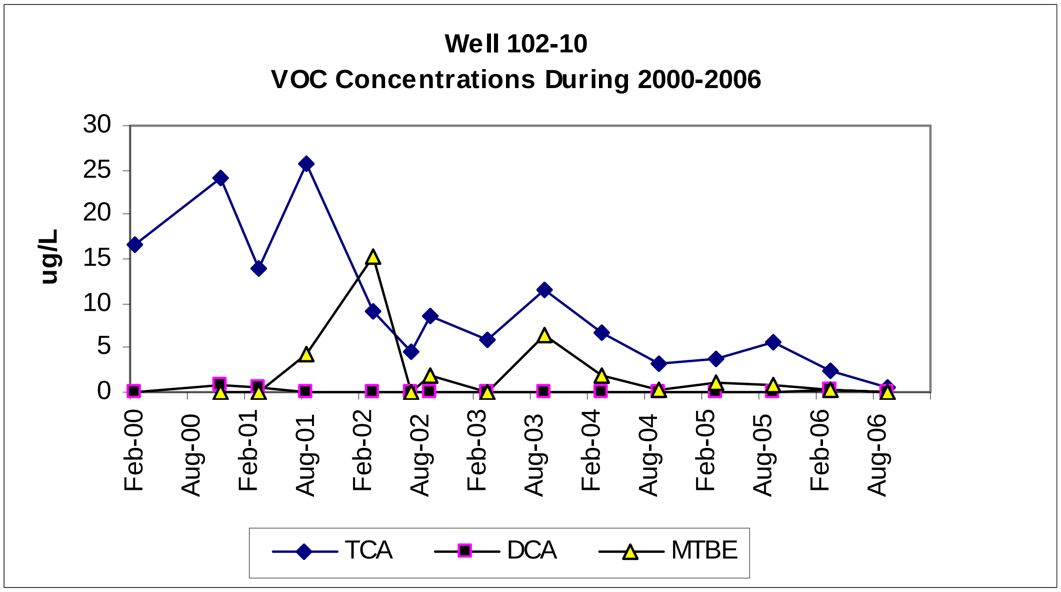


Figure 4-18.
VOC Concentration Trends in Wells Downgradient of Building 323/326.



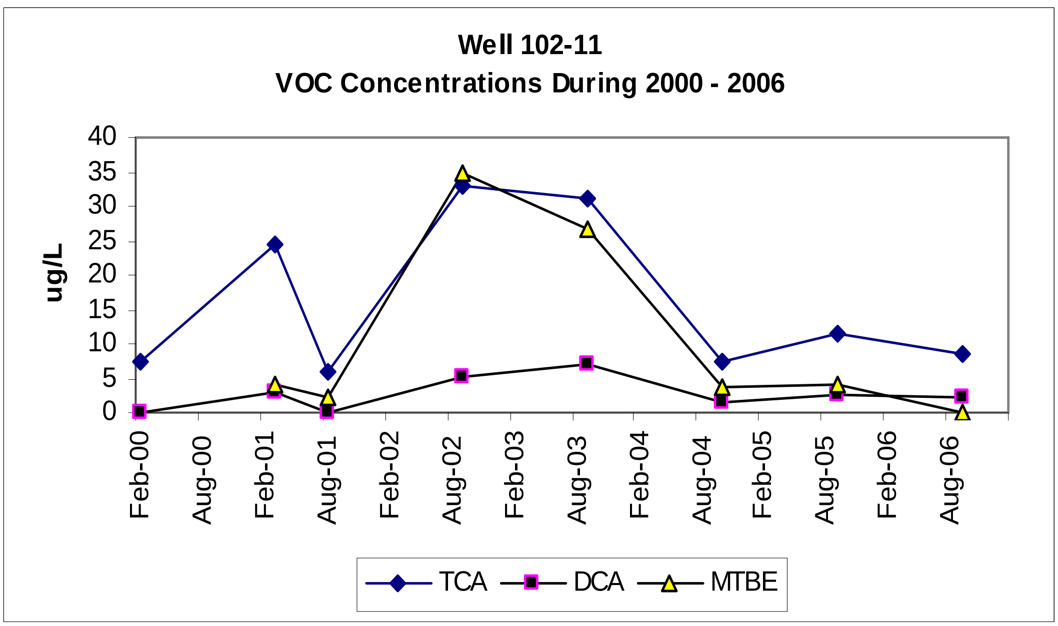
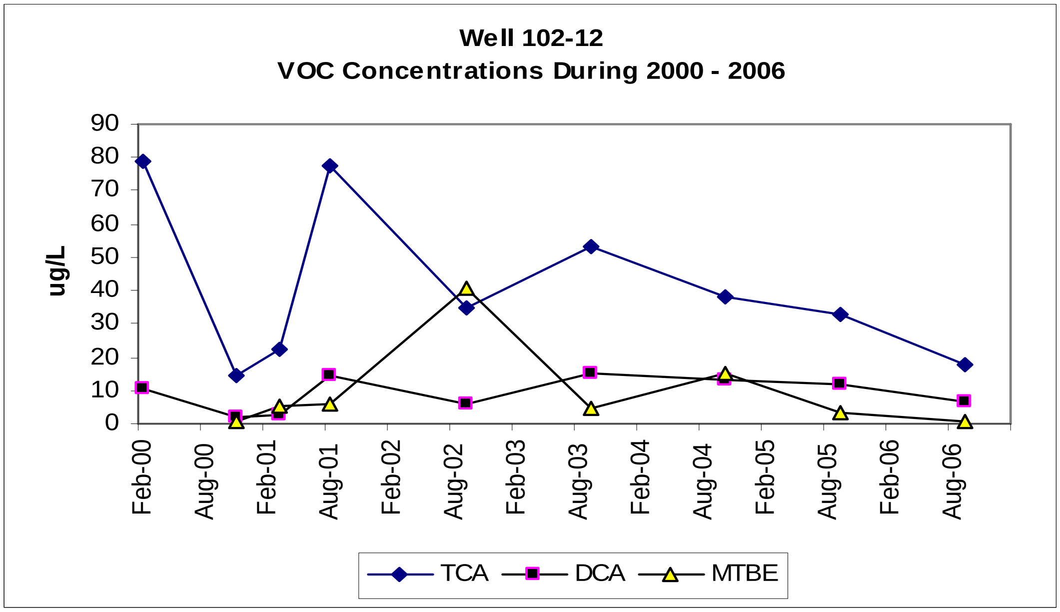
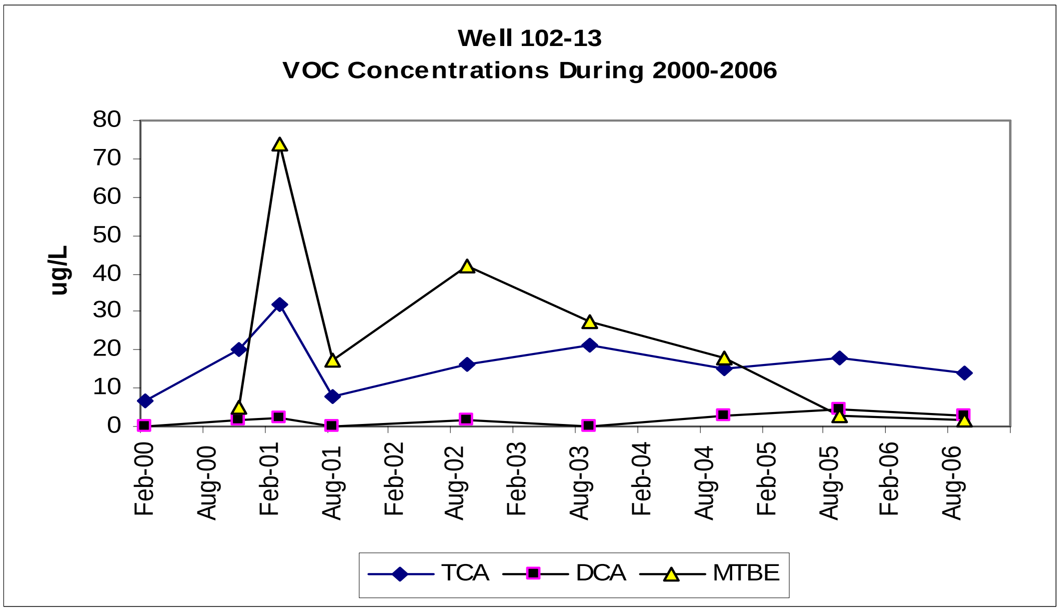


Figure 4-18 (Continued).
VOC Concentration Trends in Wells Downgradient of Building 323/326.





4.6.3 Motor Pool Monitoring Program Evaluation

Although groundwater samples collected at the Motor Pool facility during 2006 indicate that releases from historical operations continue to impact groundwater quality, the VOC concentrations have decreased over the past several years. 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 2007.

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 2006, 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.

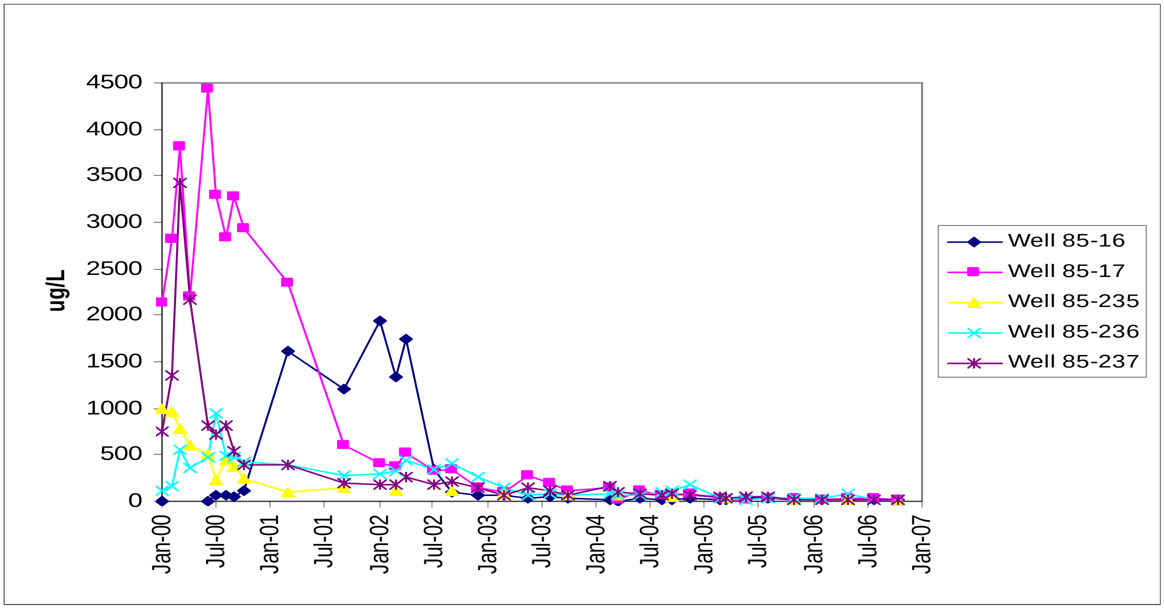
4.7.2 Service Station Monitoring Well Results

During 2006, carbon tetrachloride (and its breakdown product, chloroform) continued to be observed in the service station monitoring wells (**Figure 4-19**). The maximum carbon tetrachloride concentration was 85 μg/L, observed in the April 2006 sample from well 085-236. 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 remediation 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 2006, petroleum-related compounds continued to be detected in the groundwater (**Figures 4-21**, **4-22**, and **4-23**). The highest VOC concentrations continue to be detected in well 085-236. The April 2006 sample from well 085-236 showed a significant increase in hydrocarbon related VOC concentrations, with ethylbenzene at 75 μg/L, m/p xylene at 480 μg/L, o-xylene at 210 μg/L, n-propylbenzene at 64 μg/L, 1,2,4-trimethylbenzene at 360 μg/L, 1,3,5-trimethylbenzene at 110 μg/L, and the solvent tetrachloroethylene at a concentration of 25 μg/L. The VOC levels dropped to nearly non-detectable during the next two sample quarters in July and October 2006.

Trace 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 2006, the highest MTBE level was detected in well 085-17, at a concentration of 0.34 μg/L. The NYS AWQS for MTBE is 10 μg/L. As in previous years, no floating product was detected in the wells.

Figure 4-20.
Carbon Tetrachloride Concentration Trends in Service Station Monitoring Wells.



4.7.3 Service Station Groundwater Monitoring Program Evaluation

Analysis of groundwater samples collected at the service station facility during 2006 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 2007.

Figure4-21.
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.

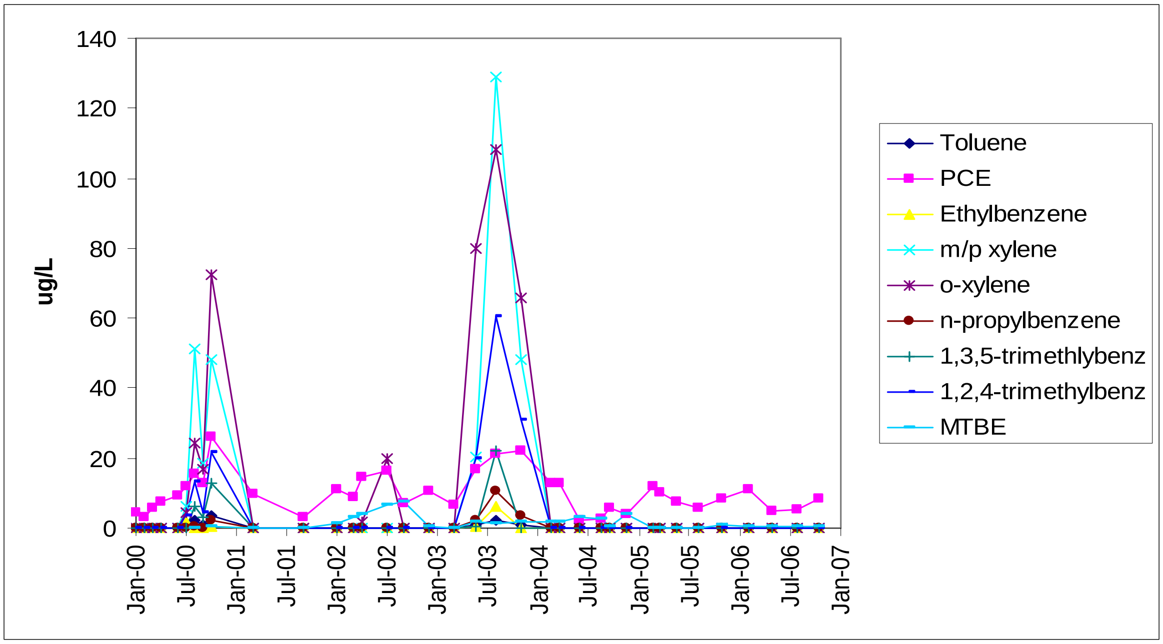


Figure 4-22.
Downgradient Well 085-236: Trend of Service Station-Related VOCs. Note that carbon tetrachloride from the upgradient carbon tetrachloride UST source area is not included.

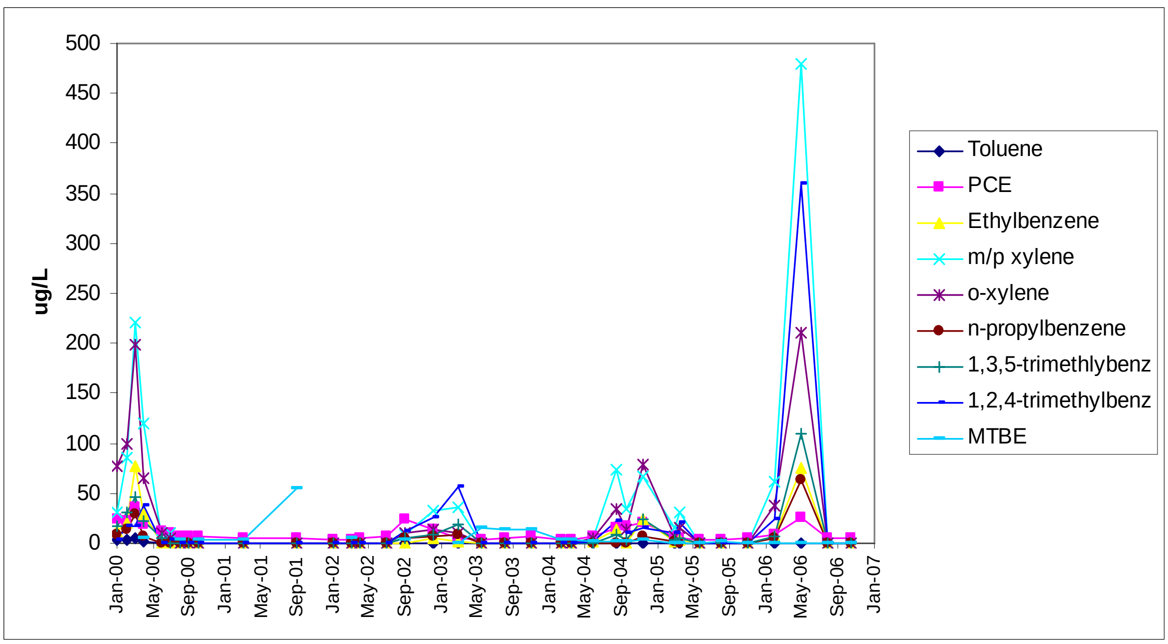
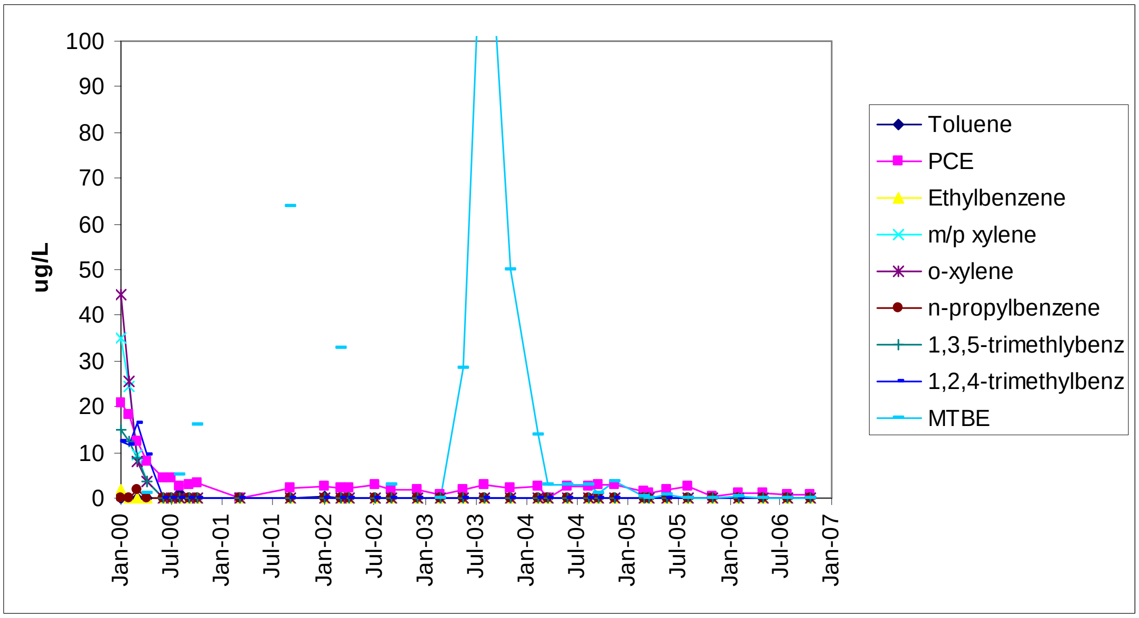


Figure 4-23. **Downgradient Well 085-237: Trend of Service Station-Related VOCs.** Note that carbon tetrachloride originating from the upgradient carbon tetrachloride UST source area is not included.



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.

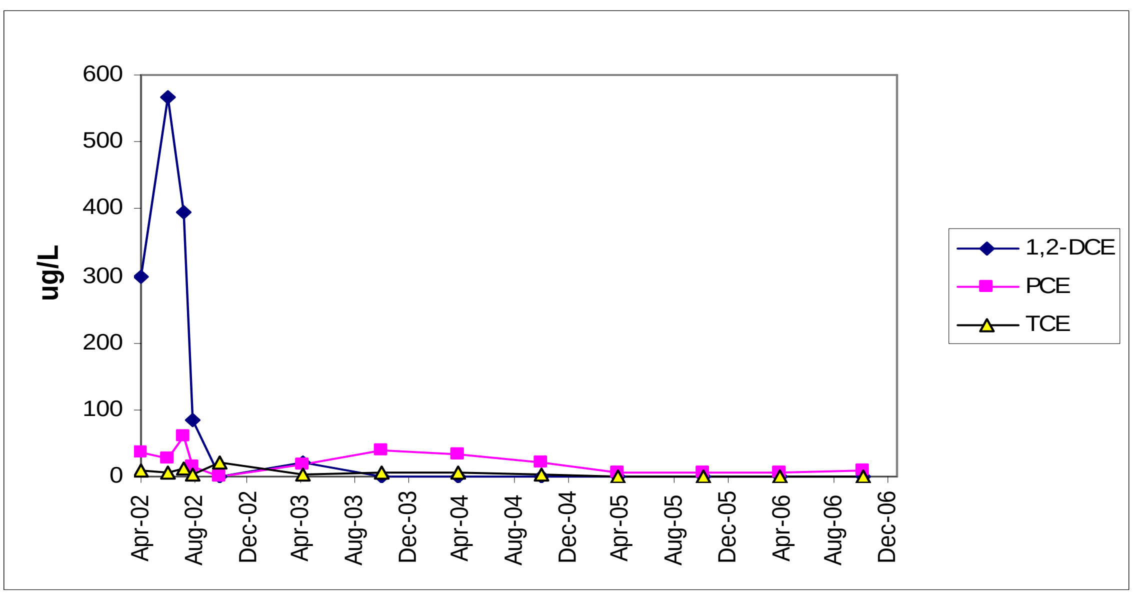
4.8.2 MPF Monitoring Well Results

BNL sampled the MPF wells in April and October 2006. The wells were also tested monthly for the presence of floating petroleum. 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 0.75 µg/L), tetrachloroethylene (up to 0.16 µg/L) and chloroform (up to 2.2 µg/L) continued to be detected in upgradient well 075-25. These compounds are related to historical spills near building 610. As in past years, several solvents continued to be detected in downgradient well 076-380. Trace levels of TCA and TCE were detected (<1 µg/L), and PCE was detected at concentrations up to 7.7 µg/L, slightly above NYS AWQS of 5 µg/L. Levels of the PCE breakdown product trans-1,2-dichloroethene dropped to non-detectable levels by the end of 2005, and remained at non-detectable levels during 2006 (**Figure 4-25**). 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 detection of 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 several MPF area wells 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 2007, 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 (WMF)

The Waste Management Facility (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 *2006 Groundwater Monitoring Report for the Waste Management Facility* (BNL 2007c). 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 2006, 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 (e.g., chlorides, sulfates, and nitrates) (**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. In February 2006, tritium was once again detected in well 056-23 at a concentration of 860 pCi/L, but decreased to non-detectable levels by August. As in past years, 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.

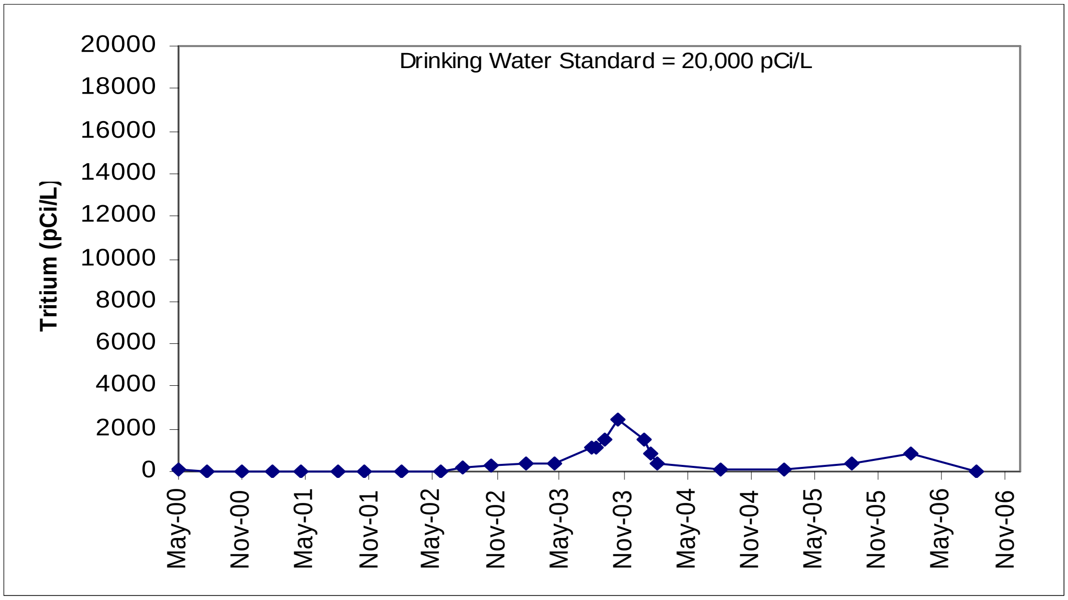
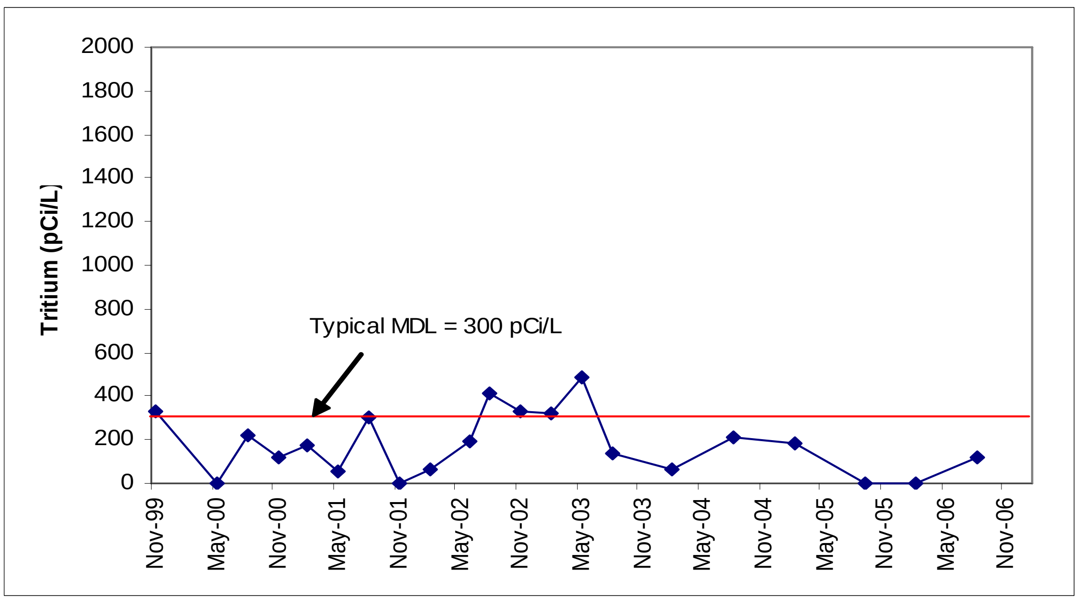


Figure 4-28.
Tritium Concentration Trends in Well 066-07, Upgradient of Waste Management Facility.



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 35.8 mg/L. Elevated sodium levels were also detected in downgradient wells 056-21 and 056-22 at concentrations of 26.4 and 29.1 mg/L, respectively. The elevated sodium concentrations are likely due to road salting operations. During 2006, no VOCs were detected at concentrations above NYS AWQS. Low levels of chloroform were detected in all of the WMF wells, with the highest level (1.1 µg/L) detected in upgradient well 066-83 which is located close to recharge basin HO. Because this basin receives secondary cooling water that was supplied from the potable water system, it is likely that the chloroform detected in the WMF monitoring wells is a chlorination by-product. A trace level of MTBE (0.24 µg/L) was detected in upgradient well 066-07, and a trace level of TCA (0.13 µg/L) was detected in downgradient well 056-23. The NYS AWQS for MTBE is 10 µg/L, and 5 µg/L for TCA.

4.9.3 WMF Groundwater Monitoring Program Evaluation

Groundwater monitoring results for 2006 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. Although there continue to be periodic detections of trace levels of tritium in the groundwater, a thorough review of Waste Management operations suggests that the tritium was not released from the WMF. For 2007, monitoring will continue as required by the RCRA Part B Permit.

During 2007, up to five new downgradient groundwater monitoring wells will be installed at the WMF. These wells are needed because the predominant groundwater flow directions in the WMF area have changed since the initial monitoring wells were installed in the mid 1990s. Because the new wells will be positioned downgradient of the buildings based on normal southeast groundwater flow directions, supply wells 11 and 12 will not have to be operated continuously for a two-week period prior to sampling the monitoring wells in order to establish the necessary northward flow patterns to use the existing surveillance wells.

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 2006, Building 801 monitoring well 065-325 was sampled two 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 two times under the LTRA, and the samples were analyzed for Sr-90 and Cs-137 (**Table 1-5**).

4.10.2 Building 801 Monitoring Well Results

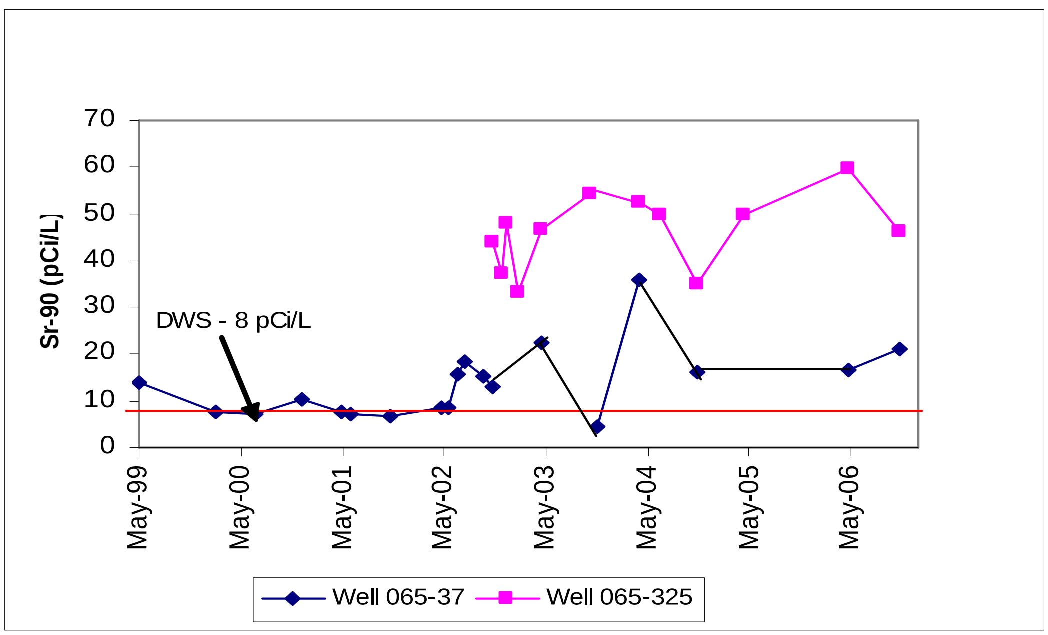
The April and October 2006 samples from well 065-325 had Sr-90 concentrations of 59.9 pCi/L and 46.1 pCi/L, respectively (**Figure 4-29**). Cs-137 was not detected in any of the samples. Sr-90 concentrations in the slightly deeper well 065-37 ranged from 16.6 pCi/L in April to 21.3 pCi/L in October 2006. Only low levels of Sr-90 were detected in deeper wells 065-169 and 065-170, with maximum concentrations of 1.7 pCi/L and 1.6 pCi/L, respectively

4.10.3 Building 801 Monitoring Program Evaluation

Sr-90 concentrations in samples collected during 2006 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 2007 will continue to be 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 LTRA 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:

- Based on TVOC concentration increases in well 115-13 and upgradient plume core well 107-40, the leading edge of the high concentration segment of the VOC plume is approaching the south boundary and should reach it during 2007. As a result, resume full-time operation of extraction wells EW-1 and -2 during the third quarter of 2007.
- 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 semi-annual frequency. Sentinel and bypass wells are sampled at a quarterly frequency.
- For consistency with previous changes made to the Current Landfill plume monitoring, delete monitoring of the system influent and effluent for metals (including iron and manganese), pesticides, PCBs, and gross alpha/beta.

5.2 Carbon Tetrachloride Pump and Treat System

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

- If significant concentrations of carbon tetrachloride are detected in monitoring or extraction wells, the system will be turned on.
- Change the monitoring well sampling frequency from shutdown phase (quarterly) to standby (semi-annually).
- Move monitoring well 095-92 to the Middle Road Pump and Treat System well network.

5.3 Building 96 Air Stripping System

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

- As an interim action to maintain hydraulic containment of the source area, modify recirculation well RTW-1 to work as a pumping well and discharge to the nearby surface drainage culvert. This will involve running a discharge line to the culvert about 300 feet away and will require a SPDES equivalency permit. This will be implemented by January 2008. Effluent sampling frequency will be performed as per the SPDES equivalency permit.
- Downgradient monitoring will continue and, if needed, downgradient recirculation wells RTW-2, RTW-3, and RTW-4 can be restarted if elevated TVOC concentrations (> 50 μg/L) 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. Maintain a monthly sampling frequency of the influent and effluent when the system is operating.
- Maintain the current sampling frequency of quarterly for the extraction wells when they are not operating.

- Since VOC concentrations didn't show a consistent decline in the source area wells, alternative methods for remediating the contamination in the silt zone upgradient of extraction well RTW-1 will be evaluated. This evaluation will include excavation of the source area, adding an additional extraction well in the source area and evaluating other remedial technologies and will be prepared by the end of 2007.
- Monitoring well sampling will continue at the current frequency.

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 operation and maintenance monitoring frequency that began in 2003.
- Continue extraction wells RW-4, RW-5 and RW-6 in standby mode during 2007. Restart the wells if extraction or monitoring well data indicate that TVOC concentrations exceed the 50 µg/L capture goal.
- Install one additional temporary well 150 feet west of MRVP-104 (**Figure 3.2.3-1**) to characterize the high-concentration portion of the plume in this area. Install two monitoring wells, one near MRVP-103 to monitor the high concentrations and one on the western edge of this plume to use as a perimeter monitoring well.
- The increased VOC concentrations (TCA, DCE) in well 095-92 **(Figure 3.2-1)** observed over the past several years where characterized in January 2007 as a follow up to last years annual report recommendation. A vertical profile well (095-92 2007 VP-1) was installed adjacent to this well. The highest concentration detected at this location was at 130 feet below grade with a concentration of TCA at 64 µg/L. This is consistent with the depth of well 095-92. The profile was sampled from a depth of 210 feet below grade to 70 feet below grade. Results are shown in **Table 3.2.3-4.** No further action is required at this time as these contaminants are expected to be captured by the Middle Road groundwater treatment system.

5.5 OU III South Boundary Pump and Treat System

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

- Maintain the routine operations and maintenance monitoring frequency that began in 2003.
- Extraction well EW-12 was placed in standby mode in 2003 and EW-8 in 2006. These wells will continue in standby mode during 2007. The wells will be restarted if extraction or monitoring well data indicate TVOC concentrations exceed the 50 µg/L capture goal.
- Place extraction wells EW-6 and -7 in standby mode in October 2007 due to low VOC concentrations in these wells. Therefore, four of the seven extraction wells will be in standby mode at the end of 2007. The highest VOC concentration observed in well EW-6 in 2006 was 6.5 µg/L in October 2006 and the maximum TVOC concentrations was 15.6 µg/L, also in October. This is well below the capture goal of 50 µg/L. Well EW-7 had a maximum VOC concentration of 8.1 µg/L of TCA in January 2006 and a TVOC maximum of 15 µg/L. Continue quarterly sampling of these wells. The wells will be restarted if extraction or monitoring well data indicate TVOC concentrations exceed the 50 µg/L capture goal.

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:

- Maintain the routine operation and maintenance monitoring frequency that began in 2005.
- Due to the low influent concentrations, and because six out of seven plume core wells have reached the cleanup objective of 20 µg/L TVOCs, it is recommended that pulse pumping of the extraction wells continue. The wells will be shut down for two months, then turned back on for one month. This process will continue and any changes to the VOC concentrations in the influent and the monitoring wells will be evaluated.

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 2007.
- The system should continue operations at 60 gpm per well except for well UVB-1, which is to remain in a standby mode. It is recommended that well UVB-4 be placed in standby beginning in October 2007 since influent concentrations to this well are at or near the drinking water standard and have been for over a year. Monthly sampling will continue and if TVOC concentrations greater than 50 µg/L are observed, well UVB-1 and UVB-4 will be restarted.

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.

- Due to low VOC concentrations (all wells are less then the capture goal of 50 µg/L TVOC), in October 2007 begin pulse pumping of the extraction wells one month on and one month off at 115 gpm for EWI-1 and 75 gpm for EWI-2. The extraction wells will be restarted if data indicate that capture goal of 50 µg/L TVOC is exceeded. If no rebound is seen (i.e., TVOC concentrations exceeding 50 µg/L) in extraction or monitoring wells after one year of pulse pumping, then petition for shutdown of this system.
- Change the monitoring well network sampling frequency from the O&M phase (semi-annual sampling) to the shutdown phase (quarterly sampling) starting in the third quarter of 2007 (July through September).

5.9 North Street Pump and Treat System

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

- Maintain the O&M sampling frequency for monitoring wells initiated in 2006.
- Change monthly sampling of the extraction wells to quarterly.
- Change system influent, midpoint, and effluent sampling frequency from weekly to twice per month.

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:

- Continue pulse pumping of both extraction wells, since the system influent concentrations have remained very low over the past year and all of the monitoring wells are already below the capture goal of 50 µg/L TVOC. The pulse pumping consists of having the system on for one month then off in standby mode for the next month. 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 the core monitoring wells or the extraction wells, the well(s) will be put back into full-time operation.
- Since the system has been operating for over two years, change the sampling frequency for the monitoring wells from start-up to the O&M phase (core and perimeter wells sampled semi-annually, and sentinel wells sampled quarterly). However, plume core wells 000-481, -482, -483, and -484 should be maintained at the quarterly sampling frequency since they are immediately upgradient of extraction well NSE-2.
- Lower the pump location four feet in monitor wells 000-482, -483, and -484 to obtain representative data from a slightly deeper portion of the aquifer.

5.11 LIPA/Airport Pump and Treat System

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

- As per the recent groundwater investigation, an additional extraction well (RW-6A) is being added to the west of Airport well RTW-1A. Five new monitoring wells are also planned. See **Figure 3.2.10-2** for the proposed location and depth of the extraction and monitoring wells. A detailed report and design for this work will be sent out under separate cover. The plan is to have this well operational by September 2007.
- For LIPA, change the groundwater monitoring frequency from the startup phase to O&M phase (core and perimeter wells sampled semi-annually, and sentinel wells sampled quarterly).
- For the Airport, since the plume has not fully reached the treatment system recovery wells, maintain the startup monitoring frequency of quarterly sampling of the monitoring wells.
- The extraction well sampling should change to quarterly, except for the Airport well RTW-1A, which should be maintained at the monthly schedule.
- Reduce system sampling and analysis from weekly to two times per month.
- Continue the airport extraction wells pulse-pumping of one week per month except for well RTW-1A, which should continue with full-time operations. This will verify that the higher concentrations have not reached the Airport System. If concentrations above the capture goal of 10 µg/L TVOCs 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.
- Shut down and place in standby mode LIPA wells EW-1L and -3L, as both of these wells have had TVOC concentrations well below the 50 µg/L capture goal throughout 2006. In addition, all of the monitoring wells in this area have concentrations less then 50 µg/L TVOC. The extraction wells will be restarted if TVOC concentrations rebound in either the plume core monitoring wells or the extraction wells greater than the 50 µg/L capture goal.

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

The following recommendations are made for the Off-Site Groundwater Monitoring program:

- Change the frequency of monitoring from semi-annual to annual.

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, via the oversight of the BNL Water and Sanitary Planning Committee.
- Install new monitoring wells in 2007 to replace those previously abandoned.
- Install an additional perimeter 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 (and slightly deeper than) well 075-189.
- Install an additional monitoring well (sentinel well) downgradient of the PFS plume. The new well is to be located in the 75-46 well cluster.
- Change the treatment system monitoring frequency from weekly to two times per month.
- Remove gross beta from the analyte list for the treatment system sampling since this sampling is no longer needed. It was previously used as a means to confirm any rapid breakthrough of the resin. However, based on operations data, breakthrough is a slow and gradual process. Thus, the two week turnaround on Sr-90 analyses is now adequate for continued verification.
- Analyze select wells for Sr-90 during the installation of temporary wells just northwest of the HFBR in the spring 2007 for the g-2 Tritium Plume. This will help enhance the monitoring of the WCF Sr-90 plume.
- Change the monitoring well sampling frequency from startup (semi-annual and quarterly) to the O&M phase (semi-annual and annually).

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:

- Submit the design for the two additional downgradient extraction wells to the regulators, and implement by the end of 2007.

- Based on low influent concentrations over 2006 and to help evaluate improving the effectiveness of removing Sr-90 from the aquifer, beginning in October 2007, implement pulse pumping (EW-1 cycle of one month on, and one month off). This will be performed to help evaluate rebounding of the Sr-90 influent concentrations. If concentrations in the extraction well increase significantly, the extraction well will be put back into full-time operation.
- Change the monitoring well sampling frequency from startup (semi-annual and quarterly) to the O&M phase (semi-annual and annually). However, maintain the new monitoring wells to be installed as part of the semi-annual frequency for approximately two years.
- Remove gross beta from the analyte list for the treatment system sampling, since this sampling is no longer needed. It was previously used as a means to confirm that there was not rapid breakthrough of the resin. However, based on the three years of operations data, breakthrough is a slow and gradual process. Thus, the two-week turnaround on Sr-90 analyses is now adequate for continued verification.

5.18 HFBR Tritium Monitoring

The following are recommendations for the HFBR tritium plume:

- Continue monitoring well sampling initiated in 2006, including semi-annual supplemental temporary well sampling.
- Install a fourth extraction well (EW-16) approximately 400 feet south of Weaver Drive as shown on **Figure 3.2.17-1**. This well will be installed and operating by late 2007, rather than waiting another one to two years for the plume to reach the Princeton Avenue firebreak. Extraction well EW-11, and possibly EW-10, will be restarted in addition to the new well to provide for the capture of tritium located further west (migrating south from the GP-341 vicinity). The pump and recharge well(s) would be operated until the tritium concentrations from Weaver Drive to the new extraction well drop below 20,000 pCi/L. The estimated operational duration of two years is based on the length of the high-concentration area slug and the time it would take to be completely captured by the new extraction well. The decision to turn the wells back to standby will be based on 1) concentrations of tritium being less than 20,000 pCi/L in the monitoring wells at Weaver Drive as well as the extraction wells, and 2) verification that the new extraction well has captured concentrations of tritium in this area greater than 20,000 pCi/L. This decision to turn the wells back to standby will be supported with data from additional permanent and temporary wells as needed.
- Temporary wells will be installed twice per year over the next several years to characterize the location of the high concentration area and results will be communicated to the regulators via the IAG conference call and quarterly/annual reports.
- Install up to five permanent monitoring wells to monitor the effects of the new extraction well on the tritium plume. A design report providing further details on the planned extraction well and additional monitoring wells will be provided under separate cover.

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

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

5.20 Building 650 (Sump Outfall) Strontium-90 Monitoring Program

The following recommendations are made for the Building 650 Strontium-90 Groundwater Monitoring Program:

- Reduce the sampling frequency for monitoring wells 076-07, -09, -10, -22, -181, -182, -184, and -265 to annual.
- Since the primary contaminant for this plume is Sr-90, delete further monitoring of gross alpha/beta, gamma spectroscopy, and tritium.

5.21 Operable Unit V

The following recommendations are made for the OU V plume groundwater monitoring program:

- The monitoring program sampling frequency will changed from semi-annual to annual for 2007.
- Continue to analyze eight OU V monitoring wells for perchlorate in 2007.

5.22 Operable Unit VI Pump and Treat System

The following recommendations are made for the OU VI EDB Pump and Treat System and groundwater monitoring program:

- Maintain the routine operation and maintenance monitoring frequency that began in third quarter 2006.
- Since there were no detections above the DWS for EDB in well 000-498 for 2006, change the sampling frequency for this well from quarterly (system start-up phase) to semi-annually (O&M phase). This will allow for consistency with the remainder of the wells in this monitoring program.

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.

5.26 Alternating Gradient Synchrotron (AGS) Complex

The following actions are recommended for 2007:

- The Building 912 wells used to track the g-2 tritium plume will be sampled semi-annually, whereas the remainder of the Building 912 wells will be sampled annually.
- Temporary Geoprobe wells will be used to track the leading edge of the g-2 plume.

5.27 Brookhaven Linac Isotope Producer Facility (BLIP)

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 2007, groundwater samples will continue to be collected on a semi-annual 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 once every two years starting in 2007, with the next set of samples being collected in 2008.

5.30 Sewage Treatment Plant

No changes to the STP groundwater monitoring program are proposed for 2007.

5.31 Motor Pool Maintenance Area

No changes to the Motor Pool groundwater monitoring program are proposed for 2007.

5.32 On-Site Service Station

No changes to the Service Station groundwater monitoring program are proposed for 2007.

5.33 Major Petroleum Facility Area

Groundwater monitoring at the MPF will continue in accordance with the NYSDEC operating permit. The wells will continue to be tested monthly for floating product and semi-annually for VOCs and SVOCs.

5.34 Waste Management Facility

Groundwater monitoring at the WMF will continue to be conducted on a semi-annual 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 semi-annually, whereas samples will be analyzed annually for metals and anions.

During 2007, up to five new downgradient groundwater monitoring wells will be installed at the WMF. These wells are needed because the predominant groundwater flow directions in the WMF area have changed since the initial monitoring wells were installed in the mid 1990s. Because the new wells will be positioned downgradient of the buildings based on normal southeast groundwater flow directions, supply wells 11 and 12 will not have to be operated continuously for a two-week period prior to sampling the monitoring wells in order to establish the necessary northward flow patterns to use the existing surveillance wells.

5.35 Building 801

The monitoring frequency for well 065-325 for 2007 will continue to be semi-annual, and the monitoring will be conducted as close as possible with planned semi-annual sampling of wells 065-37, -169, and -170 by the Environmental Restoration Program.

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