2002 BNL GROUNDWATER STATUS REPORT

July 29, 2003

Environmental and Waste Management Services Division
Environmental Restoration

Brookhaven National Laboratory
Operated by
Brookhaven Science Associates
Upton, NY 11973

Under Contract with the United States Department of Energy
Contract No. DE-AC02-98CH10886

EXPLORING EARTH'S MYSTERIES
…PROTECTING ITS FUTURE

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2002 BNL Groundwater Status Report

TABLE OF CONTENTS

(TABLE OF CONTENTS CONTINUED)

(TABLE OF CONTENTS CONTINUED)

(TABLE OF CONTENTS CONTINUED)

(TABLE OF CONTENTS CONTINUED)

(TABLE OF CONTENTS CONTINUED)

(TABLE OF CONTENTS CONTINUED)

LIST OF FIGURES

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(LIST OF FIGURES CONTINUED)

(LIST OF FIGURES CONTINUED)

LIST OF TABLES

LIST OF APPENDICES

(LIST OF APPENDICES CONTINUED)

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LIST OF ACRONYMS

2002 BNL Groundwater Status Report

µg/L	Micrograms per Liter	DCG	Derived Concentration Guide
AGS	Alternating Gradient Synchrotron	DDT	Dichlorodiphenyltrichloroethane
AOC	Area of Concern	DG	Deep Glacial
AS	Air Sparging	DMR	Discharge Monitoring Report
AS/SVE	Air Sparge/Soil Vapor Extraction	DNAPL	Dense Non Aqueous Phase Liquid
ASL	Analytical Services Laboratory	DOE	U.S. Department of Energy
ASTM	American Society for Testing and Materials	DQO	Data Quality Objective
AWQS	Ambient Water Quality Standards	DTW	Depth to Water
BERA	Brookhaven Employees Recreation Association	DWS	Drinking Water Standard
BGD	Below Ground Ducts	EDB	Ethylene Dibromide
BGRR	Brookhaven Graphite Research Reactor	EDD	Electronic Data Deliverable
BLIP	Brookhaven LINAC Isotope Producer	EE/CA	Engineering Evaluation/Cost Analysis
BLS	Below Land Surface	EIMS	Environmental Information Management System
BMRR	Brookhaven Medical Research Reactor	EM	Environmental Management
BNL	Brookhaven National Laboratory	EMS	Environmental Management System
CERCLA	Comprehensive Environmental Response Compensation and Liability	EPA	United States Environmental Protection Agency
CFR	Code of Federal Regulations	ER	Environmental Restoration
CLP-SOW	Contract Laboratory Program-Statement of Work	ERP	Emissions rate potential
COC	Chain of Custody	ES	Environmental Surveillance
CSF	Central Steam Facility	EWMSD	Environmental and Waste Management Services Division
CY	Calendar Year	fbg	feet below grade
DCA	1,1-dichloroethane	FFA	Federal Facility Agreement
DCE	1,1-dichloroethylene	FS	Feasibility Study

LIST OF ACRONYMS

2002 BNL Groundwater Status Report

ft msl	feet above mean sea level	NSRL	NASA Space Radiation Laboratory
GAC	Granular Activated Carbon	NYCRR	New York Code of Rules and Regulations
gal/hr	Gallons per hour	NYS	New York State
GeV	Giga Electron Volt	NYSDEC	New York State Department of Environmental Conservation
GPM	Gallons per minute	NYSDOH	New York State Department of Health
HFBR	High Flux Beam Reactor	O&M	Operation and Maintenance
HWMF	Hazardous Waste Management Facility	OU	Operable Unit
IAG	Inter Agency Agreement	PCBs	Polychlorinated Biphenyls
ID	Identification	PCE	Tetrachloroethylene
lb/gal	Pounds per gallon	pCi/L	pico Curies per Liter
lbs	Pounds	PE	Plant Engineering
LIE	Long Island Expressway	PLC	programmable logic controller
LIPA	Long Island Power Authority	QA/QC	Quality Assurance and Quality Control
MAG	Magothy	QAPP	Quality Assurance Project Plan
MCL	Maximum Contaminant Level	RA	Removal Action
MDL	Minimum Detection Limit	RCRA	Resource Conservation and Recovery Act
MGD	Millions of Gallons per Day	RHIC	Relativistic Heavy Ion Collider
MNA	Monitored Natural Attenuation	RI	Remedial Investigation
MPF	Major Petroleum Facility	RI/FS	Remedial Investigation/Feasibility Study
MS/MSD	Matrix Spike/Matrix Spike Duplicate	ROD	Record of Decision
msl	Mean Sea Level	SCDHS	Suffolk County Department of Health Services
MTBE	Methyl tertiary Butyl Ether	SCGs	Standards, Criteria and Guidances
NPL	National Priorities List	SCWA	Suffolk County Water Authority

LIST OF ACRONYMS

SDG	Sample Delivery Group
SDWA	Safe Drinking Water Act
SG	Shallow Glacial
SOP	Standard Operating Procedure
SOW	Statement of Work
SPCC	Spill Prevention Control and Countermeasures
SPDES	State Pollutant Discharge Elimination System
Sr-90	Strontium-90
STP	Sewage Treatment Plant
SVE	Soil Vapor Extraction
SVOC	Semi-Volatile Organic Compound
TAL	Target Analyte List
TCA	1,1,1- Trichloroethane
TCE	Trichloroethylene
TDH	Total Discharge Head
TVOC	Total Volatile Organic Compounds
USGS	U.S. Geological Survey
UST	Underground Storage Tank
VLB	Viscous Liquid Barrier
VOC	Volatile Organic Compound
WCF	Waste Concentration Facility
WMF	Waste Management Facility
WTP	Water Treatment Plant

2002 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 the quality of degraded 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 2002 BNL Groundwater Status Report is a comprehensive summary of raw data collected in calendar year 2002. It provides an interpretive technical summary of data on the performance of BNL's Groundwater Protection Program. This is the sixth annual groundwater status report issued by BNL. This document is unique in that it examines the performance of the program on a project-by-project basis, as well as comprehensively in a "watershed-like" analysis.

HOW TO USE THIS DOCUMENT- This detailed technical document includes summaries of laboratory data, as well as data interpretations. It is intended for internal BNL users, regulators, and other technically oriented stakeholders. Less technical summaries of this information can be obtained through the BNL website, BNL Community Affairs office, as well as BNL's annual Site Environmental Report. Environmental Restoration (ER) refers to work being performed under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) including measuring and monitoring of groundwater remediation performance and efforts in achieving cleanup goals. Environmental Surveillance (ES) refers to the monitoring of groundwater quality at active research and support facilities, primarily in response to DOE Order 5400.1.

Data are presented in five key subject areas:

- Improvements to the understanding of the hydrogeologic environment beneath BNL and surrounding areas,
- Identification of any new impacts on groundwater quality due to BNL's active operations,
- Progress in cleaning up the groundwater contamination,
- Performance of individual groundwater remediation systems, and
- 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 drivers of the data collection work in 2002, 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 2002. 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 and recommended changes to the groundwater protection program. The recommended changes to the Groundwater Protection Program are summarized in Section 5.

Hydrogeologic Data

The following were important hydrogeologic findings in 2002:

- Groundwater flow directions were relatively stable during 2002 in part due to the efforts of the BNL Groundwater Pump and Recharge Management Subcommittee. Supply pumping was relegated primarily to the western supply well field during the year with the exception of April through July when pumping was shifted to wells 10, 11, and 12 due to upgrade work at the water treatment plant. The Operable Unit (OU) III Middle Road Pump and Treat System, located on-site came on line in 2001. The system was designed such that treated water could be recharged to both the OU III and RA V basins. This helped to maintain an overall balance of recharged treatment system water in the central portion of the site and minimized changes to groundwater flow direction.

- Total annual precipitation in 2002 was recorded as 52.07 inches, above the average for the period of record of 48.5 inches per year. In an average year, it is estimated that 24 inches of rainfall recharge the Upper Glacial aquifer. Taking into account seasonal variations in evapotranspiration, the recharge rate for 2002 was estimated as approximately 26 inches.

- The Magothy Aquifer Characterization was completed during 2002. Information obtained from deep off-site borings in 2002 did not significantly alter the interpretation of the extent of the Magothy Brown Clay and Gardiners Clay units in these off-site areas. These are important confining units that govern the flow of groundwater from the Upper Glacial aquifer to the Magothy aquifer.

Progress in Groundwater Restoration Actions (CERCLA)

615 wells were sampled as part of the Environmental Restoration (ER) Groundwater Monitoring Program in 2002 comprising a total of 2,065 sampling events. BNL continued to make significant progress in characterizing and restoring groundwater quality at the site in 2002. Seven groundwater remediation systems were in operation by the end of 2002 with the addition of the OU III Western South Boundary system. Ten of the seventeen planned groundwater treatment plants have been constructed including the Chemical/Animal Holes Sr-90 Pilot Study Treatment system, which was operational in early 2003. Two systems remained in standby mode in 2002 as they substantially met their goal; they were the OU IV Air Sparging/Soil Vapor Extraction (AS/SVE) system, and the HFBR Pump & Recharge System. BNL expects to receive regulatory approval for closure of the AS/SVE system in August 2003. Asymptotic conditions have been achieved in plume core wells for the Building 96 treatment system. Pulse pumping of the system is proposed in 2003. Pulse pumping of Carbon Tetrachloride extraction wells was performed. The total groundwater cleanup treatment capacity was increased from 2,575 gpm in December 2001 to 2,875 gpm in December 2002. Ultimately, the total groundwater cleanup capacity will be on the order of 4,800 gpm. The Magothy aquifer groundwater characterization project was completed; a final report was published in May 2003. Additional groundwater characterization work was performed in the Building 96 system source area and immediately to the west of the system. Groundwater characterization was also performed beneath BGRR Building 701. The data obtained from these investigations refined our understanding of the BNL contaminant plumes. The progress of the groundwater restoration program is summarized in Table E-2. Other progress highlights include:

- A Five-Year Review Report was submitted for the Former Landfill in 2002 and recommended a reduction in sampling parameters and frequency.
- A Five-Year Review Report was submitted for the OU IV AS/SVE System in 2002.
- The HFBR tritium plume high concentration area continued to be monitored; geoprobe samples were collected in the vicinity of Bell Avenue.
- Sentinel monitoring wells were added downgradient of strontium-90 contamination south of the former Hazardous Waste Management Facility and downgradient of the leading edge of the BGRR strontium-90 plumes immediately south of Brookhaven Avenue.
- Additional Bypass wells were installed downgradient of the OU III South Boundary and Industrial Park systems.
- VOC concentrations in OU III Middle Road Pump and Treat system extraction wells RW-4 and RW-5 decreased to levels below groundwater standards.
- Two vertical profiles were installed to characterize the potential for deeper contamination associated with the carbon tetrachloride plume. Based on the data there is no Dense Non Aqueous Phase Liquid (DNAPL) associated with the carbon tetrachloride plume nor does there appear to be an additional upgradient source contributing to this plume at depth.

Table E-1 summarizes the status and progress of groundwater cleanup at BNL. In 2002, 701 pounds (lbs) of volatile organic compounds (VOCs) were removed from the aquifer by BNL treatment systems. To date, approximately 3,662 or about 12% of the estimated 25,000 to 30,000 lbs of VOCs in the aquifer have been removed by BNL. This estimate has been revised downward from 50,000 lbs as a result of groundwater characterization data obtained in 2000 through 2002.

Table E-1. BNL Groundwater Remediation System Treatment Summary for 1997 through 2002.

Remediation System (Start date)	1997-2001 Water Treated (Gallons)	1997-2001 VOCS Removed (Pounds)	2002 Water Treated (Gallons)	2002 VOCS Removed (Pounds) [c]
OU III South Boundary (June 1997)	1,558,436,850	1,709	343,000,000	219
OU III Industrial Park (Sept. 1999)	416,915,000	449	186,000,330	184
OU III W. South Boundary (Sept. 2002)	Not operating during this period		74,287,000	10
Carbon Tetrachloride (Oct. 1999)	88,337,300	241	34,461,000	86
OU I South Boundary (Dec. 1996)	1,740,939,000	254	377,451,000	26
HFBR Tritium Plume (May 1997) [a]	241,528,000	180	0	0
OU IV AS/SVE (Nov. 1997)[b]	--	35	--	0
Building 96 (Feb. 2001)	24,238,416	35	45,000,000	11
Middle Road (Oct. 2001)	55,353,550	39	281,000,000	184
Total	4,125,748,116	2,942	1,341,199,330	720

Notes:
[a] System was shut down and placed in standby mode on September 29, 2000.
[b] Air Sparging/Soil Vapor Extraction system performance measured by pounds of VOC removed per cubic feet of air treated.
[c] Values rounded to the nearest whole number.

Groundwater remediation is expected to be a long-term process. Some noticeable improvements in groundwater quality are evident in OU I South Boundary, the OU III South Boundary area, and the OU IV area. Groundwater remediation activities are expected to continue until approximately 2030 to meet the ultimate cleanup objective.

Figures E-1 and **E-2** summarize the extent of the primary VOC and radionuclide plumes at BNL as of December 2002, respectively.

Environmental Surveillance (Facility) Monitoring Results

During 2002, the Environmental Surveillance program monitored groundwater quality near 13 active research and support facilities. Groundwater samples were collected from 130 wells during 280 individual sampling events. No new impacts to groundwater quality were discovered during 2002.

At the Brookhaven Linac Isotope Producer (BLIP) tritium concentrations in wells located 40 feet downgradient of the BLIP target vessel did not exceed the 20,000 pCi/L drinking water standard. The maximum detected concentration of 15,100 pCi/L was observed in July. Continued monitoring of groundwater at a distance of 150 feet downgradient of BLIP showed the remnants of the slug of tritium released in 2000 by the Viscous Liquid Barrier (VLB) grout injection. The maximum tritium concentration observed at this distance was 44,100 pCi/L in April 2002, and then concentrations steadily declined to less than the 20,000 pCi/L drinking water standard by June 2002.

Groundwater quality continues to be impacted at three facilities: continued high levels of tritium at the g-2/VQ12 area of the Alternating Gradient Synchrotron (AGS) facility; low level VOCs at the Motor Pool/Facility Maintenance area and the Service Station.

High levels of tritium continue to be detected in groundwater downgradient of the g-2/VQ12 Magnet area. Tritium concentrations up to 3,440,000 pCi/L were detected in samples collected in July 2002 from a monitoring well located approximately 150 feet downgradient of the activated soil shielding. Periodic inspections of the capping system over the VQ-12 Magnet area found it to be structurally sound. It is likely that the continued presence of high levels of tritium in groundwater is due to the periodic release of residual tritium from the vadose zone (the area above the water table) following natural fluctuations in water table elevation. BNL and the regulatory agencies determined that additional monitoring would be required before completing the g-2 tritium plume Engineering Evaluation/Cost Analysis (EE/CA) and Action Memorandum.

At the Motor Pool/Facility Maintenance area, the solvents 1,1,1-trichloroethane (TCA) and 1,1-dichloroethane (DCA) continue to be detected at concentrations greater than the New York State Ambient Water Quality Standards (NYS AWQS) of 5 µg/L, but at concentrations slightly lower than those observed during 2001. TCA was detected at concentrations up to 34.5 µg/L, and DCA was detected at concentrations up to 6.2 µg/L. The gasoline additive methyl tertiary butyl ether (MTBE) was also detected, with a maximum observed concentration of 40.8 µg/L. The NYS AWQS guidance value for MTBE is 10µg/L. No floating petroleum was detected in the monitoring wells.

At the Service Station, low levels of VOCs associated with petroleum products (e.g., ethylbenzene, xylene, trimethylbenzenes) continue to be detected in several monitoring wells directly downgradient of the station. The solvent tetrachloroethylene was detected in several wells at a maximum concentration of 24.7µg/L. Additionally, the gasoline additive MTBE was detected in two wells at a maximum concentration of 32.8

μg/L. No floating petroleum was detected in the monitoring wells.

Monitoring of the leak detection systems at both vehicle maintenance facilities indicate 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 solvents and MTBE detected in groundwater at these facilities originate from historical vehicle maintenance activities, and are not related to current operations.

Emerging Issues

OU I South Boundary System

A persistent VOC hot spot remains in the aquifer south of the former HWMF. An evaluation will be undertaken in FY 04 to look at the life-cycle economics with respect to installing a third extraction well in this area. Active treatment of the hot spot would potentially reduce the duration of active remediation.

OU III Building 96 System

Groundwater characterization has determined that there is a continuing source for this VOC plume. Residual contamination is located in a shallow silty zone. The original system was not designed to address this source area. An evaluation of the source term and alternative technologies, and an evaluation to determine whether there is need for continued operation of the system will be performed.

MTBE in Sentinel Well

Suffolk County Department of Health Services (SCDHS) well 109-03 serves as a sentinel well for the Suffolk County Water Authority (SCWA) William Floyd Well Field and is located near the eastern BNL site property boundary. MTBE along with benzene, toluene and xylene were intermittently detected by BNL in 2002. Subsequent sampling of this well during 2002 by SCDHS and BNL in December did not detect any contaminants. Low-level MTBE was again detected by BNL in February and April 2003. A review of SCDHS groundwater modeling determined that BNL is not the source of this contamination and it is not a significant threat to the SCWA well field. Quarterly monitoring of the well will continue.

Building 801 Basement

In early December 2001, approximately 8,000 gallons of stormwater seeped into the basement of Building 801. This water became contaminated with strontium-90 and cesium-137 when it came into contact with the basement floor. Before the basement could be pumped out, it is estimated that between 1,350 and 2,750 gallons of contaminated stormwater might have leaked into the soils below Building 801. Strontium-90 was detected at concentrations up to 49 pCi/L during 2002 in shallow groundwater wells located immediately downgradient of Building 801. However, these values are consistent with pre-December 2001 values. Additionally, cesium-137 has not been detected in any of the groundwater samples. It is estimated that it could take years for strontium-90, and approximately 100 years for cesium-137 from the recent Building 801 stormwater release to migrate to the closest downgradient well (065-325). BNL will continue to monitor the groundwater downgradient of Building 801 on a semiannual basis, however it may be difficult to distinguish new groundwater impacts from legacy strontium-90 releases.

Brookhaven LINAC Isotope Producer (BLIP)

Although tritium concentrations in groundwater declined to less than the 20,000 pCi/L drinking water standard during 2002, monitoring conducted during the first half of 2003 once again showed elevated tritium levels (up to 37,800 pCi/L in April 2003). Although inspections of the cap and review of its design indicate that the stormwater controls (e.g., the combined gunite cap, the BLIP building, and paved areas) have not failed and are effective in protecting the BLIP target vessel activation zone, BNL is evaluating whether additional soil activation areas are present immediately upgradient of BLIP. Suspected areas include possible beam loss regions along the Linac to BLIP transfer line, and beam stops at the southern end of the Linac. The existing BLIP cap may not protect some of these potential soil activation areas.

AGS g-2 Tritium Plume

High levels of tritium continued to be detected in groundwater directly downgradient of the VQ12 source area (up to 3, 440,000 pCi/L in July 2002). Inspections of the cap and review of its design indicate that the cap over the VQ12 area has not failed and is properly positioned. It is likely that the continued release is probably related to the flushing of residual tritium from the vadose zone following natural fluctuations in water table position.

BNL and the regulatory agencies decided that additional monitoring data would be needed to better evaluate the vadose zone release hypothesis before finalizing the Engineering Evaluation/Cost Analysis (EE/CA) and submitting the Action Memorandum. An issue of potential concern is the commingling of the leading edge of the g-2 tritium plume with the strontium-90 plume coming from the Waste Concentration Facility, and the potential impact that high levels of tritium may have on the planned treatment system for the strontium-90 plume. During 2003, BNL will collect additional groundwater samples using permanent and temporary wells, and will also investigate other potential water pathways that could mobilize tritium from the vadose zone (e.g., stormwater running into cable trenches that run close to the VQ12 soil activation area, perched zones in the subsurface soils and nearby sheet piling that extends into the groundwater). The final EE/CA will be submitted to the regulatory agencies in October 2003.

1,4-Dioxane and Perchlorates

1,4-Dioxane and Perchlorates have recently emerged as potential threats to groundwater quality in a number of areas throughout the country.

1,4-Dioxane is used as a chemical stabilizer for a number of solvents such as tetrachloroethylene, 1,1-Dichloroethylene, and 1,1,1-Trichloroethane. This compound is not strippable or is poorly strippable using conventional air stripping or carbon filtration, respectively. 1,4-Dioxane is not included in current, widespread methods used to test drinking water and groundwater treatment systems (e.g., EPA Methods 524 and 624). BNL has not tested the local groundwater for this compound, which would require the use of EPA Method 8260. Testing at a number of sites across the country has detected high levels of this compound. Although a drinking water standard for 1,4-Dioxane has not been promulgated, the USEPA and some state agencies are assessing potential impacts that this compound may have on public drinking water supplies.

Perchlorates have been detected in a number of areas on Long Island. Perchlorates are used as an oxidizer and are the primary ingredient in solid propellant for rockets, missiles, fireworks, and munitions. Its presence in groundwater in some areas may be related to the use of fertilizers obtained from Chile. Its environmental occurrence coupled with its known mobility and persistence has elevated regulatory concern regarding the compound. Reduced thyroid function has been associated with developmental effects in animal testing.

Perchlorates were recently detected in a deep Upper Glacial aquifer test well installed by SCDHS immediately east (downgradient) of BNL. Although a source for the perchlorates has not yet been identified, the BNL the Sewage Treatment Plant and/or Safeguard and Security Division's Live-Fire Range may need to be investigated. Groundwater wells located at these facilities have not been tested for perchlorates to date.

Proposed Changes to the Groundwater Protection Program

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

- Reductions in groundwater monitoring for both the OU I Current and Former Landfill Programs as specified in the 2002 Environmental Monitoring Report, Current and Former Landfills.
- Proposed uniform phases for remediation system groundwater monitoring consisting of a system start-up phase of quarterly sampling followed by a reduction to semi-annual sampling for core and perimeter wells during the routine system operation and maintenance phase. This is followed by a period of quarterly sampling frequency prior to system shutdown and finally a system standby monitoring period of reduced sampling frequencies for key plume core wells. This was proposed to the regulators in a June 2003 letter.
- Performed evaluation of the OU I South Boundary System to evaluate life-cycle economics with respect to installing an additional extraction well to reduce the operation time of the system.
- Maintain pumping of OU III Carbon Tetrachloride System well EW-15. Periodically pulse pump EW-13 and EW-14 due to rebounding of carbon tetrachloride concentrations in the aquifer.
- Begin pulse pumping OU III Building 96 System and monitor for TVOC rebound. Install five additional monitoring wells to monitor VOCs to the west of the system. Perform an evaluation to determine the need for continued operation of the system.
- Shut down OU III South Boundary extraction well EW-12 based on VOC concentrations dropping below NYS AWQS and place on stand-by.
- Proposed monitoring frequency reduction for the OU III HFBR Tritium program.
- Place OU III Middle Road extraction wells RW-4 and RW-5 in standby mode due to low VOC concentrations. Continue monitoring extraction wells.
- Decommission the OU IV Area of Concern (AOC) 5 AS/SVE system.
- Proposed suspension of routine groundwater surveillance in the Biology Department greenhouse area.
- Proposed suspension of routine groundwater surveillance for metals in the Shotgun Range and the Live-Fire Range area.

Table E-2
Groundwater Restoration Progress

Operable Unit	Project	Target	Mode	Treatment Type	Treatment Progress	Years of Operation	Groundwater Quality Highlights
OU I	OU I South Boundary (RA V)	VOCs	Operational	Pump and Treat (P&T)	280 lbs of VOCs treated to date	6 of 14	The decline in VOCs leveled off. The mean total VOC concentration in the monitoring wells decreased from approximately 55 µg/L in 1999 to 25 µg/L in 2002. The hot spot near the former HWMF showed a total VOC decrease in 2002 from 196 µg/L to 125µg/L.
	Current Landfill	VOCs tritium	Long-term Stewardship	Landfill capping	Cap is maintained and stable	7 of 30	VOCs and tritium stable or slightly decreasing.
	Former Landfill	VOCs Strontium-90 (Sr-90) tritium	Long-term Stewardship	Landfill capping	Cap is maintained and stable.	6 of 30	Continued decline in Sr-90. VOCs have declined to below New York State Ambient Water Quality Standards (NYS AWQS) since 1998.
	Former HWMF	Sr-90	Long-term Stewardship	Monitoring	NA	NA	Sr-90 plume downgradient from former HWMF was characterized in 2001 and 2002.
OU III	Chemical/Animal Holes	Sr-90	Construction	P&T with ion exchange	Pilot Study remediation system start-up in February 2003	0 of 8	The highest Sr-90 concentration observed in 2002 was 1,130 pCi/L in well 106-16.
	Carbon Tetrachloride source control	VOCs (carbon tetra-chloride)	Operational	P&T, carbon adsorption	327 lbs of VOCs treated to date	3 of 4	Two temporary wells were installed to characterize the extent of deeper carbon tetrachloride contamination. Treatment is operating as planned. Petition for shutdown anticipated in 2004.

Table E-2
Groundwater Restoration Progress

Operable Unit	Project	Target	Mode	Treatment Type	Treatment Progress	Years of Operation	Groundwater Quality Highlights
	Building 96 source control	VOCs	Operational	Recirculation wells with air stripping	46 lbs of VOCs treated to date	2 of 2	System is in operation. Shutdown petition is planned for 2003. Significant reduction in VOCs has been observed in system influent and monitoring wells. Characterization work in 2002 detected total VOCs up to 3,720 µg/L in silt zone near RTW-1 and 850 µg/L immediately west of system.
	South Boundary	VOCs	Operational	P&T with air-stripping	1,928 lbs of VOCs treated to date	5 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, which spiked up during 2002. Recommended placing EW-12 on stand-by due to low VOC concentrations.
	Middle Road	VOCs	Operational	P&T with air-stripping	223 lbs of VOCs treated to date	1 of 25	Eastern extraction wells showing low VOC concentrations. Recommend placing RW-4 and RW-5 on stand-by due to low VOCs.
	Western South Boundary	VOCs	Operational	P&T with air-stripping	10 lbs of VOCs treated to date	1 of 11	System in operation. Maximum total VOCs in monitoring well during 2002 was 53 µg/L.
	Industrial Park	VOCs	Operational	In-well stripping	633 lbs. of VOCs treated to date.	3 of 12	VOC high concentrations continued to increase in the eastern portion of system. A new bypass well was installed in 2002 on Carleton Drive.
	Industrial Park East	VOCs	Design	P&T with carbon treatment	NA	0 of 5	Completed pre-design groundwater characterization work.
	North Street	VOCs	Design	P&T with carbon treatment	NA	0 of 4	The plume remains defined in anticipation of treatment system start-up.

Table E-2
Groundwater Restoration Progress

Operable Unit	Project	Target	Mode	Treatment Type	Treatment Progress	Years of Operation	Groundwater Quality Highlights
	North Street East	VOCs	Design	P&T with carbon treatment	NA	0 of 10	Pre-design groundwater characterization work completed in 2002. System construction will be completed in 2004.
	Long Island Power Authority (LIPA) Right of Way	VOCs	Design	P&T wells with carbon treatment	NA	0 of 10	System construction began in April 2003. Plume concentrations remained relatively stable in 2002.
	Airport	VOCs	Design	Recirculation wells with carbon treatment	NA	0 of 10	System construction began in April 2003.VOC concentrations at Airport remained < NYS AWQS.
	Magothy	VOCs	Design	NA	NA	NA	The Magothy characterization report was finalized in May 2003. Additional monitoring wells will be installed in 2003 at the south boundary and in conjunction with the North Street and Airport monitoring network. Two additional off-site extraction well have been proposed to the DOE.
	HFBR tritium	Tritium	The pump & recharge system remained in standby	Monitoring	0.2 Curies removed for off-site disposal. 180 pounds of VOCs were also removed from the aquifer and treated by this system.	NA	The high concentration area continues to migrate south and is now located at Bell Ave. The peak concentration observed in 2002 was 254,000 pCi/L in temporary well 85-238 located along Bell Ave.
	BGRR/Waste Concentration Facility (WCF)	Sr-90	Design scheduled for fall 2003	P&T with Ion Exchange	NA	0 of 30	Sentinel monitoring wells were installed just south of Brookhaven Ave. Groundwater characterization work was performed at Bldg. 701/702.

Table E-2
Groundwater Restoration Progress

Operable Unit	Project	Target	Mode	Treatment Type	Treatment Progress	Years of Operation	Groundwater Quality Highlights
OU IV							
	AS/SVE system	VOCs	Decommissioning	Air sparging/ soil vapor extraction	35 lbs. of VOCs were treated to date.	4 of 4	System to be decommissioned in 2004.
	AOC 6/650 sump outfall	Sr-90	Long Term Response Action	Monitored Natural Attenuation	Plume slowly migrating to south within monitoring-well network.	NA	The Sr-90 plume continues to migrate slowly to the southwest from the Bldg. 650 sump outfall. Sr-90 concentrations in well 76-28 remained at or below detectable levels. Contaminated soils were excavated in these areas in 2002.
OU V	STP	VOCs tritium	Long term Response Action	MNA	NA	NA	Low-level VOC plume concentrations remained stable during 2002. Tritium was detected in two wells above the detection limits but well below NYS AWQS and continued to slowly decline.
OU VI	Ethylene Dibromide (EDB)	EDB	Design	P&T with carbon treatment	NA	0 of 10	Treatment system construction scheduled for 2004. The highest EDB concentration observed in 2002 was 4.6 µg/L.

1.0 INTRODUCTION AND OBJECTIVES

The mission of Brookhaven National Laboratory's (BNL'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 has impacted.
- Monitoring - monitoring the effectiveness of pollution-prevention efforts, as well as progress in restoring the quality of affected groundwater.
- Communication - communicating the findings and results of the program to regulators and stakeholders.

The BNL Calendar Year (CY) 2002 Groundwater Status Report is a comprehensive summary of groundwater data collected in 2002 that provides an interpretation of information on the performance of the Groundwater Protection Program. This is the sixth annual groundwater status report issued by the Laboratory. This document is unique in that it examines performance of the program on a project-by-project (facility-by-facility) basis, as well as comprehensively in a "watershed-like" analysis.

HOW TO USE THIS DOCUMENT. This document is a detailed technical report that includes analytical laboratory data, as well as data interpretations conducted by BNL's groundwater group. This technical document is intended for internal users, regulators, and other technically oriented stakeholders. Generalized summaries of this information can be obtained through BNL's website, the Community Affairs office, as well as the annual Site Environmental Report.

Data are presented in five key subject areas:

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

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

Section 1 discusses the drivers of the data collection work in 2002, the site's groundwater classification, and the objectives of groundwater monitoring. 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 2002. The groundwater cleanup data and progress towards achieving the site's cleanup goal are described in Section 3. Section 4 outlines the groundwater surveillance data used to verify that operational and engineered controls are preventing further contamination from the site's active experimental and support facilities. Section 5 is a summary of the proposed recommendations to the Groundwater Protection Program identified in Chapter 3.

Appendices A and **B** include hydrogeologic data that supports the discussions in Section 2. **Appendices C** and **D** contain the analytical results for each sample obtained under the Environmental Restoration (ER) and Environmental Surveillance (ES) Groundwater Monitoring Programs, respectively. Due to the volume of these data, all of the report appendices are included on a CD ROM; which 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. A hardcopy of the results can be printed from the CD ROM. The groundwater results are arranged by specific monitoring project and analytical group; Volatile Organic Compounds (VOCs), Semi-Volatile Organic Compounds (SVOCs), metals, chemistry, pesticides/ PCBs, and radionuclides. The data are organized further by well ID and the date of sample collection. Chemical/radio nuclide 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 [Groundwater Quality and Classification]) are identified by bold text. By including the complete results, the reader can analyze the data in detail. **Appendix E** contains information on sample collection, analysis and Quality Assurance/Quality Control (QA/QC). **Appendix F** consists of data supporting the remediation system discussions in Section 3 and **Appendix G** is a compilation of data usability report forms.

1.1 Groundwater Monitoring Program

Groundwater monitoring at BNL is performed for two reasons:

1. Meet regulatory requirements.
2. Monitoring is an integral part of ISO 14001 Environmental Management Systems (EMS).

1.1.1 Regulatory Drivers

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA): On December 21, 1989, the BNL site was included as a Superfund Site on the National Priorities List (NPL). The U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and New York State Department of Environmental Conservation (NYSDEC) integrated the DOE's response obligations under the Comprehensive, Environmental Response, Compensation, and Liability Act (CERCLA), the Resource Conservation and Recovery Act (RCRA), and New York State (NYS) hazardous waste regulations into a comprehensive Federal Facilities Agreement (FFA). This IAG was finalized and signed by these parties in May 1992 (EPA 1992). The IAG includes a requirement for groundwater monitoring.

New York State Regulations, Permits, and Licenses: The monitoring programs for the Current Landfill and Former Landfill are designed in accordance with post-closure Operation and Maintenance (O&M) 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 (SPCC) Plan.

The BNL's Waste Management Facility (WMF) is a NYSDEC permitted hazardous waste storage facility (NYSDEC Permit No. 1-422-00032/00102-0). Groundwater monitoring is required under a permit for the WMF. This program is specifically designed as a secondary means of verifying the effectiveness of the facility's administrative and engineered controls.

DOE Orders: DOE Order 5400.1, Chapter IV - *Environmental Monitoring Requirements* states that "Groundwater that is or could be affected by DOE activities shall be monitored to determine the effects of operations on groundwater quality and quantity and to demonstrate compliance with DOE requirements and applicable federal, state and local laws and regulations" (DOE 1988).

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). The 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, the Laboratory followed federal drinking water standards, NYS Drinking Water Standards (NYSDWS), and NYS Ambient Water Quality Standards (NYS AWQS) for Class GA groundwater as the goals for protecting and remediating groundwater.

For drinking water supplies, the applicable federal maximum contaminant levels (MCLs) are set forth in 40 CFR (Code of Federal Regulations) 141 (primary MCLs) and 40 CFR 143 (secondary MCLs). In NYS, the SDWA requirements on the distribution and monitoring of public water supplies are promulgated under the NYS Sanitary Code [10 NYCRR Part 5], that is enforced by the Suffolk County Department of Health Services (SCDHS) as an agent for the NYS Department of Health (NYSDOH). These regulations apply to any water supply that has at least five service connections, or 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's and DOE's 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, Strontium-90 (Sr-90), and gross beta), NYS AWQS (for gross alpha, radium-226, and radium-228), and 40 CFR 141/DOE derived concentration guides (DCGs) (for determining the 4 mrem/yr dose for other beta-/gamma-emitting radio nuclides).

Tables 1-1, 1-2, 1-3, and **1-4** show the regulatory and the 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 Order, best management practice, and our commitment to environmental stewardship. BNL monitors its groundwater resources for the following reasons:

<u>Groundwater Resource Management:</u>

- Refine the conceptual hydrogeologic model of the site and maintain a current assessment of the dynamic patterns of groundwater flow and water table fluctuations to support initiatives in protecting, managing, and remediating groundwater;

- Determine the natural background concentrations for comparative purposes. The site's background wells provide information on the chemical and radiological composition of groundwater that has not been affected by BNL's activities. These data are a valuable reference for comparison with those on groundwater quality from affected areas. This network of wells also can warn us of any contaminants originating from potential sources that may be located upgradient of the BNL site; and,
- Ensure that potable water supplies meet all regulatory requirements.

<u>Groundwater Surveillance:</u>

- Verify that operational- and engineered-controls effectively prevent groundwater contamination.
- Trigger early action and communication should the unexpected happen (e.g. control failure).
- Determine the efficacy of the operational and engineered control measures designed to protect the groundwater;
- Demonstrate compliance with applicable requirements for protecting and remediating groundwater.

<u>Groundwater Restoration</u>

- Track a dynamic groundwater cleanup problem when designing, constructing, and operating treatment systems;
- Measure the performance of the groundwater remediation efforts in achieving cleanup goals;
- Protect public health and the environment during the cleanup period;
- Define the extent and degree of groundwater contamination; and,
- Provide early warning of the arrival of a leading edge of a plume thereby triggering contingency remedies to protect public health and the environment.

The details of the monitoring are described in the BNL Environmental Monitoring Plan (BNL 2000a, 2002). The Environmental Monitoring Plan includes: a description of the source area: description of groundwater quality; criteria for selecting locations for groundwater monitoring; and, and frequency of sampling and analysis. **Figure 1-1** highlights BNL, Operable Unit locations designated as part of the CERCLA program, and key site features. Details on the screen depths, sampling parameters, frequency and analysis by well are listed in **Tables 1-5** through **1-8**. Figure **1-2** shows the locations of wells monitored as part of The Laboratory's groundwater protection program.

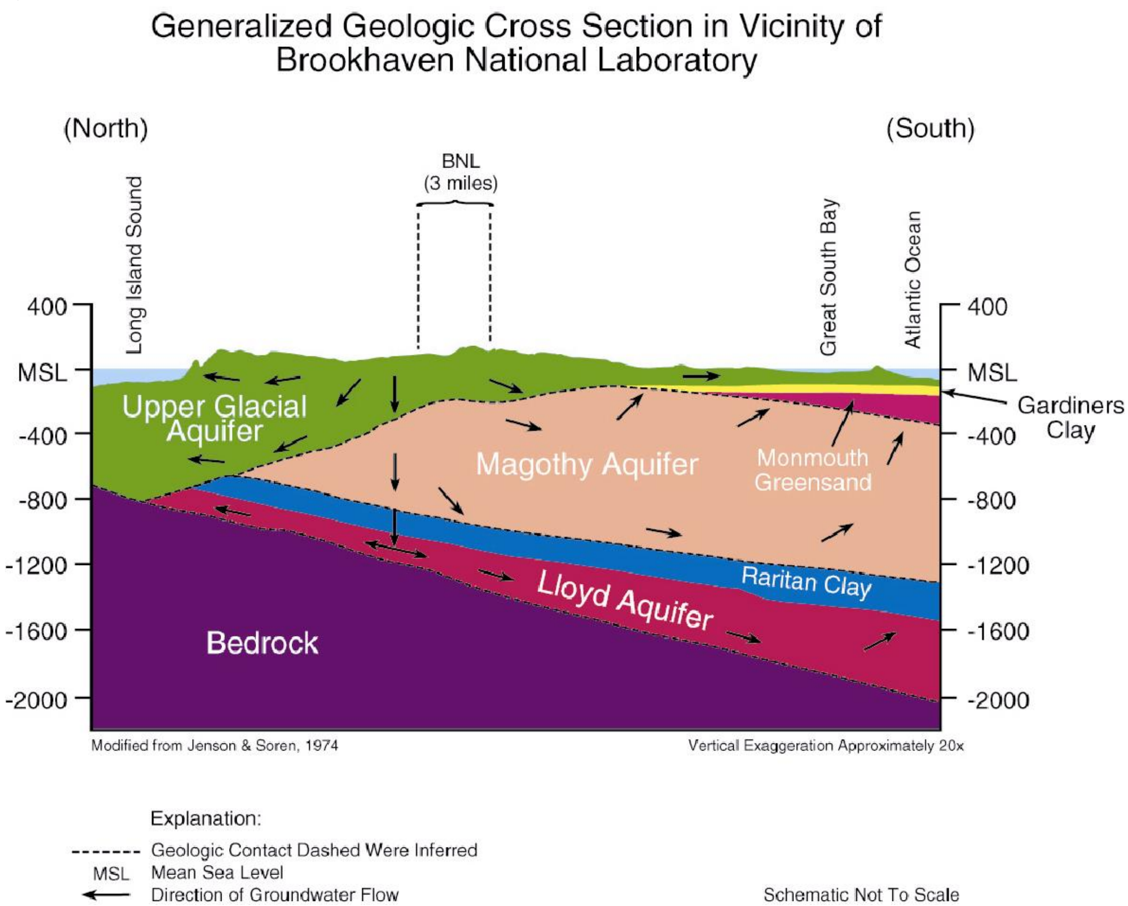
Starting in 2001, BNL has been using a structured Data Quality Objective (DQO) process to review and refine the groundwater monitoring and remediation projects. The results of these DQO reviews are documented annually in the updates to the Environmental Monitoring Plan.

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 2002 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 United States Geologic Survey report (USGS) by Scorca et al. (1999) *Stratigraphy and Hydrologic Conditions at the Brookhaven National Lab and Vicinity, Suffolk County, New York, 1994-97,* and by Wallace deLaguna (1963) *Geology of Brookhaven National Laboratory and Vicinity, Suffolk County New York.* The stratigraphy underneath BNL consists of approximately 1,300 feet of unconsolidated deposits overlying bedrock (**Figure 2-1**). Among these unconsolidated deposits, the Groundwater Monitoring Program currently focuses on the Upper Pleistocene deposits, the Gardiners Clay, and the upper portions of the Matawan Group-Magothy Formation.

Figure 2-1



The Pleistocene deposits, are about 100 to 200 feet thick and are divided into two primary hydrogeologic units. The Pleistocene deposits are divided into undifferentiated sand and gravel outwash and moraine deposit; and, the finer-grained, more poorly sorted stratigraphic Upton Unit. The Upton Unit typically is encountered within the lower portion of the Upper Glacial aquifer beneath various 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 upper portion of the Upper Glacial aquifer (near the Sewage Treatment Plant [STP]) and reworked Magothy deposits. The Gardiners Clay is a regionally defined geologic unit that is discontinuous beneath parts of BNL and areas to the south. Typically, it is characterized by variable amounts of massive 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 Upper Glacial aquifer and Gardiners Clay. 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, underlying BNL is a massive, locally continuous, grey-brown clay layer within the upper portion of the Magothy aquifer (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 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. **Figure 2-2** shows the locations of pumping wells and recharge basins. Under natural conditions, recharge to the regional aquifer system is derived solely from precipitation; **Figure 2-3** illustrates the trends in annual precipitation at BNL. A regional groundwater divide exists immediately to the north of BNL near Route 25. It is oriented roughly east-west, and appears to coincide with the regional recharge area. Groundwater to the north of this divide flows north, ultimately discharging to the Long Island Sound (**Figure 2-1**). Shallow groundwater in the vicinity of BNL generally flows south and east, ultimately to Moriches Bay and the Atlantic Ocean, and towards major local surface-water bodies, such as the Peconic River and Carmans River. Vertical flow is predominantly downward near areas of recharge, becoming essentially horizontal as groundwater moves towards regional discharge areas, and ultimately moving upward toward them (e.g., Carmans River and Great South Bay). Superimposed on the natural regional field of groundwater flow are the artificial influences, due to pumping and recharging. The BNL site is within the deep recharge area for the Upper Glacial and Magothy aquifers.

2.1 Hydrogeologic Data

Various hydrogeologic data collection and summary activities were undertaken as part of our 2002 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 about 950 on-site and off-site wells screened at various depths within the Upper Glacial aquifer and upper portions of the Magothy aquifer. The data are used to characterize the groundwater flow-field (direction and rate) and to evaluate seasonal and artificial variations in its flow patterns. In addition, water level data from the USGS off-site wells supplemented our data.

During 2002, water level data were collected during four synoptic events from March 18 to 21, June 17 to 19, September 23 to 26, and December 16 to 19, measuring 917 to 952 wells each period. Water levels were measured with electronic water level indicators following BNL's Standard Operating Procedure (SOP) EM-SOP-300. **Appendix A** (located on the enclosed CD-ROM) has the depth-to-water (DTW) measurements and the calculated groundwater elevations for these quarterly synoptic measurements.

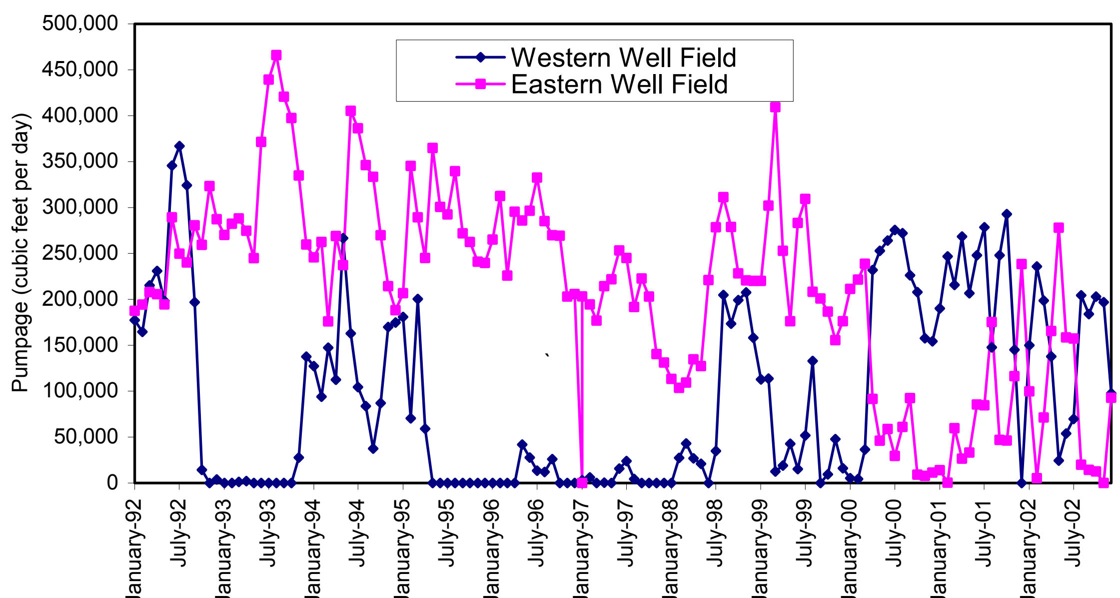
Other water level data beyond those described above include historic values for select USGS wells, and quarterly data for certain BNL wells, collected in 2002, that were used to develop the long-term and short-term hydrographs discussed in Section 2.2 (Groundwater Flow).

2.1.2 Summary of Data on Pumpage of Onsite Supply/Process/Remediation Wells

Groundwater at BNL is withdrawn by pumping from the aquifer system at various locations to supply potable process water and to hydraulically contain and remediate contaminated groundwater. Pumping data were used to aid in interpreting groundwater flow directions, in the areas of these pumping centers. **Figures 2-4** and **2-5** show the pumping wells' locations, and their effects are discussed in Section 2.2 (Groundwater Flow).

Table 2-1 is a total pumpage report summarizing the monthly and total water usage for 2002 for the six on-site potable process supply wells (4, 6, 7, 10, 11, and 12). It includes information on the wells' screened intervals and the pumps' capacities. These wells primarily withdraw groundwater from the mid upper glacial zone of the Upper Glacial aquifer. The variation in monthly pumpage primarily reflects demand, and the well's maintenance schedules. The western potable well field includes wells 4, 6, and 7; the eastern field contains wells 10, 11 and 12. The BNL Pump and Recharge Management Subcommittee currently prefers that the western well field be used as the primary source of water. Using the western well field minimizes the effects of supply well pumping on the BNL plumes. **Figure 2-6** summarizes monthly pumpage for the eastern and western well fields.

Figure 2-6. Summary of BNL Supply Well Pumpage 1992 through 2002



The western well field was the primary source except for March-July when the water treatment plant services for wells 4, 6, and 7 was down for an upgrade. During this period, wells 10, 11, and 12 were used. Overall, BNL's pumping of potable water decreased since 1999. This reduction generally is due to water conservation measures throughout the Laboratory.

Table 2-2 summarizes the monthly and total water usage for 2002 by the five on-site process supply wells (101, 102, 103, 105, and 9). These process wells except for well 9 were taken out of service in 2002. Water pumpage for remediation systems is summarized in **Table 2-3** and discussed in detail in Section 3 of this report.

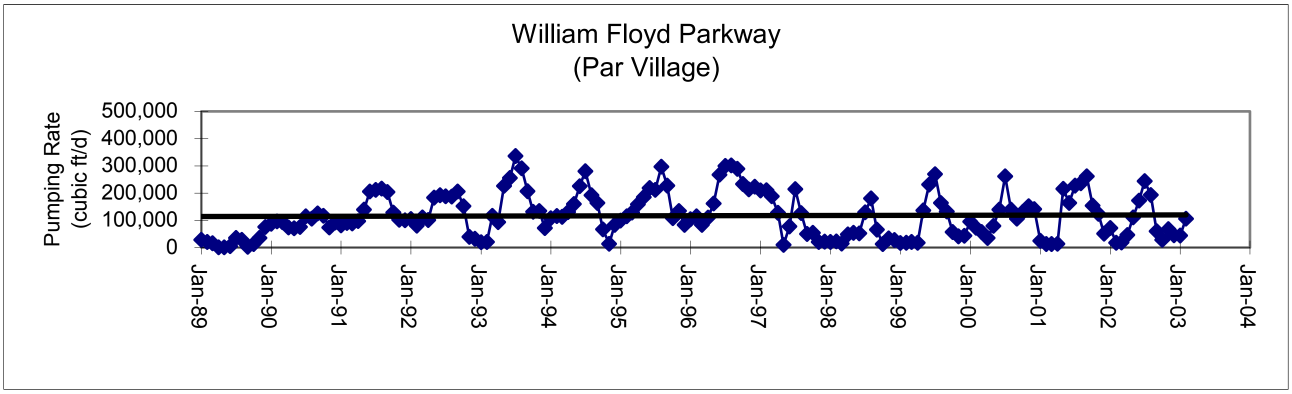
Additional information on water usage was obtained for each groundwater remediation system. **Table 2-3** summarizes the monthly and total water usage for 2002 by the seven groundwater remediation systems.

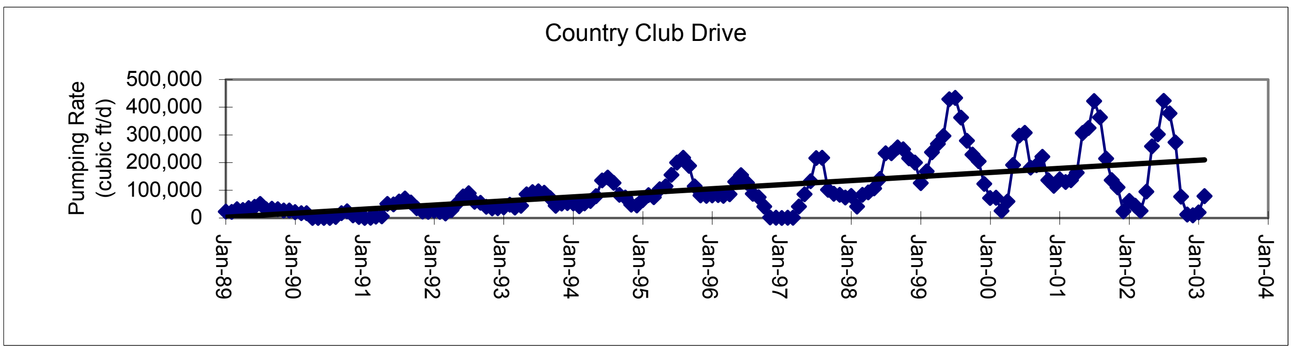
2.1.3 Offsite Water Supply Wells

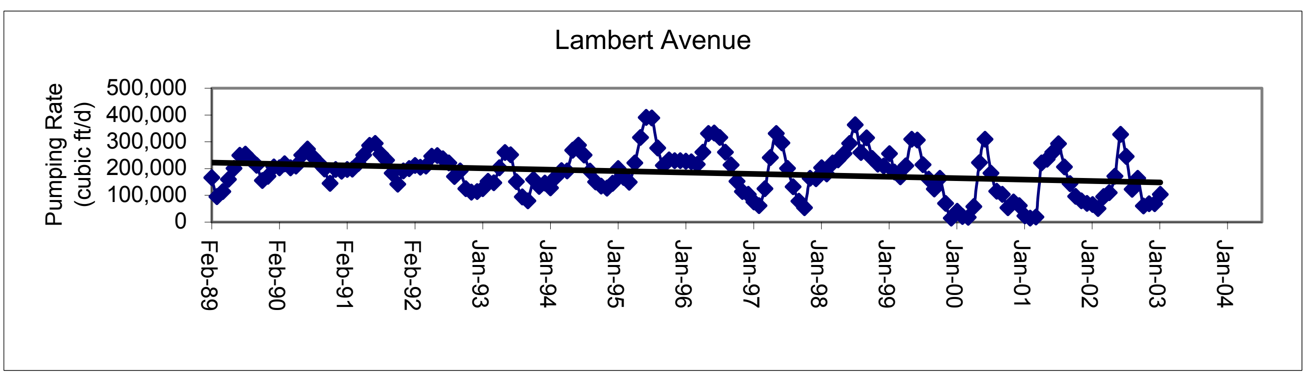
Several Suffolk County Water Authority SCWA well-fields are located in areas surrounding BNL. Currently, the two closest SCWA potable well-fields are: William Floyd (Parr Village) Well Field, and Country Club Drive Well Field (see **Figures 2-2** and **2-7** for locations of the SCWA well fields). Other SCWA well fields (e.g., Lambert Avenue and Main Street-Mastic Well Fields) are sited south of Sunrise Highway.

Parr Village Well Field, located along William Floyd Parkway to the west/southwest of BNL (**Figure 2-2**), 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, lying south/southeast of BNL, consists of two water supply wells that withdraw groundwater from the mid Upper Glacial aquifer. Information for 1989 through 2002 is provided below as **Figure 2-8**. In 2002, the William Floyd (Parr Village) and Country Club Drive Well Fields produced 246 and 448 millions of gallons per year, respectively. Lambert Avenue (south of Brookhaven National Laboratory near Sunrise Highway) produced 354 million gallons in 2002 and has averaged approximately 509 million gallons of water produced per year. While there are seasonal variations, the pumpage rate at William Floyd and Lambert Avenue has been reasonably steady for the last 10 years. However, pumpage at Country Club Drive is increasing.

Figure 2-8
Suffolk County Water Authority Pumping Near Brookhaven National Laboratory







2.1.4 Summary of Onsite Recharge and Precipitation Data

Onsite recharge and precipitation data for 2002 provides information on recharge to the aquifer system underlying BNL. Components of this recharge include sources of artificial recharge (i.e., on-site recharge basins) and natural recharge from precipitation.

Table 2-4 summarizes the monthly and total flow of water through the eleven on-site recharge basins. Their locations are shown on **Figure 2-2**. Section 2.2 (Groundwater Flow) discusses the effects associated with recharge. Eight of the basins (HN, HO, HP, HS, HT 1, HT 2, HX and HZ) receive water originally withdrawn by BNL's potable and process supply wells that is not consumed or is lost via evaporation. Flow into these basins is monitored monthly. Generally, the amount of water recharging to the groundwater system via these basins reflects supply well pumpage. Annual water supply flow diagrams show the general relationships between recharge basins and the supply wells and are published in the annual Site Environmental Reports. In addition, the volume of water recharged at several basins includes storm water runoff.

The remaining three recharge basins (RA V, OU III, and Western South Boundary), summarized in **Table 2-4**, were constructed for 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 located adjacent to 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 RAV 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 2002 (125, 701 and 241, 852 CFD yearly average for the OU III and RA V basins, respectively) is significantly greater than that from other individual on-site basins. A new recharge basin became operational in 2002 and receives water from the OU III Western South Boundary system.

Other important sources of artificial recharge, not included in **Table 2-4**, include a storm- water 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 and is near several contaminant plumes. At the sand filter beds, approximately 10 percent of the treated effluent (or 13 million gallons annually) seeps directly to the underlying water table via leaks in the underlying tile-drain collection system. The remaining treated effluent (approximately 140 million gallons annually) is discharged from the STP to the Peconic River. Most of it recharges the water table, except during times of seasonally high water levels, such as the spring. Over the last few years, this total effluent has decreased about 50% due to routing of cooling water to recharge basins and improved water management practices.

Table 2-5 summarizes the data on monthly and annual precipitation from 1949 to 2002 collected on-site by the BNL Meteorology Group, Department of Applied Science, with the maximum, minimum, average monthly, and average values. Variations in the water table generally can be correlated with the amount of precipitation. As **Table 2-5** shows, total annual precipitation in 2002 was 52.07 inches, above the yearly average of 48.49, and significantly more than the total annual precipitation in 2001, which was 45.55 inches. Monthly precipitation for 2002 varied from 1.16 inches (February) to 6.40 inches (October).

Precipitation provides the majority of 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 soils and recharges the ground water system (Aronson and Seaburn, 1974; Franke and McClymonds, 1972). In 2002, it is estimated that the recharge rate at BNL was approximately 26 inches.

2.2 Groundwater Flow

This evaluation includes the following: a presentation of groundwater flow patterns within the Upper Glacial aquifer (on contour maps for shallow-glacial and deep-glacial zones); an evaluation of the magnitude of the three-dimensional components of flow (by horizontal, and vertical hydraulic gradients);

and, an assessment of short-term and long-term seasonal fluctuations of water levels (through well hydrographs and trends in precipitation).

2.2.1 Water Table Contour Maps

Figure 2-4 shows groundwater elevation contour maps representing the configuration of the water table for March, June, September, and December 2002. The contours were generated from the water level data collected during each synoptic round from shallow glacial wells, assisted by a computer-aided contouring package (SURFER and 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 [Hydrogeologic Data]).

Groundwater flow in the shallow Upper Glacial aquifer in 2002 generally was characterized by a southeasterly component in the site's northern portion, with a gradual transition to a more southerly direction at the southern boundary and beyond. Flow directions in the east portion of BNL are predominately to the east and southeast (**Figure 2-2**). This pattern is consistent with comparable historical data published by the Suffolk County Department of Health Services (SCDHS) and USGS.

The highest water table elevations on-site occurred in the northwestern section, (nearest the groundwater divide), varying from a high of approximately 47 feet above mean sea level (msl) in March and June, to a low of approximately 46 feet above msl in December. The lowest elevations were along the southern boundary, with a high of approximately 31 feet above msl in March, June and September and a low of approximately 30 feet above msl in December. In 2002, the lack of typical seasonal variation in precipitation during the year was reflected in a range in groundwater elevations of only one foot in terms of highs and lows for the year. The NYSDEC issued a drought warning for New York State in January 2002. Drought extremes were not observed at BNL based on the hydrograph data.

Localized hydrogeologic disturbances are evident on the quarterly contour maps. They result from active pumping wells; on-site recharge basins, and other artificial recharges. Influences from the pumping wells can be seen as cones of depressions, most notably near potable supply wells 7 and 12 and in the vicinity of the extraction wells along the southern boundary.

Influences from recharging activities can be observed as localized mounding of the water table, particularly around the recharge basin HO and the RA V basin (in the central site), and also near the HP/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 (Hydrogeologic Data). However, mounding also reflects the ability of the underlying deposits to transmit water, which varies. 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. Near-surface clay layers underlying portions of the STP, in conjunction with the recharging water at the STP sand filter beds, cause mounding near the STP equivalent to that at basin HO.

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 Carman's River being a discharge boundary.

2.2.2 Deep Glacial Contour Maps

Figure 2-5 shows the potentiometric surface contour maps of the deep glacial zone for March, June, September, and December 2002. 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 glacial zone for 2002 are similar to those in the shallow glacial 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 to the south/southwest of BNL, the deep glacial contour maps also suggest flow towards 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, they are not as pronounced as those observed at the water table. Such hydrogeologic effects generally decrease with depth in the saturated aquifer zone. Furthermore, mounding is not inferred beneath the STP sand filter beds because there it is also 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 Upper Magothy Aquifer Contour Map

The addition of wells installed as part of the Magothy Characterization effort allowed for an Upper Magothy potentiometric surface map to be generated for the fourth quarter 2002 (**Figure 2-7**).

The patterns for groundwater flow in the Upper Magothy for 2002 are similar to those in the deep glacial zone. Groundwater flow directions were 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.

2.2.4 Horizontal and Vertical Hydraulic Gradients

Horizontal and vertical hydraulic gradients were calculated to evaluate spatial variation in the horizontal and vertical components of flow. Hydraulic gradients provide information on the driving force behind groundwater flow, and can be used with estimates of aquifer parameters (such as hydraulic conductivity and porosity) to assess the velocities of flow.

Horizontal hydraulic gradients were estimated for 2002. **Table 2-6** summarizes representative, average, horizontal hydraulic gradients for different portions of the on-site and off-site areas. The central, northern, and eastern on-site areas and southeastern off-site areas usually are characterized by lower horizontal hydraulic gradients, typically approximately than 0.001 feet/foot. The southern portions of the site and areas immediately to the south (in North Shirley) have relatively moderate gradients (generally between 0.0008 and 0.0018 feet/foot). Areas with higher gradients include localized areas immediately downgradient of the recharge basins (seasonally ranging from 0.0016 [June 2002] to 0.0023 feet/foot [December 2002]), and off-site near the Carmans River (approximately 0.0040 feet/foot).

Vertical hydraulic gradients were calculated on and off-site for March, June, September, and December 2002, based on water level data from BNL's monitoring of groundwater elevation. **Appendix A** has the values for each quarter. **Table 2-7** summarizes the magnitude and direction of vertical hydraulic gradients in 2002 for these well clusters. **Figure 2-9** depicts the directions of vertical flow within each well cluster.

Calculations of the vertical gradients for 2002 indicate that vertical flow on-site and immediately off-site is predominantly downward, becoming almost horizontal in some southern areas downgradient from the groundwater divide/regional recharge area. Ultimately, flow moves upward closer to natural groundwater discharge boundaries (e.g., the Carmans River). These directions are consistent with, and supported by, numerous regional investigations, regional groundwater modeling studies, and the widely accepted conceptualized model of the Long Island groundwater system.

Vertical groundwater flow is downward in 2002 for most of the on-site and off-site well clusters, especially between the Upper Glacial and Deep Glacial aquifers. Downward vertical hydraulic gradients ranged from 0 to 0.0268 feet/foot within the Upper Glacial aquifer to Mid Glacial zones (**Table 2-7**), and from 0.001 to 0.0100 feet/foot within the Upper Glacial aquifer to Deep Glacial zones. In several on-site and off-site well clusters, groundwater flow within the Upper Glacial aquifer was almost horizontal (i.e., no measurable vertical gradient). As expected, at two of the well clusters close to the Carmans River and Peconic River (natural groundwater-discharge boundaries), vertical gradients and flow were consistently upward (cluster 800-23/-22/-21 and 600-18/-16/15). In addition, upward flow between the Upper Glacial and Magothy aquifers at these locations also is likely to be influenced by the presence of the Gardiners Clay and/or Magothy Brown Clay, confining the water level in the Magothy aquifer.

2.2.5 Well Hydrographs

Groundwater hydrographs are useful in estimating recharge rates and the location of the water table relative to contaminant sources. Long-term (typically 1950-2002) and short term (1997 through 2002) well hydrographs were constructed from water level data obtained for select USGS and BNL wells respectively. These hydrographs track fluctuations in water level over time. Precipitation data also were also compared to natural fluctuations in water levels. **Appendix B** contains the well hydrographs and precipitation- trend graphs, together with a map depicting the locations of these wells.

Seven long-term hydrographs were constructed from historical data on water level elevation obtained from wells installed and maintained by the USGS and BNL(2001 data was not available for well S-74289 due to problems with access). 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. These fluctuations correlate reasonably with long-term precipitation trends for a similar period.

Quarterly data on water levels collected during 2002 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. They fell to the expected seasonally low elevations during the fall and winter (e.g., primarily in September and December 2002). This seasonal fluctuation, while out of phase with historical trends, generally correlates to the short-term trends in precipitation given in **Appendix B**.

A New York State drought warning was issued for Long Island in January 2002. Drought extremes were not observed at BNL based on the hydrograph data.

2.3 New Geologic Data

An investigation of the Magothy Aquifer was completed in late 2002. Geologic data were obtained from a number of deep borings. Information from this investigation is summarized in the *"Magothy Aquifer Characterization Report"* (ARCADIS G&M, May, 2003). Newly obtained data did not alter the site geologic model as presented in the 2001 Groundwater Status Report.

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3.0 Environmental Restoration Groundwater Monitoring and Remediation

Groundwater remediation systems have operated at Brookhaven since 1997, beginning with the Operable Unit (OU) I South Boundary pump and treat system. The goal of groundwater remediation as defined by the OU III Record of Decision (ROD), is to prevent and minimize plume growth and achieve MCLs in the Upper Glacial aquifer in 30 years or less.

There are presently seven groundwater remediation systems in operation at BNL, two in stand-by mode and eight planned. **Figure 3.0-1** shows the locations. (Note: the Chemical Holes strontium-90 pilot system was operational during the first quarter of CY 2003. This is the eighth system to come on line). This figure also delineates the groundwater capture zones for each of the systems. In addition to the groundwater treatment systems, two landfill areas were capped (Current and Former), which minimizes them as sources of groundwater contamination.

In general, Brookhaven uses two types of groundwater remediation systems to treat VOC contamination, pump and treat with air stripping or carbon treatment, or recirculation with in-well 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. The two types of treatment utilized at BNL are air stripping and granular activated carbon. Treated water then is introduced back into the aquifer via recharge basins, injection wells or dry wells. Pump and treat is a standard environmental cleanup industry technology and particularly lends itself to on-site applications at BNL where recharge to groundwater is not an issue.

Recirculation wells with in-well air stripping are an innovative groundwater remediation technology and have been an alternative technology in off-site areas. Here, the limited space for recharge and the noise generated by air stripper towers are important factors. This technology is based on a remediation well with two hydraulically isolated screen zones set some distance apart. Contaminated water is pumped up from the deeper zone in the contaminant plume, and treated below the ground surface with a shallow tray air stripper. The treated water then is returned to the aquifer via the shallow recharge screen. Off gas generated by the air stripping process is passed through granular activated carbon and is sent back to the in well air strippers for reuse. **Table 3.0-1** summarizes both the operating and planned remediation systems.

This section gives an overview of groundwater monitoring and remediation efforts at Brookhaven during 2002. The section is organized first by Operable Unit, and then by the specific groundwater remediation system and/or monitoring program. The time covered is from January 1 to December 31, 2002. **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.

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 shown. Results exceeding the corresponding groundwater standard or guidance criteria (see Section 1.1.1 [Regulatory Drivers]) are shaded. Inclusion of the complete results allows the reader to analyze them in detail. In addition, the entire report is included on the CD-ROM with active links to tables and figures.

Contaminant plumes are represented by maps depicting the areal extent and magnitude of contamination; they were developed by contouring the highest contaminant concentration for a particular well cluster. This method presents the significant plumes in a manner consistent with the objectives of this report. VOC plumes are simplified somewhat by using the TVOC values for drawing the contours, except for those consisting almost exclusively of one chemical (i.e., OU III Carbon Tetrachloride, OU VI EDB).

The extent of plumes containing VOC contamination was contoured to represent the typical NYS AWQS of 5 µg/L (there is no standard for Total VOCs (TVOCs) that incorporates all the VOCs analyzed by EPA Method 524.2); similarly, individual radiochemical plumes were contoured to their appropriate MCL. The exception to this is the High Flux Beam Reactor (HFBR) Tritium Plume that is contoured to 1,000 pCi/L (relative to the NYS AWQS of 20,000 pCi/L), reflecting the elevated public sensitivity to this plume historically.

A total of 2,065 groundwater samples were obtained from 650 monitoring wells during 2002 under the various EM programs. **Figure 3.0-2** provides a summary of the number analyses performed by analytical method.

An assessment of the BNL groundwater pump and treat system performance modeling is provided in Section 3.0.2. The purpose of this assessment is to determine whether the cleanup is progressing as forecasted in technical documents supporting the OU III ROD.

There have been significant changes in the distribution of contaminant plumes since the ER Groundwater Monitoring Program started in 1997 that can be attributed to the following effects:

- The beneficial effects of active remediation systems,
- Various source removal actions,
- The impacts of BNL pumping and recharge on the groundwater flow system,
- Radioactive decay, biological degradation, and natural attenuation,
- The addition of permanent monitoring wells to enhance the existing networks and,
- Newly acquired data from groundwater characterization filling gaps in the data.

The extent of contamination for a given plume was determined primarily using CY 2002 data from permanent monitoring wells unless otherwise noted. Groundwater characterization work was performed during CY 2002 as part of the OU III Building 96, HFBR Tritium, Magothy and Carbon Tetrachloride projects. These data were used to define the various contaminant plumes both on and off-site. In several cases data from early 2003 was utilized. This is noted on the specific figures.

A single representative round of monitoring data was chosen for each plume, typically, the last of the year because it includes the most comprehensive sampling round for the year. This report also serves as the fourth quarter report for remediation systems. Plots incorporating all the historical data were made of trends in concentration for the key wells in each plume to identify any changes. Data from monitoring wells sampled under BNL's ES Monitoring Program also supplement some ER data.

A total of 2,065 groundwater samples were obtained from 650 monitoring wells during 2002 under the various ER projects. **Figure 3.0-2** provides a summary of the number of analyses performed by analytical method.

Figure 3.0-2 Summary of Laboratory Analyses Performed for EM Program in 2002

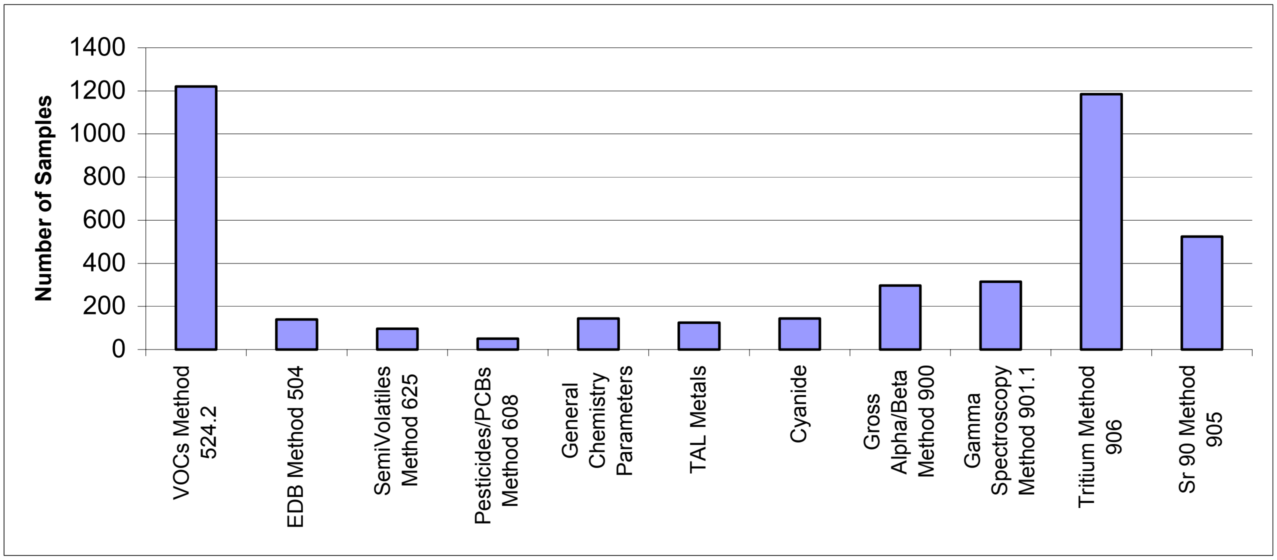

Table 3.0-1 Summary of Groundwater Remediation Systems at BNL

Operable Unit	System Status	Project	System Type	Recharge Method
OU I	Operational	South Boundary	Pump and treat (A)	Basin
OU III	Early 2004	North Street East (O)	Pump and treat (C)	Recharge wells
	Operational	Carbon tetrachloride	Pump and treat (C)	Basin
	Operational	Building 96	Re-circulation (C)	In-well
	Operational	Middle Road	Pump and treat (A)	Basin
	Operational	W. South Boundary	Pump and treat (A)	Basin
	Operational	Industrial Park (O)	Re-circulation (C)	In-well
	February 2004	LIPA (O)	Pump and treat (C)	Recharge wells
	October 2003	North Street (O)	Pump and treat (C)	Recharge wells
	December 2003	Industrial Park East (O)	Pump and treat (C)	Recharge wells
	December 2003	Airport (O)	Re-circulation (C)	In-well
	March 2005	BGRR Sr-90	Pump and treat (I)	(To be determined)
	January 2003	Chemical Holes Sr-90	Pump and treat (I)	Dry wells
	Operational	South Boundary	Pump and treat (A)	Basin
	Stand-by	HFBR Tritium	Pump and recharge (*)	Basin
OU IV	Stand-by	1977 Spill	AS/SVE (C)	Not applicable
OU VI	Summer 2003	Ethylene dibromide (O)	Pump and treat (C)	Recharge wells

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

3.0.1 Model Assessment of BNL Groundwater Pump and Treat System Performance

3.0.1.1 Purpose

BNL's fourteen VOC groundwater treatment systems (with a combined treatment capacity of about 4500 gpm), in combination with natural attenuation, are expected to prevent and minimize plume growth and restore the Upper Glacial aquifer to drinking water standards by the year 2030 (within 30 years of the signing of the OU III ROD). This is the stated groundwater cleanup goal. Three other treatment systems are planned to treat or control groundwater plumes of radionuclides. It is important to assess whether the cleanup is progressing as planned.

The selection of this cleanup strategy is documented in the OU III and OU VI RODs. The strategy was developed on the basis of groundwater flow and solute transport model predictions. Comparisons of changes in groundwater quality data to model predictions are a useful analytical approach to index the groundwater cleanup performance. The purpose of this assessment is to determine whether the cleanup is progressing as forecasted in technical documents supporting the OU III and OU VI RODs.

This assessment focuses on VOCs in OU III. Future assessments will expand into OU IV, OU V, OU VI, OU I as well as radionuclides.

3.0.1.2 Assessment Approach

The approach to this assessment for the BNL 2002 Annual Groundwater Status Report is as follows:

- Compare predicted vs. actual cumulative VOC mass removal with time.
- Compare Feasibility Study (FS) model predictions of VOCs in OU III groundwater in 2002 with the 2002 groundwater quality data.

Since the OU III ROD signing numerous sub-models have since been developed to support the design of the individual systems. In addition, a number of predesign characterization studies have been performed which have better defined the nature and extent of contamination, particularly in the offsite areas. However, the model originally developed to support the OU III FS and select the remedial strategy is again used in this "watershed" view of the cleanup performance.

The only change made to the FS model was to update the Magothy brown clay based on the findings of the Magothy Characterization project (Arcadis Geraghty & Miller, 2003). The starting concentrations for the model are based on the OU III FS, which is a compilation of 1998 data. In addition, the FS model assumed longitudinal dispersivity to be 30 feet. This dispersivity assumption is at the high end of the ranges that have since been applied at BNL. As noted earlier, pre-design studies since 1999 have redefined the extent of contamination. These changes are especially significant in the offsite areas. Nevertheless, this approach does offer some insight into how the cleanup is proceeding based on the information known at the time of the OU III ROD signing. A 2002 model prediction is also presented. It is a culmination of remedial design predictions.

3.0.1.3 Discussion of Results

Figure 3.0-3 shows the comparison of the measured cumulative VOC mass removal with time with the FS model prediction and a 2002 estimated cumulative mass removal based on system designs (which is based on pre-design characterization data and design predictions). Several observations and interpretations drawn from these comparisons are:

- The actual mass removal does not match the FS model prediction very well (**Figure 3.0-3**). This is because (1) the FS assumed that all the treatment systems would start at the same time in 1998 (in actuality the construction is being phased from 1997 through 2004), and (2) the starting concentrations in the FS model were considerably higher (especially in the Middle Road area onsite).

- The actual mass removal data matches the 2002 model prediction. The actual mass removal at the end of year 2002 is 3,655 pounds and the 2002 model prediction is 4,008 pounds.

- The updated 2002 forecast included the predictions of more detailed sub-models used during the design process. These sub-models have more detailed finite-difference model grids. This, combined with better characterization, data have significantly improved the estimates.

- The updated 2002 forecast includes a more up to date startup schedule for each of the 14 VOC treatment systems. The construction schedule for the treatment systems was revised in 2001. In general, construction schedules were primarily delayed due to access problems. Even with the construction schedule extension, the forecasted leveling off of cumulative mass removal still occurs at approximately 2012.

- The minor delay in the construction schedule is compensated by better than expected VOC removal performance in several systems. These include, the Carbon Tetrachloride project and the HFBR pump & recharge system. When the HFBR pump and recharge system was operating it captured and treated a significant quantity of VOCs.

- The 2002 model predicted there would be a mass removal increase in year 2003. This reflects the start of additional off-site groundwater remediation systems. The model prediction will be updated according to reflect the actual starting dates and modification in design of the offsite remediation systems to 2004.

Comparisons of the 2002 OU III VOC groundwater quality data to FS model predictions of VOCs for 2002 are shown in **Figure 3.0-4.** Several observations and interpretations drawn from this comparison are:

- The FS model under predicts the VOC concentration in the aquifer in year 2002. The reasons for this discrepancy include: an over estimate of dispersion for five years of travel and the FS model assumption that all the treatment systems would start at the same time in 1998 (in actuality the construction is being phased from 1997 through 2004),

- The travel paths and extent of contamination are similar for both the measured and the modeled OU III VOC plume.

- Some new "hot spots" appear in the 2002 data that are not represented in the FS model simulations. For example, the significance of the Carbon Tetrachloride and Building 96 plumes were not fully characterized in the FS model runs used to support the OU III ROD. In addition, the offsite contamination has been better defined through a number of pre-design characterization studies.

The following conclusions can be drawn from this assessment:

Since the signing of the OU III ROD, pre-design characterization efforts have continued, and a number of systems have been designed and constructed on a schedule somewhat different than the simple assumptions used in the OU III FS. Some of the designs utilized new sub-models to address very site-specific design issues. The introduction of new sub-models, new plume data, additional systems not contemplated during the OU III FS modeling (e.g., Carbon Tetrachloride, Building 96, Western South Boundary) and variation in assumed startup times for certain treatment systems greatly complicates a "simple" comparison of changing groundwater quality data to model predictions.

Because the duration of treatment system operations has been relatively short, clear trends at the "watershed" scale are still difficult to discern.

The next watershed view assessment should modify its approach. The approach should update the FS model with the designed wells systems/pumping rates to actual staggered start times. The initial concentrations in the model should factor in the pre-design data collected in 2000/2001, but the model start time should remain 1997 when the first treatment system went into operation. The simulation should be run with and without dispersion. Initially, the "zero" dispersion simulations would be expected to provide the most realistic results. However after 15-30 years of simulation, simulations with dispersion would be expected to provide the most realistic results. The updated FS model should be run out thirty years to provide a comprehensive assessment whether all the treatment systems as designed and deployed, combined with natural attenuation, will achieve the cleanup goal.

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3.1 Operable Unit I

The three sources of groundwater contamination contained within OU I were the former Hazardous Waste Management Facility (HWMF), the Current Landfill and the Former Landfill. The former HWMF was BNL's central RCRA receiving facility for processing, neutralizing, and storing hazardous and radioactive wastes before off-site disposal until 1997, when a new WMF was constructed along East Fifth Avenue. Several hazardous materials spills were documented at this former location. This facility has been characterized and soil remediation is scheduled to begin in 2003.

Presently, VOC concentrations in wells downgradient of the Former Landfill are below groundwater standards. The Former Landfill has been a source for Strontium-90 (Sr-90) groundwater contamination. The highest strontium-90 (Sr-90) concentrations have migrated south of Princeton Avenue.

The Current Landfill and former HWMF plumes become commingled south of the HWMF, partially caused by the pumping and recharge effects of the former Spray Aeration System, which operated from 1985 to 1990. This system was designed to treat VOC contaminated groundwater originating from the former HWMF. The VOC plume is depicted in **Figures 3.1-1** (plan view) and **3.1-2** (cross sectional view). The plume extends off-site, approximately 3,300 feet south of the site property boundary. 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 recharged to the ground in the RA V basin, located to the northwest of the Current Landfill (**Figure 3.1-1**).

A second system (North Street East System) is being planned to treat the off-site portion of the plume (**Figure 3.0-1**). Groundwater pre-design characterization work was performed during 2001 as part of the planned North Street East groundwater remediation system. The purpose of this effort was to define the leading edge of the plume and the extent of the higher VOC concentrations in this area in support of remedial design. Eleven temporary vertical profile wells were installed and sampled as part of this effort. The data from these locations was considered in developing **Figure 3.1-1**. The construction of the off-site groundwater remediation system is scheduled for 2003 with system start-up in early 2004.

Tritium is detected below the 20,000 pCi/L NYS AWQS in several monitoring wells in the Current Landfill/OU I South Boundary/North Street East projects. Sr-90 is detected in on-site wells, several of which exceed the 8 pCi/L NYS AWQS.

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3.1.1 Current Landfill Monitoring

Data obtained from the Current Landfill groundwater monitoring program are presented in this section along with conclusions and recommendations for future monitoring. The *2002 Environmental Monitoring Report, Current and Former Landfill Areas* (BNL, 2003a), was prepared in accordance with the requirements of 6 NYCRR Part 360 Section 2.1.5, Solid Waste Management Facilities (effective December 31, 1988). This report summarized the status of groundwater quality in the vicinity of the Current Landfill, giving conclusions and recommendations about the effectiveness of the cap and future monitoring efforts. This section reiterates those conclusions and recommendations.

3.1.1.1 Landfill History and Cap Description

The Current Landfill operated from 1967 to 1990. It was used for the disposal of putrescible waste, sludge containing precipitated iron from the BNL Water Treatment Plant, and anaerobic digester sludge from the Sewage Treatment Plant. The latter contained low concentrations of radionuclides, and possibly metals and organic compounds. Limited quantities of laboratory wastes containing radioactive and chemical material were disposed of at the landfill. During its operating life, this landfill was unlined and did not have a leachate control system.

The current Landfill was capped in the fall of 1995 in accordance with 6 NYCRR Part 360. This cap consists of a geotextile fabric overlain by a 12-inch gas-venting layer followed by a 40-millimeter double-sided textured geomembrane topped with a 24-inch thick protection layer and 6 inches of topsoil. The *Construction Certification Report for the Former Landfill* (CDM 1995a) has more information on the landfill's construction and maintenance.

3.1.1.2 Groundwater Monitoring

<u>*Well Network:*</u> The Current Landfill monitoring program, a network of eleven monitoring wells located immediately adjacent to the landfill, was designed for post-closure monitoring following the NYSDEC requirements (**Figure 3.1.1-1**). These wells are used to determine the cap's effectiveness in preventing the continued leaching of contaminants from the landfill, and to document the anticipated long-term improvements to groundwater quality.

<u>*Sampling Frequency and Analysis*</u>: The Current Landfill wells are sampled quarterly. The samples are analyzed for VOCs, metals, cyanide, gross alpha/beta, gamma spectroscopy, tritium, and Sr-90 as detailed in **Table 1-6**.

3.1.1.3 Monitoring Well Results

The primary VOCs that have been consistently detected in Current Landfill Monitoring Program wells are chloroethane and benzene. The complete results for the eleven Current Landfill monitoring wells can be found in **Appendix C**. The highest VOC value during 2002 was 43 µg/L of chloroethane in well 88-109, which is located immediately east and adjacent to the landfill. **Figure 3.1.1-2** plots the historical trend in concentrations of VOCs for this and several other monitoring wells in the area. VOC trends in other Current Landfill wells were stable or slightly increasing in 2002.

Tritium and strontium-90 were detected several times at concentrations well below the NYS AWQS. They occurred in wells that have a previous history of low-level tritium and/or strontium-90 contamination. There have been no detections of radionuclides exceeding groundwater standards in wells 87-24, 88-22, and 88-23 since 1998. These wells are all screened in the mid to deep Upper Glacial Aquifer to monitor the vertical extent of contamination from the Current Landfill.

Conventional landfill leachate parameters were below applicable NYS AWQS except for ammonia. This is the only leachate parameter that has been detected historically at concentrations exceeding the NYS AWQS of 2 mg/L. The highest concentration in 2002 was 8 mg/L in well 88-109. Ammonia is a common landfill contaminant and is generated by the degradation of organic material.

Iron and magnesium were the only metals detected above NYS AWQS in 2002. Their concentrations are expected to fall relatively slowly due to their sorption to aquifer materials, thereby reducing mobility.

3.1.1.4 Groundwater Quality Evaluation

These data are used to support the following site-specific decision developed from the data quality objective (DQO) process.

1. Are the controls effectively eliminating further discharges to soils and groundwater below the landfill?

Data show that, in general, contaminant concentrations have been decreasing following the capping of the landfill in 1995. Studies by Oweis and Biswas (1993) suggest that a period of two to ten years may be required before groundwater quality improvements are observed downgradient of the landfills, depending on the underlying hydrogeology. At the end of 2002 the landfill has been capped eight years. Groundwater quality has been slowly improving. The furthest downgradient wells (87-27, 87-26, 87-24, 87-23, 88-22, and 88-23) would not be expected to see groundwater quality improvement for at east four years following capping. The time of travel from the landfill to the OU I South Boundary pump and treat system is approximately 10-15 years. The trend in the data suggests that the cap is effective in mitigating contamination. Additional groundwater quality improvement is expected to slowly continue.

3.1.1.5 Recommendations

The following recommendations were presented in the *2002 BNL Environmental Monitoring Report, Current and Former Landfill Areas* (BNL, 2003a) and have been implemented:

- Reduce the frequency of sampling in the mid to deep Upper Glacial wells 087-24, 088-22, and 088-23 for VOCs from semi-annually to annually. Reduce the frequency of sampling these wells for metals and water chemistry from quarterly to semi-annually. Lowering the sampling and analysis frequencies for these wells is based on the absence of any detection above groundwater standards since 1998, and the consistently low concentrations where detections were recorded. These wells are screened significantly below the depth of the contaminants' migration from the landfill, and serve as perimeter data-points for the vertical extent of contamination. Changes in the vertical migration pathway for contaminants from the Current Landfill are not anticipated.

- Reduce the frequency of sampling for radionuclides from quarterly to annually. Tritium and Sr-90 were detected in several wells over the past several years at concentrations slightly above background. However, based on the low and consistent findings for radionuclides, together with the historical baseline that was established for radionuclides at the Current Landfill, a reduction in the frequency of sampling is recommended.

3.1.2 Former Landfill Groundwater Monitoring

Data obtained from the Former Landfill groundwater monitoring program are presented in this section along with conclusions and recommendations for future monitoring. The 2002 Environmental Monitoring Report, Current and Former Landfill Areas (BNL 2003a) was prepared in accordance with the requirements of 6 NYCRR Part 360 Section 2.1.5, Solid Waste Management Facilities (effective December 31, 1988). This report summarized the status of groundwater quality in the vicinity of the Former Landfill, presenting conclusions and recommendations about the effectiveness of the cap and future monitoring efforts. This section reiterates those conclusions and recommendations.

3.1.2.1 Landfill History and Cap Description

The Former Landfill is an unlined waste disposal area originally used by the United States Army in the 1940's for waste disposal prior to the development of BNL. Disposal activities ceased in 1966, and the landfill was covered with soil. The Interim Landfill is also unlined, and was reportedly used for approximately one year following the closing of the Former Landfill. The Slit Trench is unlined as well, and is believed to have operated during the 1960s.

An estimated three tons per day of waste material were deposited in the Former Landfill, of which a small percentage was radioactive or hazardous waste. Waste materials included laboratory debris, irreclaimable partially decontaminated equipment, contaminated clothing, radioactive animal carcasses, and sanitary wastes. Sewage sludge was also periodically disposed of in the landfill.

The Former Landfill and Slit Trench were capped in November 1996 and the Interim Landfill in October 1997. The Former Landfill cap was constructed in accordance with 6 NYCRR Part 360. The cap consists of a geotextile fabric overlain by a 12-inch gas-venting layer followed by a forty-millimeter double-sided textured geomembrane topped with a twenty-four inch thick protection layer and six inches of topsoil. Additional details regarding the cap construction may be obtained from the *Construction Certification Reports for Former Landfill* (CDM Federal, 1997) and the Interim Landfill (PW Grosser, 1997).

3.1.2.2 Groundwater Monitoring

Well Network: The monitoring program, consisting of a network of eight monitoring wells sited immediately adjacent to the landfill, was designed to provide post-closure monitoring as per NYSDEC requirements (**Figure 3.1.2-1**). The program was started after the Former Landfill was capped in 1996 to verify whether the cap effectively prevents the continued leaching of contaminants from the landfill, and to document anticipated long-term improvements to groundwater quality.

Sampling Frequency and Analysis: These Former Landfill area wells are monitored quarterly. The samples are analyzed for VOCs, pesticides/PCBs, metals, cyanide, gross alpha/beta, gamma spectroscopy, tritium, and strontium-90 as described in **Table 1-6**.

3.1.2.3 Monitoring Well Results

There were no VOC detections exceeding groundwater standards in the Former Landfill Area wells during 2002. **Appendix C** contains the complete 2002 analytical results. A detailed evaluation of VOC, radionuclide, leachate parameters, metals, and pesticides/PCBs is provided in the *2002 BNL Environmental Monitoring Report, Current and Former Landfill Areas (BNL, 2002a)*. The contaminants of concern for the Former landfill wells are VOCs and strontium-90.

VOC concentrations have been low in all of the Former Landfill wells over the past five years with minimal exceedances of the NYS AWQS. Little or no VOCs have been detected in upgradient wells 87-22, 87-72 and 86-42. TCE and 1,1-dichloroethane (DCA) consistently were detected in the downgradient wells (97-17, 97-64, 106-02, and 106-30), though NYS AWQS for these compounds were not exceeded in 2002 nor have they been since 1998 (in well 106-30).

Strontium-90 formerly was detected in well 97-64 which is screened at the water table and located less than 100 feet downgradient of the landfill footprint. Strontium-90 concentrations in this well have shown a steadily declining trend since 1998 when it was last detected above the NYS DWS of 8 pCi/L (at a concentration of 12 pCi/L). The highest concentration in this well during 2002 was 2.9 pCi/L in January.

3.1.2.4 Groundwater Quality Evaluation

These data are used to support the following site-specific decisions developed from the DQO process.

1. Are the controls effectively eliminating further discharges to soils and groundwater below the landfill?

Data show that contaminant concentrations have been decreasing following the capping of the landfill in 1996. Studies by Oweis and Biswas (1993) suggest that a period of two to ten years may be required before groundwater quality improvements are observed, depending on the underlying hydrogeology. 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 remaining contamination. Based on the declining VOC and strontium-90 concentration trends in downgradient wells it does appear that the landfill cap is performing as planned.

The strontium-90 plume (as defined by concentrations exceeding 8 pCi/L) has migrated south of well 97-64 and continues to attenuate (see Section 3.2.13).

3.1.2.5 Recommendations

The following recommendation was presented in the *2002 BNL Environmental Monitoring Report, Current and Former Landfill Areas* (BNL, 2002a) and has since been implemented:

- Due to the low concentrations detected, the substantial historical databases, and the stability of the water-chemistry parameters, reduce the frequency of analysis for these parameters from quarterly to semi-annually.

3.1.3 South Boundary Pump and Treat System

This section summarizes the operational data for 2002 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 to provide hydraulic control at the site boundary.

Quarterly reports were prepared with the operational data from January 1, 2002 through September 30, 2002. A monthly Discharge Monitoring Report (DMR) is submitted to EPA and NYSDEC for treated effluent water from the air-stripping tower. This section summarizes the 2002 operations and gives a detailed evaluation of monitoring well analytical data.

3.1.3.1 System Description

Two groundwater extraction wells, EW-1 and EW-2, provide hydraulic control of the VOC plume. Groundwater is extracted at a total maximum flow rate of 700 gallons per minute (gpm). The actual rates vary during the extraction system's life, according to operational monitoring data. **Table 3.1.3-1** shows the depths of the extraction wells and pump settings.

Table 3.1.3-1. OU I Extraction Well Construction Data

Well	Screen Interval (Feet below grade)	Pump Setting (Feet below grade)
(EW-1, 115-27)	150-190	170
(EW-2, 115-43)	100-140	120

Each wellhead is enclosed in a reinforced concrete vault with the top slab at grade. The vaults are located along the southern boundary of the site. Piping within the vaults is schedule 80 PVC, transitioning to PVC water pipe before exiting through the vault's wall. The pipes are 4-inch (EW-1) and 6-inch (EW-2) diameter, increasing to 8- inches in the vault, and join an 8-inch diameter pipe, at the start of the common force-main to the treatment facility.

The groundwater treatment facility consists of a treatment control building and an air-stripping tower located north of Brookhaven Avenue between Fifth and Sixth Streets. The treatment facility is designed for limited automatic operation, defined as automatic equipment shutdown with manual restart. Any alarm condition will signal a common trouble alarm at BNL's Central Chilled Water Facility requiring physical inspection of the main control panel to determine the source of the alarm.

The stripping tower is 6 feet in diameter and 48 feet tall, and is equipped with a minimum of 20 feet of 2-inch plastic packing. The latter is based on the requirements to remove 1,1-DCA. One of two centrifugal blowers supplies air to the tower at a normal flow rate of 6,550 scfm, providing an air/water ratio of 70:1 at the maximum water flow rate of 700 gpm.

The water discharged from the air-stripping tower flows by gravity to the adjacent recharge basin to the east. The basin can receive a continuous flow of 1,500 gpm that includes a sufficient factor of safety to account for OU I discharge, variations in subsurface soil, and fouling of the basin over time. The OU III HFBR Tritium Pump and Recharge System also discharged to this same basin until September 29, 2000. The OU III Middle Road System began partially discharging to this basin in October 2001.

3.1.3.2 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) located downgradient of the Current Landfill and former HWMF **(Figure 3.1.3-1)**. The network was organized into core, perimeter and bypass wells as part of the groundwater DQO process. The wells are designated as follows:

- Background – background water quality results will be utilized to determine whether a contaminant slug is traveling toward the remediation system
- 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 – data used to determine whether plume capture performance is being met.
- Other – these wells are not officially part of the OU I South Boundary but are shown on the location Figures as they are used as data points for mapping purposes.

Sampling Frequency and Analysis: The wells are monitored and analyzed for VOCs, tritium, strontium-90, gross alpha/beta, and gamma spectroscopy (**Table 1-6**).

3.1.3.3 Monitoring Well/Vertical Profile Well VOC Results

The Current Landfill and former HWMF are considered source areas for the VOC plume. A discussion of monitoring well data specific to the Current Landfill source area is provided in Section 3.1.1. Distributions of TVOC concentrations for this plume were derived from sampling in the fourth quarter round (November 2002). Supplemental data were obtained from monitoring wells sampled under the Current Landfill Post Closure Monitoring Program during October 2002. **Figure 3.1-1** shows the areal extent of TVOC contamination from the Current Landfill/former HWMF area.

The primary VOCs on-site in this plume include chloroethane and DCA, the signature contaminants for the Current Landfill. 1,1,1-Trichloroethane (TCA), 1,1-dichloroethene (DCE), trichloroethene (TCE), and chloroethane are prevalent in the plumes' off-site (North Street East) segment. The OU I South Boundary/North Street East plume (defined by TVOC concentrations greater than 5 µg/L) extends south from the Current Landfill to an area approximately 2,250 feet south of North Street (approximately 7,300 feet long as measured from the Current Landfill). Its maximum width is about 1,300 feet at the southern site boundary. The plume segments with higher concentrations (greater than 50 µg/L) are approximately 300 feet wide. The areas of the plume displaying the highest VOC concentrations (greater than 100 µg/L) are located approximately 500 feet downgradient of the former HWMF (well 98-59), and off-site, south of well 000-124. The contamination in the vicinity of well 98-59 has remained persistently high during the treatment period.

The extent of the plume south of well 000-124 was based on the eleven vertical profile wells installed during 2001. The leading edge of the plume was estimated using an average groundwater velocity for this area of 0.75 feet per day.

Figure 3.1-2 shows the vertical distribution of VOCs. The transect line for cross-section A-A' is shown on **Figure 3.1-1**. DCA and chloroethane are primarily detected in the Shallow Glacial aquifer near the source areas, and in the deep Upper Glacial aquifer at the site's 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 Gardiners Clay and the Upton Unit underlie the deep Upper Glacial aquifer from the source areas to the Princeton Avenue firebreak, but are absent south of this area. There, the Magothy Brown Clay unit lies immediately below the Upper Glacial aquifer and extends some distance to the south of North Street.

Data obtained from plume perimeter wells (**Figure 3.1.3-1**) indicates that the VOC plume did not shift laterally during 2002 and remains bounded by the current network of wells. **Figure 3.1.1-2** gives the historical trends in VOC concentration for key plume core and bypass wells along the Current Landfill/HWMF/North Street East Plume. **Table 3.1.3-2** summarizes VOC detections in monitoring wells exceeding the NYS AWQS during 2002. **Appendix C** has the complete 2002 analytical results from the monitoring of the 57 OU I South Boundary System Program wells.

- Plume core well 98-59 (**Figure 3.1.1-2**) began to show a steady decreasing trend in TVOC concentrations during 2002 after peaking at 239 µg/L in 2001. The fourth quarter 2002 TVOC concentration was down to 125 µg/L. This well is screened in the Upton Unit immediately above the Gardiners Clay.

- Plume core well 115-36, situated between the firebreak road and the extraction wells, continued to display a declining trend in TVOCs that was established in 1999. The TVOC concentration was 11 µg/L during 2002, a marked decrease from concentrations greater than 100 µg/L prior to 1999.

- TVOC concentrations in plume core wells 115-14 and 115-31, both located adjacent to the extraction wells, were stable to slightly decreasing during 2002, ranging from 5 to 53 µg/L.

- TVOC concentrations in bypass wells 115-42 and 000-138 showed slight decreases during 2002.

- Plume core well 000-124 continued to display a decreasing trend in TVOCs, begun in 1998, as concentrations dropped to 21 µg/L in 2002. The peak concentration in this well was 487 µg/L in 1998.

Groundwater characterization work performed in 2001 along with declining TVOC concentrations in well 000-124 indicate that the core of the high concentration slug of contamination previously observed at the location of well 000-124 continued to migrate south and decrease in concentration. The south boundary pump and treat system appears to have created a break in the plume that is characterized by a region of low level TVOCs from south of the extraction wells to just south of the Long Island Expressway (**Figure 3.1-1**).

There were no detections of VOCs above NYS AWQS in upgradient perimeter wells during 2002.

3.1.3.4 Radionuclide Monitoring Results

The on-site monitoring wells are analyzed for tritium and strontium-90, gross alpha/beta and gamma spectroscopy semi-annually. Offsite wells are analyzed for tritium at a quarterly frequency and gross alpha/beta, gamma spectroscopy and strontium-90 annually. **Table 3.1.3-3** summarizes radionuclide detections in monitoring wells above detectable levels during 2002. The complete radionuclide results for these wells is provided in **Appendix C**.

Tritium has historically been detected in OU I South Boundary Monitoring Program wells below the NYS DWS of 20,000 pCi/L. The maximum detection during 2002 was 24,600 pCi/L in well 98-30 during the third quarter. A plot of historical tritium results for this well is shown in **Figure 3.1.3-2**. Tritium in this well has been steadily increasing since 2000 and began exceeding the NYS DWS in 2002. Well 98-30 (located approximately 900 feet downgradient of the former HWMF) is the only on-site well that continues to show increasing tritium concentrations. In the vicinity of the Former HWMF a slug has migrated south towards 98-30. In general, stable or decreasing tritium trends are observed for the remainder of the wells. Results from the fourth quarter 2002 sampling round are posted on **Figure 3.1.3-3**. Concentration trends for select monitoring wells in which tritium has been detected are indicated in **Figure 3.1.3-2**.

Strontium-90 has historically been detected in three wells located within and downgradient of the former HWMF (88-26 and 98-21) at concentrations above the NYS DWS of 8 pCi/L. 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 **(Figure 3.1.3-4)**. In 2001, additional groundwater characterization work was performed and groundwater samples were collected at thirteen locations downgradient of the former HWMF. The strontium-90 detections were observed at two distinct depth intervals. The peak concentration during this characterization was 65.4 pCi/L. Details from the 2001 characterization can be found in the *2001 BNL Groundwater Status Report (BNL, 2002)*. The mixing of the strontium-90 vertically within the aquifer is probably the result of the hydraulic effects of the former spray aeration system pumping and recharge. The extent of strontium-90 concentrations greater than the NYS DWS of 8 pCi/L is shown in **Figure 3.1.3-5**. This area is estimated for 2002 based on the 2001 characterization results along with existing monitoring well data. The leading edge of this plume was defined as being north of locations 108-38 and 108-42. Sentinel monitoring wells were installed in 2002 downgradient of the leading edge of the plume. There were no strontium-90 detections in these wells in 2002. The peak strontium-90 concentration during 2002 was 7.8 pCi/L in well 98-30 during the third quarter. Historical trends for monitoring wells in this area in which strontium-90 has been detected are provided in **Figure 3.1.3-6**. The area of strontium-90 contamination appears to be migrating south based on the decreasing concentrations in well 88-26 and the increasing concentrations in downgradient wells 98-21 and 98-30.

3.1.3.5 Systems Operations

The extraction wells are currently sampled every two months. The influent and effluent of the air-stripper tower are sampled once per month. All samples are analyzed for volatile organic compounds. In addition, the influent and effluent samples are analyzed for pH weekly, and iron and manganese monthly. **Table 3.1.3-4** provides the effluent limitations for meeting the requirements of the State Pollutant Discharge Elimination System (SPDES) equivalency permit. In addition to the parameters listed in **Table 3.1.3-4**, the effluent is sampled for metals, pesticides, PCBs, strontium-90 and gross alpha/beta annually, although the permit does not require this. The equivalency permit was renewed in 2002.

Table 3.1.3-4. SPDES Parameter Effluent Concentrations for 2002

Parameter	Threshold Value* (µg/L)	Maximum Measured Value
pH	9.0	6.39 – 7.98
Benzene	0.8	<MDL**
Chloroform	7.0	<MDL
Chloroethane	5.0	<MDL
1,2-Dichloroethane	5.0	<MDL
1,1-Dichloroethene	5.0	<MDL
1,1,1-Trichloroethane	5.0	<MDL
Carbon Tetrachloride	5.0	<MDL
1,2-Dichloropropane	5.0	<MDL
Methylene Chloride	5.0	0.98B
Trichloroethylene	5.0	<MDL
Vinyl Chloride	2.0	<MDL
1,2-Xylene	5.0	<MDL

* Maximum effluent concentration (µg/L) allowed – Equivalent to a SPDES Permit.

** Minimum Detection Limit (MDL) = 0.5 µg/L

The following is a summary of the OU I operations for 2002. BNL's Plant Engineering Division (PE) performed routine maintenance checks on this system daily, in addition to their routine and non-routine maintenance. BNL's Environmental and Waste Management Services Division (EWMSD) collected the samples. Full details are recorded in the system's operation and maintenance log. The daily operations and maintenance inspection logs are available in the project files and at the treatment facility.

January-September 2002:

The system operated normally from January through May with only one minor shut down due to a broken blower belt. On June 25, 2002 the system was shut down so that the annual extraction well cleaning could be performed. This cleaning continued through July 11, 2002 when the system was restarted. Continuing system problems were experienced for the remainder of the month due to alarm and blower problems, and the failure of the EW-2 motor. The system was shut down again on July 29, 2002 for the EW-2 motor replacement and restarted on August 7, 2002.

For the remainder of August continuing problems were experienced with automatic shut downs of the system due to high-pressure alarms. The system was restarted daily to keep it running while diagnostic tests were conducted on the pressure switches and alarm system. No problems with these systems were detected. At the end of the month the influent pipe was disassembled and a clog in the influent cone strainer was found. The clog consisted of iron scaling from the well cleaning.

On September 4, 2002 the treatment system was restarted after the iron scaling was removed. A larger drip leg was installed under the cone strainer along with valves so that any additional scaling can be removed without shut down of the system. The system operated normally for the remainder of the month.

A total of 268,909,000 gallons of water was pumped and treated during the first three quarters of 2002.

October 2002:

The system operated normally, with no interruption. A total of 39,881,000 gallons were pumped and treated. The extraction wells were not sampled this month, but the air-stripper influent and effluent were sampled. All effluent discharges met the equivalency permit requirements.

November 2002:

The system operated normally, without interruption. A total of 38,156,000 gallons were pumped and treated. The extraction wells, influent, and effluent were sampled in November 2002. All effluent samples met the equivalency permit requirements. On November 8, 2002 the recharge basin was cleaned. The bypass outlet for the recharge basin was used so that the system did not have to be shut down.

December 2002:

The system operated normally, without interruptions. A total of 30,505,000 gallons were pumped and treated. The air-stripper influent and effluent were sampled in December 2002. All effluent samples met equivalency permit requirements.

3.1.3.6 Systems Operational Data

Extraction Wells

During 2002, 377,451,000 gallons were pumped and treated by the OU I system, with an average flow rate of 636 gpm. **Table 2-3** gives monthly pumping data for the two extraction wells. VOC and tritium concentrations for EW-1 (115-43) and EW-2 (115-27) are provided in **Table F-1** in **Appendix F** (located on the enclosed CD-ROM). TVOC levels in both wells continued to be relatively stable over the past year with the highest reported concentration of 14 µg/L in EW-2 (**Figure 3.1.3-7**). Year-end tritium levels in wells EW-1 and EW-2 were 610 pCi/L and 1,100 pCi/L, respectively.

System Influent and Effluent

VOC and tritium concentrations in 2002 for the air-stripper influent and effluent are summarized in **Tables F-2** and **F-3** in **Appendix F**. Radiological (strontium-90, gross alpha/beta and gamma spectroscopy), pesticide, and metals data for the effluent are shown in **Table F-4**. TCA, DCA, DCE, chloroethane, chloroform, and TCE influent concentrations to the air stripper tower versus time are illustrated in **Figure 3.1.3-8**. The concentration of 1,1 DCA has steadily decreased over the six years of OU I operation; there was little change in other compounds, after an initial decrease in TCA and choroethane.

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 permit equivalency conditions.

Cumulative Mass Removal

The mass of TVOCs removed from the aquifer by the OU I treatment system was calculated. Average flow rates for each monthly monitoring period were used, in combination with the TVOC concentration in the air-stripper's influent to calculate the pounds per month removed. The cumulative mass of TVOCs removed by the treatment system vs. time was then plotted (**Figure 3.1.3-9**). It shows that 26 pounds of TVOCs were removed during 2002; cumulatively, 280 pounds have been removed since the system started. (Note: The 1996 RA V Design modeling estimated that the system would remove 260 to 300 pounds by 2006 to 2011). The data for this figure are summarized in **Table F-5**.

Air Discharge

Table 3.1.3-5 below presents the VOC air emission data for the year 2002 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 period. That value was converted from µg/L to pounds per gallon (lb/gal), which was multiplied by the average pumping rate (gallons per hour (gal/hr)) to compare with the regulatory value. All VOC air emissions were well below allowable levels.

Table 3.1.3-5. OU I South Boundary System Air Stripper VOC Air Emissions Data for 2002*

Parameter	**Allowable ERP****	**Jan-Mar**	**Apr-Jun**	**Jul-Sep**	**Oct-Dec**
Carbon Tetrachloride	0.016	<0.0002	<0.0002	<0.0002	<0.0002
Chloroform	0.0086	0.00042	0.00039	0.00035	0.00042
1,1 - Dichloroethane	10***	0.00117	0.00113	0.00081	0.00111
1,2 - Dichloroethane	0.011	<0.0002	<0.0002	<0.0002	<0.0002
1,1 - Dichloroethene	0.194	0.00009	0.00011	<0.0002	0.00009
Chloroethane	10***	0.00061	0.00066	0.00057	0.00059
1,1,1 - Trichloroethane	10***	0.00026	0.00025	0.00015	0.00022
Trichloroethene	0.119	<0.0002	<0.0002	<0.0002	<0.0002

* Actual Emission Rate reported as the average rate (lb/hr) for each quarter.
** Emission Rate Potential (ERP) based on NYSDEC Air Guide 1 Regulations.
***6 NYCRR Part 212 restricts emissions of VOCs to a maximum of 10 pounds per hour without controls.

Sampling of tritium air emissions, from three sites near the RAV basin, ceased after October 2001 as groundwater concentrations have remained at or near detectable levels since 1999. **Figure 3.1.3-10** compares the tritium concentrations in the air-stripper's influent and effluent since the system started in December 1996.

Recharge Basin

There are nine plume perimeter-monitoring wells in the immediate area surrounding the RA V recharge basin that are sampled and analyzed for tritium. These wells are used to monitor water quality and water levels to assess the impact of the recharge basin on the aquifer. **Appendix C** (located on the enclosed CD-ROM) contains the data for these wells. The highest detection of tritium was 1,110 pCi/L in well 76-177.

Beginning November 1, 2001 the RAV recharge basin began receiving 650 gpm of treated groundwater from the OU III South Boundary and Middle Road treatment systems.

3.1.3.7 Groundwater Model Assessment

The modeling was updated in 2002 to assess ways to better remediate one local area of persistent contamination south of the former HWMF (vicinity of monitoring well 98-59) and to optimize and manage the operational life of the system.

Modeling Objectives

The BNL groundwater model was used to re-assess the OU I South Boundary System performance and to assist in identifying means to improve its performance. This section summarizes the model approach, assumptions and results. The model was applied to help answer the following questions:

- Under the existing operational configuration, how many more years of operation is it estimated to take to achieve the cleanup goals?
- Can modifications to the pumping schedules for the existing pumping wells maintain hydraulic control of the target plume segment and improve life cycle cost effectiveness?
- Will additional extraction well(s) in the area of persistent contamination significantly decrease the operational time and does such an action make sense from a life cycle cost perspective?
- A strontium-90 plume has been delineated in the area south of the former HWMF. Will this plume be entrained by the OU I South Boundary system? If so when?

Model

The BNL Regional Groundwater Flow model (Arcadis Geraghty & Miller, 1999) coupled with a contaminant fate and transport simulator (MT3D) was used for this task. The grid cell size in the area of interest is approximately 75 feet by 75 feet. The layer thicknesses in the Upper Glacial aquifer are approximately 30 feet thick. The groundwater flow model is considered calibrated. The contaminant transport predictions were calibrated as part of this task with local data.

Key Assumptions

The key model assumptions for this task are

- Simulations of TVOC were used to estimate the concentration of the plume after treatment. The OU I plume being treated has four VOC compounds, which make up more than 90% of the TVOC sum. The cleanup goals are based on individual VOCs. Therefore using TVOC to forecast plume concentrations is conservative when making comparisons to standards that are individual contaminant based.
- The retardation factor for the TVOC plumes is 1.5. This means that the contamination is assumed to migrate at 66% of the groundwater flow velocity.

- The dispersivity parameter was assumed to be zero in all directions adding additional conservatism to the predictions greater than 5 years into the future.

- The starting position of the TVOC plumes was assumed to be as mapped from pre-design data and annual report data. The interpretation of these data was refined as part of the solute transport model calibration for this task.

- The slope and shape (linear or non-linear) of the aquifer sorption isotherm determines the rate that VOCs can migrate and be removed from the aquifer. These model simulations assumed a linear isotherm.

- Biodegradation, decay or contaminant transformation was assumed not to occur.

<u>Contaminant Transport Model Calibration</u>

Three indices were used to determine the degree of contaminant fate and transport model calibration. They were:

- The predicted vs. actual cumulative mass removal with time by the groundwater extraction wells.
- The predicted vs. actual TVOC concentrations with time at key groundwater-monitoring wells.
- The predicted vs. actual extent of TVOC contamination after 5 years of operation.

These calibration indices are summarized in **Figures 3.1.3-11 and 3.1.3-12**.

Figure 3.1.3-13 presents the predicted vs. actual cumulative mass removal with time by the groundwater extraction wells. It also illustrates the model predictions performed as part of the RA V design (CDM, 1996) and the recently updated model predictions (2002). The 1996 design model predictions were reasonable for the first two years of operation, but significantly under predict the mass removal in latter years. The updated 2002 model predictions match the observations very well.

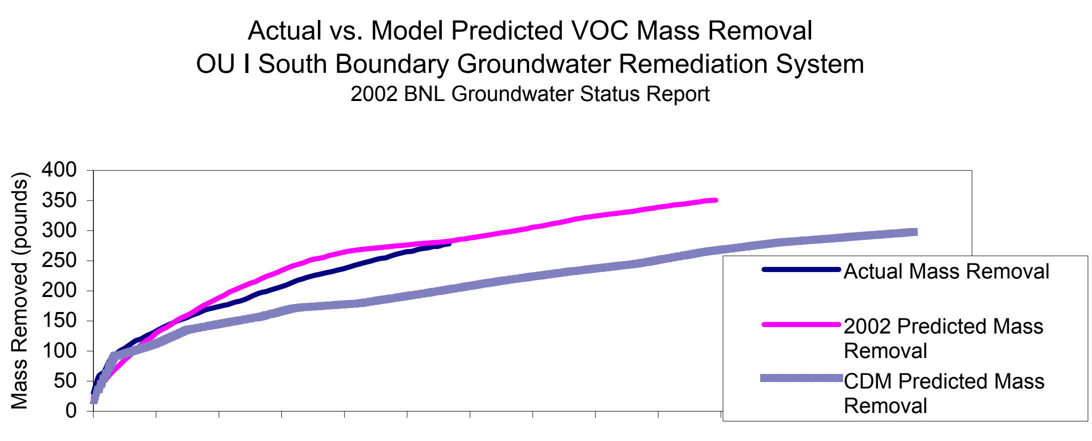
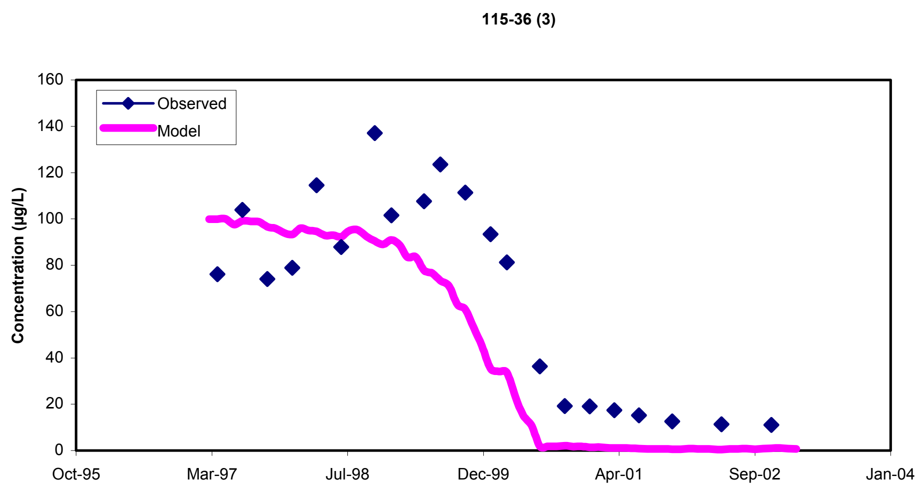
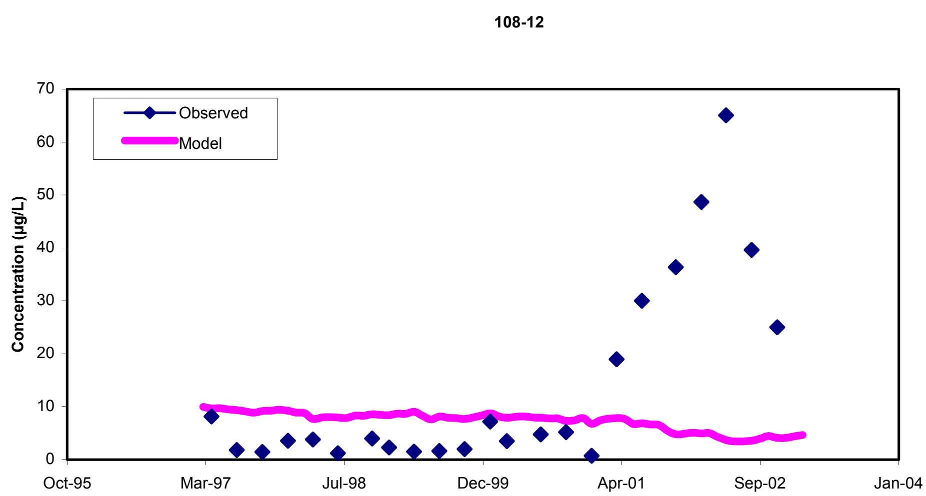


Figure 3.1.3-11 Predicted vs. actual cumulative mass removal with time.

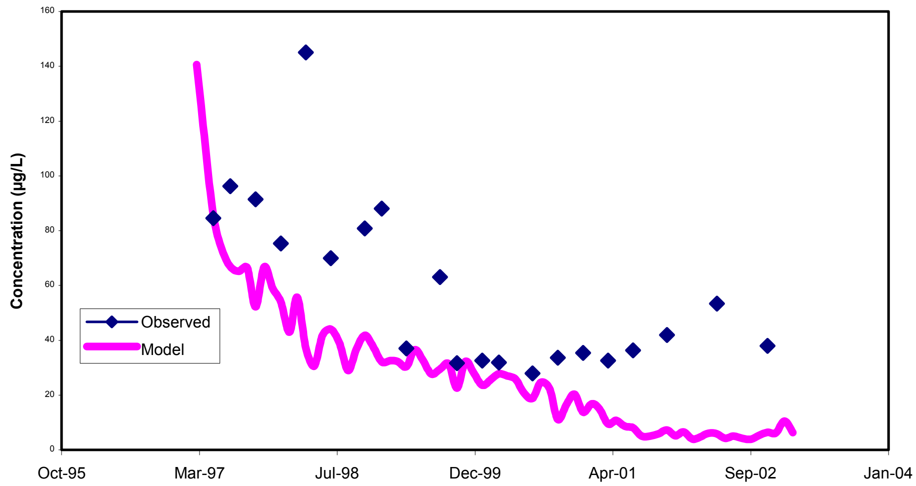
Figure 3.1.3-12 presents the predicted vs. actual TVOC concentrations with time at key groundwater monitoring wells. Well 115-36 is located in the core of the plume about 600 feet north of the extraction wells. The model predictions match the data well. Well 108-12 is on the eastern fringe of the plume near the south boundary. The model predictions are conservative in this area until 2001. The model did not predict the recent slug observed. Well 115-14 is located in the core of the plume in the vicinity of the extraction wells. The model predictions match the data well. Well 98-59 is located in the vicinity of the persistent contamination. The model predictions are reasonable, if not conservative. Well 88-109 is located immediately downgradient of the Current Landfill. Low levels of VOCs are still being released from the landfill in this area. The model does not account for this. Well 107-26 is located in the core of the plume about 800 feet north of extraction wells. The model predictions match the data well.

Figure 3.1.3-12 Predicted vs. actual TVOC concentrations at key groundwater monitoring wells



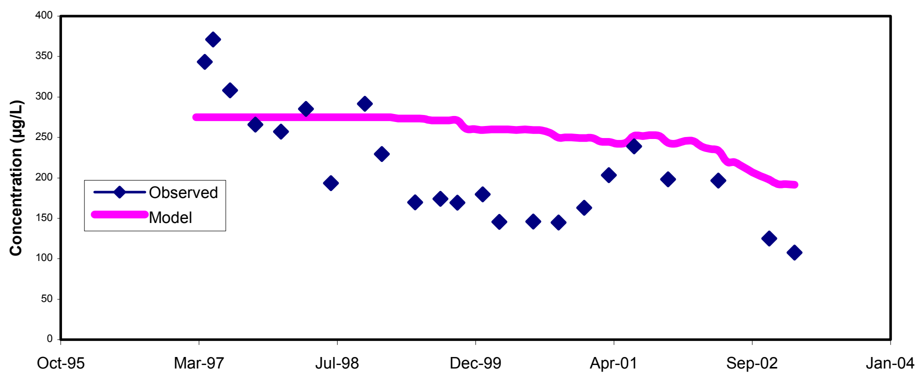


115-14

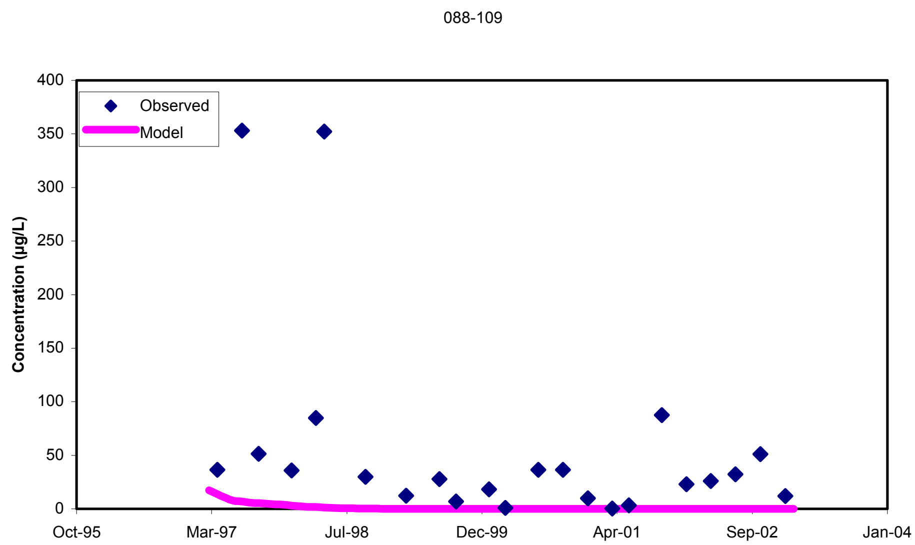


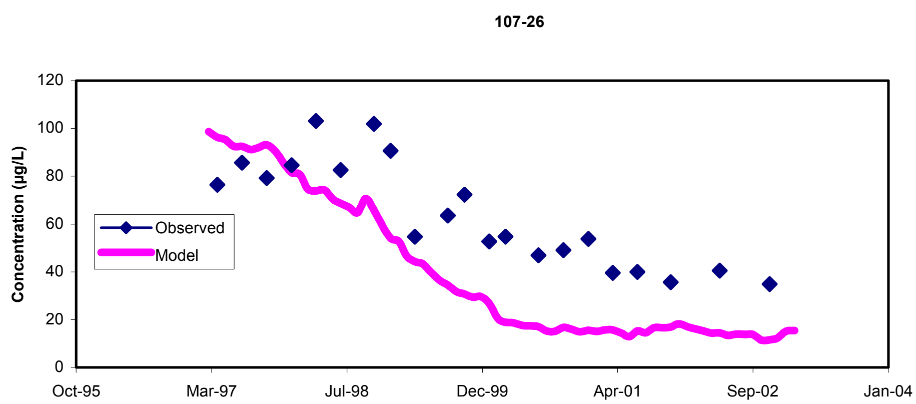
160
140
120
100
80
60
40
20
0
Concentration (µg/L)
Observed
Model
Oct-95
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04

098-59



400
350
300
250
200
150
100
50
0
Concentration (µg/L)
Observed
Model
Oct-95
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04





The model does not account for the weak source of contamination coming from the Current Landfill. However, this is not expected to impact the cleanup goals. While the cap is preventing rainfall infiltration into the waste, the contamination released prior to capping is still working its way through the subsurface environment. Groundwater quality continues to slowly improve although there continues to be a tailing affect that is not accounted for in the model.

Figure 3.1.3-13 compares the simulated extent of the TVOC plume as of December 2002 with the observed November 2002 plume. This figure shows a good match between predicted and observed distribution of TVOC contamination.

Based on these indices, the updated model is suitably calibrated for the stated objectives. It will provide better predictions of the operating duration and performance of the OU I South Boundary system. The applications of this updated model are discussed below in Section 3.1.3.8 System Evaluation.

3.1.3.8 System Evaluation

The pump and treat system continued to maintain hydraulic control of contaminants from the Current Landfill and former HWMF and to prevent their further migration across the site's southern boundary. No permit equivalencies have been exceeded and no operating difficulties were experienced beyond normal maintenance. There have been no air emission 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.

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

1. Was the BNL Contingency Plan Activated?
No. There were no unusual or unexpected concentrations of VOCs observed in monitoring wells associated with the OU I South Boundary Pump and Treat System.

2. If not, has the plume been controlled?

Yes. Since the cleanup goals have not been met, it must be verified that the plume is not growing. An analysis of the plume perimeter and bypass wells reveals that there have been no significant increases in VOC concentrations during 2002; thus, we conclude that the plume has not grown and continues to be controlled.

Groundwater elevation data is obtained from many of the OU I South Boundary Monitoring program wells. Groundwater contour maps were generated from these data (**Figures 2-4** and **2-5**). The capture zone for the OU I South Boundary Pump and Treat System is indicated in **Figure 3.0-1**. The capture zone depicted is inclusive of the 50 μg/L isocontour, that is the capture goal of this system.

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

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

However, some portions of the targeted cleanup area do not appear to be progressing as quickly as simulated in the groundwater modeling performed during the design of the system. Camp Dresser & McKee (1995, 1996) carried out a series of groundwater model simulations as part of the Engineering Evaluation /Cost Analysis (EE/CA) and 30% design of the system. These simulations focused on the most prevalent and design limiting contaminant 1,1-DCA. The predicted 1,1-DCA concentrations after 5 and 10 years of RA V operation are shown in **Figure 3.1.3-16**. Only the "hot spots" were simulated in these runs. After 5 years of operation (2001) the 30% design model runs indicated that the 1,1-DCA concentrations in the aquifer would be reduced to about 30 μg/L. The plume data map for 2002 generally support this, with the following exceptions:

- TVOC concentrations at well 98-59, southwest of the former HWMF, remain high at 125 μg/L (see **Figure 3.1-1 and Figure 3.1.3-12**). Monitoring Well 98-59 is screened in the Upton Unit, which is a silty unit near the base of the Upper Glacial aquifer. It appears that contamination is "trapped" or moving very slowly in this unit.

- Even though the Current Landfill is capped, it remains a weak source of contamination. TVOC levels as high as 51 μg/L were detected at its downgradient edge. Concentrations in groundwater are declining in this area; however, it will take several more years to fully flush out the contaminants beneath the landfill cap.

These types of local limitations are not unexpected. Earlier design reports (CDM, 1995, 1996) identify some of these risks. Comparing the 1995 prediction for 2001 (**Figure 3.1.3-16**) with the 2002 prediction for 2001 (**Figure 3.1.3-17**), along with the cumulative mass removal curves (**Figure 3.1.3-11**), it is clear that the rate of aquifer cleanup is not progressing at the rate predicted in 1996. The 1996 30% design report predicted an operational duration of 7 to 14 years.

3a. Under the existing operational configuration, how many more years of operation is it estimated to take to achieve the cleanup goals?

The updated model (without dispersion) predicts that 22 years of additional treatment (27 years of total treatment) with the existing system will be required to capture the contamination trapped in the Upton Unit. Nevertheless, predicting the duration for this system with certainty is complicated (hence uncertain) because of the lower permeability of the Upton Unit.

The hydraulic conductivity of the Upton Unit has not been directly measured. It has been estimated from groundwater flow model calibrations. Because this unit is rather thin yet permeable, the groundwater flow model predictions of water levels are not highly sensitive to the Upton Unit hydraulic conductivity. Therefore the estimates of Upton Unit hydraulic conductivity are simple at best. Nevertheless, the Upton Unit hinders the cleanup performance of the OU I South Boundary system.

For this task, not only was the groundwater flow model calibration used in estimating the hydraulic parameters but fate and transport data as well. Simply said, the Upton Unit parameters used in the CDM 30% design model were able to match the observed water levels and flow patterns, but were unable to match the recent contamination data. The area near monitoring well 98-59 was predicted to cleanup considerably faster than is actually occurring. The updated model matches the contamination data much better. Despite confidence in this latest prediction of duration, there is still considerable uncertainty.

This prediction varies considerably from the 30% design estimate. The reasons for the difference between the 1996 and 2002 predictions include:

1. Contamination “trapped” in Upton Unit - the model was recently updated with relatively new stratigraphic data from the USGS Water-Resource Investigation Report (Scorca et al., 1999). This update added the Upton Unit in the lower portion of the Upper Glacier aquifer. The Upton Unit consists of greenish sand with 5-10% clay content. Previous models accounted for this region as the “unidentified unit”. For example, the BNL regional model (Arcadis Geraghty & Miller, 1999) assigned a horizontal and vertical hydraulic conductivity value of 40/0.8 ft/day, respectively to this unit of fine materials. The CDM model of OU I (CDM, 1996) assigned a 100/1 ft/day hydraulic conductivity value to the “unidentified unit”. The recent USGS report shows the Upton Unit extends further south than the prior modeling efforts, especially in the OU I area. This is an important refinement in the model. Monitoring well 98-59, which has consistently shown elevated levels of VOCs and a slow reduction in concentration after 5 years of treatment is screened in the Upton Unit.

2. Model calibration increased the estimated retardation factor. The retardation factor was assumed to be 1.3 in the CDM 30% design model. Based on five years operating data and an updated model calibration, the retardation factor is now estimated to be 1.5. This updated retardation factor slows the predicted rate of contaminant migration by about 10 percent.

The Upton Unit along with the OU I TVOC plume location is shown in **Figure 3.1.3-13**. This figure shows that the Upton Unit is present south of the former HWMF where the high concentration area of the plume is migrating. This part of the plume moves slowly in the low permeability Upton Unit.

Taking into consideration the Upton Unit and the refined calibration of the contaminant fate and transport (discussed earlier in this report), the updated model (without dispersion) now predicts that the existing operational configuration will take 22 more years of operation (27 years total) to achieve the capture or cleanup objective for the entire target area. In fact, after 14 years of operation about 200-300 µg/L of TVOC contamination is predicted to remain trapped in the Upton Unit (see **Figure 3.1.3-18**). After 14 years of treatment, only this hot spot trapped in the Upton Unit remains above the cleanup goals. Unfortunately, the hot spot is predicted to remain 2400 feet from the extraction wells. Therefore treatment of this trapped area is highly inefficient under the existing configuration. After 27 years of treatment the model predicts that the peak concentration in the hot spot will be reduced to about 25 µg/L TVOC. This location is approximately 2,400 ft north of the current pumping wells. The current pumping wells are not ideally located to treat this contamination migrating through the lower permeability Upton Unit.

<u>3b. Will additional extraction well(s) in persistent areas of the aquifer significantly decrease the operational time?</u>

The CDM 30% design model recommended that the duration estimate be periodically updated, as performance data was made available. The 30% design recommended that if persistent areas of contamination existed after 3-4 years of operation, that the need for a third extraction well in the vicinity of grid 107 be evaluated to cost-effectively shorten the operating period. The 5 years of performance data show persistent contamination in the area of monitoring well 98-59 south of the former HWMF.

A third well, EW-3, was simulated to treat the stagnant plume segment south of the former HWMF (**Figure 3.1.3-19**). The simulated pumping schedule for this alternative is:

EW-1 = 100 gpm
EW-2 = 400 gpm
EW-3 =200 gpm.

The total pumping remained at 700 gpm, well within the treatment capacity of the existing units.

The model predicts that a three well system will reduce the peak TVOC concentration to 45 µg/L with only four more years of treatment (see **Figure 3.1.3-19**). The model supports adding a third well in this area of the aquifer to significantly decrease the operational time.

Preliminary life-cycle cost comparisons indicate that if the system must operate for another 22 years, adding a third extraction well (plus piping) at an approximate capital cost of $150,000 to $200,000 would be cost effective. A more detailed engineering study should be performed to assess life-cycle economics.

However, there remains considerable uncertainty in the exact duration of operation because of the subsurface complexities. For planning purposes, a 14-year operational period should remain until additional monitoring data are evaluated.

3c. Can modifications to the pumping schedules for the existing pumping wells maintain hydraulic control of the target plume segment and improve life-cycle cost effectiveness?

Varying the pumping schedule of EW-1 and EW-2 alone is not predicted to significantly reduce the forecasted operational life of the system. Adding a third well in the stagnant area while keeping the total pumping rate at 700 gpm may significantly reduce the operational time as noted above.

3d. If the existing pump and treat system were to cease after 10 years of operation, could the groundwater cleanup goals be achieved via Monitored Natural Attenuation (MNA)?

If the existing pump and treat operation were to cease after 10 years of treatment (2007), the model predicts that 20 years of natural attenuation (2027) will reduce the peak concentration of TVOC to about 38 µg/L. The model predicts this peak concentration would still be located within the BNL property boundary. Based on these model predictions, it is reasonably possible that 10 years of operation of the existing system combined with 20 years of MNA could achieve the cleanup goals. A more detailed engineering study should be performed to assess life-cycle economics compared with other options discussed above.

3e. A strontium-90 plume has been delineated in the area south of the former HWMF. Will this plume be entrained by the OU I South Boundary system? If so when?

A strontium-90 plume has been delineated in the area south of the former HWMF in the upper portion of the Upper Glacial aquifer. The peak concentration of the plume is 65 pCi/L. **Figure 3.1.3-5** shows the distribution of the strontium-90 in the Upper Glacial aquifer in 2002. The updated model was used to evaluate whether the OU I South Boundary remediation system will entrain the strontium-90 plume during operation.

BNL soil column studies determined the distribution coefficient, Kd, of strontium-90 ranges from 2.8 cm^3/g to 11.7 cm^3/g (Fuhrman, 1995). Assuming Kd is 3.0 cm^3/g, the soil bulk density is 1.65 g/cm^3 and the effective porosity of the Upper Glacial aquifer is 0.24, the retardation factor of strontium-90 was calculated to be 20. It was assumed that the strontium-90 plume position is as mapped in the 2001 BNL Groundwater Status Report.

The model predicted the strontium-90 plume will move downgradient about 150 feet after four years of operation with an updated three-well remediation system, and 400 feet after 27 years operation with the existing remediation system. The model predicted that neither the existing remediation system configuration nor a proposed three well remediation system would capture the strontium-90 plume within the systems respective operational life.

This analysis reconfirms that there is a low risk of the strontium-90 plume reaching the OU I South Boundary system at concentrations greater than drinking water standards. Nevertheless, it is prudent to monitor well data in the area, in addition to evaluating the results of the Chemical Holes Strontium-90 groundwater remediation pilot study. This is expected to refine strontium-90 groundwater transport parameter estimates.

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 (**Figure 3.1.3-1**). The average TVOC concentrations continue to decline however, a number of individual wells continue to exceed groundwater standards. The Mann-Kendall statistical test also shows a continuing decreasing trend. **Figure 3.1.3-14** plots the mean concentration of each plume core well computed from measurements since 1997. Kendall-Mann is a nonparametric trend analysis (Gilbert, 1987) used to aid in determining the slope in groundwater quality data. It is particularly useful when the residuals from a regression analysis are not normally distributed, or for an unknown distribution. Aquifer cleanup continues to be demonstrated based on the continued decreasing slope to the trend of average TVOC concentrations in plume core wells. Changes in the makeup of the plume are shown in **Figure 3.1.3-15**, which compares the TVOC plume from 1997 to 2002. The cleanup goals for this system have not yet been achieved. Asymptotic conditions have not yet been achieved, but are expected in the next few years. Asymptotic conditions of target TVOCs in plume core wells can indicate that the practical limits of treatment have been reached.

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

Yes, the mean TVOC concentration is presently less than 50 μg/L and showing a decreasing trend (**Figure 3.1.3-14**).

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

One of ten plume core wells continues to have TVOC concentrations exceeding 50 μg/L. This is well 98-59 located in the hot spot south of the former HWMF.

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

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

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

No. MCLs have not been achieved for individual VOCs in plume core wells.

3.1.3.9 Recommendations

The following are recommendations related to the OU I South Boundary groundwater remediation system and groundwater monitoring programs:

1. A baseline of over five years of groundwater data has been obtained from many of the OU I South Boundary Program wells, and it has been demonstrated that the system is functioning as planned. A routine operation and maintenance monitoring frequency will be implemented in August of 2003. Plume core and perimeter wells will be monitored on a semi-annual frequency.

Sentinel, and bypass wells will continue to be sampled at a quarterly frequency. This reduction in sampling frequency for plume core and perimeter wells was already implemented for many of the OU I South Boundary Program wells in 2001. Maintain current monitoring for tritium and strontium-90. Extraction wells EW-1 and EW-2 will be sampled quarterly instead of every two months beginning in August 2003.

2. Commission an engineering study in FY 04 to evaluate the life-cycle economics of the following options:
    i. Continue to operate the existing system for as long as 2027,
    ii. Install a third groundwater extraction well in BNL Grid 98 to directly pump the persistent hot spot in the vicinity of monitoring well 98-59. This would result in completing active operation by 2007.
    iii. Operate the existing system until 2007 and then rely on monitored natural attenuation until 2027.

   Since the performance of each option is essentially equal, the decision on which option to pursue would be based primarily on life-cycle economics. This is an adaptive approach to groundwater remediation and is consistent with CERCLA guidance and the OU III ROD.

3. Coordinate the groundwater remediation system with findings from the former HWMF characterization.

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), and includes Building 96, Building 208, the Alternating Gradient Synchrotron (AGS) area, and the former carbon tetrachloride underground storage tank. The eastern portions of the plume have sources in OU IV and the Former Landfill and Animal/Chemical Holes areas. **Figure 3.2-1** is a simplified representation of the plumes using TVOCs, done for clarity. 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, tetrachloroethene (PCE), and Carbon Tetrachloride. The primary OU III VOCs detected in on-site monitoring wells include Carbon Tetrachloride, TCA, and PCE; Carbon Tetrachloride and PCE are the main contaminants detected in off-site groundwater.

The OU III VOC plume extends overall from the AGS/Waste Concentration Facility (WCF) area in the northern part of the site, south to the vicinity of Flower Hill Drive off-site (a distance of approximately 18,000 feet). The maximum width of its main body is about 1,500 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 less than 50 μg/L. This contamination most likely results from multiple small source areas in the northern and central portions of the site, and its distribution has been complicated by earlier changes in the on-site groundwater flow system due to changes in pumping and recharge. The basis for this representation of the lobe of the plume is the extensive vertical profile characterization conducted under the OU III RI, in addition to data points from several existing monitoring wells.

The two most prominent source areas are the Building 96 area, and the former Carbon Tetrachloride underground storage tank. Onsite portions of the plume displaying the highest VOC concentrations during 2002 were south of Building 96 in Geoprobe samples (primarily PCE and lower concentrations of TCA, with TVOCs up to 3,718 μg/L), continuing south to the Middle Road with TVOC concentrations of 2,948 μg/L and the south boundary with TVOC concentrations up to 1,471μg/L. TVOC levels range up to 1,613 μg/L (primarily Carbon Tetrachloride and PCE) in the off-site industrial park area. Characterization of the Magothy Aquifer was completed in 2002 and the data was compiled in the *Magothy Aquifer Characterization Report* (BNL, 2003).

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

A comparison of the OU III plumes in 1997 and 2002 is provided in **Figure 3.2-4**.

Sections 3.2.1 through 3.2.6 summarizes and evaluates the groundwater monitoring and system operations data for the OU III operational groundwater treatment systems. Sections 3.2.7 through 3.2.14 summarize the various OU III groundwater-monitoring programs for areas not currently addressed by groundwater treatment systems (i.e., North Street, Long Island Power Authority (LIPA)/Airport etc.).

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3.2.1 Carbon Tetrachloride Pump and Treat System

This section summarizes the operational data from the OU IIII Carbon Tetrachloride Pump and Treat System, and offers conclusions and recommendations for future operation and monitoring. This system began operating on October 6, 1999. This summary is prepared annually and discusses the operational data from January 1, 2002 through December 31, 2002. In addition, a monthly DMR is submitted to EPA and NYSDEC for treated effluent water from the granular activated carbon units.

As part of BNL's Facility Review in 1997, a 1,000-gallon underground storage tank (UST) that was used in the 1950s for an experiment at the former Chemistry Department complex was unearthed at the southwest corner of Rowland Street and Rochester Street.

After the experiment finished in June 1955, the UST, which contained carbon tetrachloride, was pumped out. However, based upon follow-up sampling, it is apparent that some of the carbon tetrachloride remained in it. Access to, and removal of, the tank was difficult because it was buried 20 feet below grade. It was removed on April 10, 1998 by BNL's Plant Engineering (PE) Department and supervised by SCDHS as part of the Brookhaven Facility Review Project. A small hole was found on the side of the tank. The tank contained approximately 15 inches of water contaminated with carbon tetrachloride at levels of 560,000 µg/L. Following the tank removal, 179,000 µg/l was detected in monitoring well 85-98. More detailed findings on the tank release are discussed in the *Summary Report for the Carbon Tetrachloride Investigation*, (P. W. Grosser 1999).

These findings lead to pumping out the highest concentrations in the groundwater. This tank area was considered a significant source of groundwater contamination. Removing the source was the focus of the removal action. This action is further discussed in the *Final Action Memorandum for the Carbon Tetrachloride Tank Groundwater Removal Action*, (BNL 1999a).

The Removal Action consisted of pumping and treating groundwater from monitoring well 085-98 for approximately nine days between January 14 - 29, 1999. Samples were taken each day. In this time, 87,300 gallons of groundwater were pumped and treated. The highest concentration of carbon tetrachloride was 183,000 µg/l; it fell to 25,000 µg/l on the final day of pumping. The volume of carbon tetrachloride removed was estimated as 4.6 gallons or 60 pounds.

Two groundwater extraction wells were installed in the summer of 1999 and consisted of a well at the source area and another immediately to the south. The pump and treat system began operating on October 6, 1999.

Groundwater characterization was again undertaken in 2001 due to the presence of high concentrations of carbon tetrachloride downgradient of the remedial action (beyond the capture zone of the extraction wells) including the installation of new permanent monitoring wells. A third extraction well was constructed in the vicinity of the Weaver Drive recharge basin. Start-up of this well took place in December 2001.

During 2002 two additional vertical profiles were installed to determine the depth of contamination immediately upgradient of the former source and near well 95-88 where deeper carbon tetrachloride has been detected. Significant deeper contamination was not detected at either location in these profiles. A report detailing the findings will be published during the summer 2003.

3.2.1.1 System Description

The Carbon Tetrachloride Pump & Treat System, consisting of three groundwater-extraction wells, is located in a building (TR-829) at the southwest corner of Rowland Street and Rochester Street. The first well, EW-13, is sited in the source area, adjacent to the building. The second well, EW-14, is further south, on the west side of Rochester Street. In December 2001 a new extraction well (EW-15) was added to the system. EW-15 is located 1,100 feet east south east of the treatment building (**Figure 3.2.1-1**). This was located to capture the high concentration portion of the plume, which had migrated downgradient of the two existing wells. Each well consists of a submersible pump sending water to three 2,500-pound granular activated carbon filter vessels housed in the treatment shed. Treated groundwater returns to the on-site drainage system via a 4-inch PVC pipe to a catch basin on Rowland Street.

The 2002 pumping schedule for the three wells is summarized in **Table 2-3**. The treatment system is designed to operate at rates up to 70 gpm. Operational monitoring data suggests that actual rates vary during the life of the system. Each well is 6-inches in diameter with a 20- foot long, 20- slot, 304 stainless-steel screen. **Table 3.2.1-1** shows the extraction well and pumps settings.

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Table 3.2.1-1. Carbon Tetrachloride Extraction Well Construction Data

Well	Screen Interval (Feet below grade)	Pump Setting (Feet below grade)
(EW-13, 085-158)	32-52	42
(EW-14, 085-159)	32-52	42
(EW-15, 095-278)	65-85	75

The groundwater treatment facility consist of the treatment shed set on a concrete slab housing three 2,500-pound granular activated carbon absorber vessels in series, PVC piping, valves and gauges, including starter and electrical panels, lighting, and space heating.

To evaluate the performance of the system, six sample ports are located in the treatment building. Four locations evaluate the performance of the carbon units, taking samples at the influent point, midpoint 1, midpoint 2, and at the effluent. Three additional sampling points are located on the influent piping from the extraction wells.

The water is discharged via a 4-inch PVC pipe from the treatment building to a nearby catch basin near the intersection of Rochester and Rowland Streets. The catch basin is piped to an open drainage channel near the supply and material area that drains to a storm water recharge basin. **Figure 3.2.1-2** shows the piping route.

3.2.1.2 Groundwater Monitoring

Well Network: A network of 23 wells was designed to monitor the extent of the plume and the effectiveness of remediation. The BNL Groundwater Model was used to site the wells. The network was organized into plume core, perimeter, Bypass Detection and bypass/Middle Road Tracking wells as part of the DQO process; well designations/locations are shown in **Figure 3.2.1-3**. The wells are designated as follows:

- Plume Core – utilized to monitor the high concentration or core area of the plume. In addition, plume core wells will be used to provide data for measuring the performance of the source control measure.
- Perimeter – used to monitor the horizontal and vertical boundaries of the plume.

- Bypass (Middle Road Tracking) – used to determine whether the contamination already downgradient of the groundwater remediation system will be captured by the Middle Road system.

Sampling Frequency and Analysis: The wells are sampled quarterly, and samples are analyzed for VOCs (see **Table 1-6**).

3.2.1.3 Monitoring Well Data Plume Description

Carbon tetrachloride is the primary contaminant in this plume that extends from the former UST southeast to the vicinity of the Weaver Road recharge basin, a distance of approximately 1,300 feet (**Figure 3.2.1-4**). The width of the plume as defined by the 50 µg/L isocontour is approximately 120 feet. **Table 3.2.1-2** summarizes monitoring well VOC results exceeding the NYS AWQS. The complete 2002 analytical results from the monitoring of wells in the Carbon Tetrachloride Program are provided in **Appendix C**.

- Plume core well 85-98, located just south of the former UST, displayed carbon tetrachloride concentrations greater than 150,000 µg/L in 1999. A decreasing trend was observed in this well, beginning in 1999 with the start of groundwater pumping, and continued during 2001 with a concentration of 7 µg/L reported during the fourth quarter **(Figure 3.2.1-5)**. The concentration increased to 158 µg/L during the fourth quarter of 2002. This increase is in response to the shutdown of EW-13 in early October of 2002 and a rebound in carbon tetrachloride concentrations.

- Plume core well 85-17 is sited next to the BNL service station on Rochester Avenue and downgradient of the source area. It also continued to show declining carbon tetrachloride trends during the past year, from 3,760 µg/L in 2001 to 154 µg/L during the fourth quarter of 2002 **(Figure 3.2.1-5)**.

- Plume core well 85-161 is located approximately 120 feet downgradient from well 85-98. The declining carbon tetrachloride concentration trend in this well since 1999 continued, with a fourth quarter result of 12 µg/L in 2001 **(Figure 3.2.1-5)**.

- Plume core well 95-183 is approximately 450 feet downgradient of EW-13. Carbon tetrachloride concentrations in this well have decreased from greater than 2,000 µg/L in 2000 to 20 µg/L during in December 2002 **(Figure 3.2.1-5)**.

- Plume core wells 95-277 and 95-279 were installed in 2001 after groundwater characterization of the downgradient segment of the plume. Both wells displayed decreasing carbon tetrachloride concentrations in 2002 **(Figure 3.2.1-5)**.

The carbon tetrachloride concentrations in the plume core area have declined significantly in response to the removal action. Carbon tetrachloride was not detected in any of the bypass wells in the vicinity of Weaver Drive during 2002, which indicate the plume is being controlled.

Two groundwater vertical profiles were installed in December 2002 to determine the vertical extent of contamination both near the former carbon tetrachloride tank and in the vicinity of well 95-88. The locations of the two vertical profiles are shown in **Figure 3.2.1-6.** The vertical profile VP-1 was sampled to a depth of 185 feet. There was no carbon tetrachloride detected in this profile. VP-2 detected carbon tetrachloride at depths consistent with the known plume in the vicinity of well 95-88. Based on the data from these vertical profiles there is no Dense Non Aqueous Phase Liquid (DNAPL) associated with the carbon tetrachloride plume nor does there appear to be an additional upgradient source contributing to this plume at depth.

3.2.1.4 Systems Operations

Operating Parameters

The influent, midpoints, and effluent of the carbon vessels were sampled twice a month. The extraction wells were sampled monthly. All samples are analyzed for VOCs In addition; the pH of the influent and effluent samples is measured monthly. The parameters for sampling pH and VOCs adhere to the requirements of the SPDES equivalency permit. All effluent samples during this period of operation were below the permit levels (**Table 3.2.1-3**).

Table 3.2.1-3. SPDES Equivalency Permit Levels January 1 - December 31, 2002

Parameters	Permit Limit (µg/l)	Max. Observed Value
pH	5.5/6.5** - 8.5	5.9 – 6.6
Bromodichloromethane	50.0	<0.5
Carbon Tetrachloride	5.0	<0.5
Chloroform	7.0	<0.5
Methylene Chloride	5.0	.88B
Tetrachloroethylene	5.0	<0.5
Toluene	5.0	<0.5
Trichloroethylene	5.0	<0.5
Xylene (o-isomers)	5.0	<0.5
Xylene (sum of M&P isomers)	10.0	<0.5

***Maximum effluent allowed by Requirements Equivalent to a SPDES Permit**
****pH value lowered by NYSDEC to 5.5 in September 2000.**
B - Detected in blank

System Operations

The following summarizes the systems operations for each month of 2002. BNL's PE Division performed daily routine maintenance checks, in addition to sampling and routine and non-routine maintenance work. Details are given in the system's operation and maintenance manual. The daily operations and maintenance inspection logs are available in the project files and the treatment system building (TR-829).

January 2002:

The system was shutdown on January 8 and started on January 9 for a routine carbon change-out. The system operated the rest of the month with EW-13 at 20 gpm, EW-14 off (turned off in December 2002) and EW-15 at 50 gpm. A total of 3,383,600 gallons were pumped and treated. The system's flow rate averaged 78 gpm during this month.

February 2002:

There was a shutdown of the system from February 20 to February 27 due to unexpectedly high concentrations of carbon tetrachloride in well EW-15. This was a precautionary measure to make certain there was not breakthrough prior to the next scheduled change out. A routine carbon change-out was performed on February 27 and the system was restarted later that day. A total of 2,185,000 gallons were pumped and treated in October. The system flow rate averaged 72 gpm during this month.

March 2002:

The system remained operational the entire month. A total of 3,030,000 gallons were pumped and treated in March. The system flow rate averaged 68 gpm during this month.

April 2002:

The system was shut down on April 16 and started on April 17 for a routine carbon change-out. The system operated the rest of the month with EW-13 at 20 gpm, EW-14 off and EW-15 at 50 gpm. A total of 3,202,000 gallons were pumped and treated in December. The system flow rate averaged 77 gpm during this month.

May 2002:

The system remained operational the entire month. A total of 3,179,000 gallons were pumped and treated in May. The system flow rate averaged 71 gpm during this month.

June 2002:

The system was shut down on June 13 and started on June 14 for a routine carbon change-out. The system operated the rest of the month with EW-13 at 20 gpm, EW-14 off and EW-15 at 50 gpm. A total of 3,073,400 gallons were pumped and treated in December. The system flow rate averaged 74 gpm during this month.

July 2002:

The system remained operational the entire month. A total of 3,080,600 gallons were pumped and treated in May. The system flow rate averaged 70 gpm during this month.

August 2002:

There was a shut down of the system on August 13 to August 14 for a routine carbon change-out. The system operated the rest of the month with EW-13 at 20 gpm, EW-14 off and EW-15 at 50 gpm. A total of 3,033,900 gallons were pumped and treated in August. The system flow rate averaged 68 gpm during this month.

September 2002:

The system remained operational the entire month. A total of 3,105,000 gallons were pumped and treated in May. The system flow rate averaged 72 gpm during this month.

October 2002:

Extraction well EW-13 was shut off due to low influent concentrations of carbon tetrachloride, but will continue to be sampled on a monthly basis. The system was shut down October 22 for a routine carbon change-out and was restarted later that day. A total of 2,660,000 gallons were pumped and treated in October. The system flow rate averaged 60 gpm during this month.

November 2002:

The system remained operational the entire month. A total of 2,233,000 gallons were pumped and treated in May. The system flow rate averaged 52 gpm during this month.

December 2002:

The system remained operational the entire month. A total of 2,295,000 gallons were pumped and treated in May. The system flow rate averaged 51 gpm during this month.

Approximately 34,461,000 gallons of water were pumped and treated in 2002 by the OU III Carbon Tetrachloride system.

3.2.1.5 Systems Operational Data

System Influent and Effluent

All parameters in the permit equivalency conditions were below the regulatory limit specified in the SPDES permit equivalency.

The overall influent water quality to the carbon vessels continued to show a decrease in the concentrations of contaminants. The influent carbon tetrachloride concentration at the beginning of system operation in October 1999 was 11,000 µg/l. The concentration was 64 µg/l at the end of December 2002. **Tables F-6** through **F-9** in **Appendix F** (located on the CD-ROM) summarize carbon tetrachloride concentrations in the influent, effluent and midpoint samples.

Plots of the concentrations of carbon tetrachloride in the extraction wells and in the influent to the carbon vessels against time are shown in **Figure 3.2.1-7**. Extraction well EW-13 showed a decline from January to October, with a high of 29 µg/L in January 2002, falling to 12 µg/L in October. There was a rise in concentrations during the last two months of the year with 41 µg/L in November and 69 µg/L in December following the shut down of this well in October. EW-14, which remained off during 2002, showed a steady rise, from 31 µg/L in January 2002 to 97 µg/L in July 2002, then declined to 70 µg/L by December 2002. Extraction well EW-15 showed a generally steady decline from 901 µg/L in January 2002 to 69 µg/L in December 2002. The combined influent water quality also showed a steady decrease for the year.

Cumulative Mass Removal

The mass of carbon tetrachloride removed from the aquifer was calculated using average flow rates for each monthly monitoring period and influent concentrations to the carbon treatment system. **Table 2-3** lists monthly pumpage rates for 2002. These rates were used in determining mass removal of carbon tetrachloride.

Table F-10 in **Appendix F** gives total pounds of mass of carbon tetrachloride removed by the treatment system; **Figure 3.2.1-8** plots mass removal versus time. Approximately 86 pounds (6.52 gallons) of carbon tetrachloride were removed during 2002, with a cumulative total of 327 pounds (27.20 gallons) since the system started.

3.2.1.6 System Evaluation

<u>Carbon Tetrachloride Groundwater Model Assessment</u>

The centerline axes of the carbon tetrachloride and Building 96 TVOC plumes are about 350 feet apart. Due to their proximity, they have been simulated together in a local sub-model to assess and improve the performance of the groundwater remediation systems designed to provide contamination source control. **Figure 3.2.1-9** shows the actual cumulative mass removed by the carbon tetrachloride system vs. an earlier model prediction. This trend plot shows that the addition of EW-15 was very effective in returning the performance of the carbon tetrachloride system back to what was expected. This modeling evaluated system performance and overall progress toward remediation objectives and goals, including evaluating different extraction/injection operations and predicting the effects of different operational and pumping schedules in an effort to optimize operation.

<u>Modeling approach</u>

For the design of these systems separate, local groundwater models were used. For example, Arcadis Geraghty & Miller (AG&M, 1999) developed a local Building 96 sub-model to design the Building 96 groundwater recirculation wells. This local model incorporated an important shallow silt layer near the Building 96 contamination source area. BNL (Bennett, 1999, 2000) developed a local model of the carbon tetrachloride plume.

For this updated model assessment, the BNL "Onsite Sub-model" was used. This model includes the following features:

- The shallow silt zone in the vicinity of the Building 96 source area
- Average 2002 onsite pumping and recharge data
- Cell sizes in the area of interest are approximately 50 by 70 feet

- Retardation factor is 1.1; dispersivity is assumed to be zero
- The initial plume concentrations were based on the plume maps presented in this 2002 BNL Groundwater Status report.

The starting time for the simulation was January 2003. The model was run forward through the end of 2003 under the following operational conditions.

Carbon Tetrachloride	EW-13	0 gpm	
	EW-14	30 gpm	
	EW-15	40 gpm	
Building 96	RTW-1	30 gpm	
	RTW-2	20 gpm	
	RTW-3	20 gpm	
	RTW-4	20 gpm	

Carbon tetrachloride plume model results

- Groundwater performance data and model projections suggest that the carbon tetrachloride system is nearing its cleanup objectives (i.e., source control).

- **Figure 3.2.1-10** is a predicted cumulative mass removal curve for the carbon tetrachloride system by pumping well through the end of 2007 under the above outlined pumping scheme. This projection suggests that the EW-14 is no longer productive in terms of removing significant contamination after 2003 and EW-15 is no longer productive after 2004.

- Monitoring well data in the vicinity of the tank spill area has displayed concentration rebound when either EW-13 or EW-14 is turned off. These wells should be periodically pulse operated through 2003 to determine whether this affect is diminishing, which could indicate that the source has been significantly controlled.

- The predicted groundwater flow field suggests that when both EW-14 and EW-15 operate simultaneously, a hydraulic stagnation point develops between the two wells. This apparently causes contamination in the Chilled Water Facility area to migrate slowly or stagnate between the two extraction wells. Operating EW-15 only and shutting down EW-14 would clear this contamination from the aquifer more quickly. However, this type of operational mode should only be deployed when it is clear that no significant contamination rebound is occurring in the tank spill area. Turning off EW-14 prematurely could create the spread of additional contamination from the spill area. The operations of EW-14 and EW-15 must be coordinated to be effective.

- The carbon tetrachloride system will be placed in a shutdown phase of operation beginning August 2003. During this phase data will be collected quarterly for a two-year period to demonstrate that the system objectives have been met.

- Based on the model projections, it is reasonable to predict that EW-14 should go into standby mode in December 2003. It is predicted that EW-15 will be effective through 2004 and then can go into standby mode. According to **Figure 3.2.1-10**, the predicted carbon tetrachloride concentrations in December 2004 will be approximately 50-100 µg/L

- According to the model predictions, the remaining low-level carbon tetrachloride contamination after 2004 **(Figure 3.2.1-11)** will migrate to and be captured by the Middle Road system by 2012 (see **Figure 3.2.1-12**). This contamination will migrate through an already contaminated aquifer segment. The Middle Road system is designed to treat VOCs and is projected to operate through 2025. Therefore, the remnant of the carbon tetrachloride is predicted not to impact the Middle Road system.

The pump and treat system continued effectively in 2002, removing high concentrations of carbon tetrachloride from the plume downgradient of the former underground storage tank.

The performance of the OU III Carbon Tetrachloride Pump and Treat system can be evaluated based on the six major decisions identified for this system after applying the DQO process.

1. Was the BNL Groundwater Contingency Plan Triggered?

No. There were no detections of either carbon tetrachloride or any other contaminants in wells associated with this monitoring network during 2002 that triggered the BNL Groundwater Contingency Plan.

2. Were the cleanup goals met?

No. This system was designed as a source control measure that when integrated with the other groundwater treatment systems and natural attenuation, will result in meeting the OU III ROD cleanup goals. This system has not yet met its cleanup objectives, but is approaching its shutdown phase of operation.

Initial model estimates indicate that 90% of the carbon tetrachloride plume will be remediated within four years. However, a number of assumptions were required to develop such an estimate. Carbon tetrachloride trends in plume core wells from near EW-13 and EW-14, downgradient to EW-15, continued to decline during 2002. However significant mass remains in the aquifer. **Figure 3.2.1-13** plots the mean concentration of plume core wells since 1998. The third extraction well (EW-15) began operation in December 2001. During 2002 EW-15 was responsible for a significant portion of the overall carbon tetrachloride mass removal. The OU III Middle Road Pump and Treat System will capture any carbon tetrachloride contamination that has previously migrated south of the presently configured remediation system.

3. If not, has the plume been controlled?

Yes. Groundwater monitoring data from bypass wells indicate that the plume is controlled. However, there has been a minor westward shift of the plume fringe in the vicinity of wells 85-162, 95-185, and 95-186 in response to wells EW-13 and EW-14 being turned on and off during 2002. EW-15 is currently controlling and treating the downgradient portion of the high concentration segment of the plume. Additional groundwater characterization consisting of two vertical profiles was conducted during 2002 to determine whether there was a deeper component to the carbon tetrachloride plume. The results of this effort determined that the plume was confined to the shallow Upper Glacial Aquifer (**Figure 3.2.1-6**)

Groundwater water table contour maps were drawn (**Figures 2-4** and **2-5**). The capture zone for the Carbon Tetrachloride Pump and Treat System is indicated in **Figure 3.0-1**. The capture zone depicted includes the 50 µg/L isocontour, which is the capture goal of this system.

4. Is the System operating as planned?

Yes. The system continues to be very effective at removing carbon tetrachloride from the Upper Glacial aquifer and is operating as planned. Monthly samples continue to be obtained from both EW-13 and EW-14, which are in stand-by mode. Carbon tetrachloride concentrations in EW-14 rebounded slightly and then stabilized during 2002. Carbon tetrachloride concentrations in EW-13 also increased during fourth quarter 2002 sampling subsequent to the well being placed on stand-by in October 2002. Influent carbon tetrachloride concentrations have continued to steadily decline in EW-15 during 2002. A comparison of the carbon tetrachloride plume between 1999 and 2002 is shown in **Figure 3.2.1-14**. While the plume has grown since 1999 it is now being controlled and the remedial action is effective.

Figure 3.2.1-9 shows both the actual and predicted mass removals of VOCs versus time. Indications are that the mass removal rate generally is tracking as planned.

5. Have asymptotic conditions been demonstrated?

No. Average TVOC concentrations for the plume core wells are plotted in **Figure 3.2.1-13**. Based on the trend demonstrated in that figure, the asymptote has not been reached and concentrations continue to steadily decline. The Mann-Kendall statistical test indicates a declining trend for TVOC concentrations in these wells. Kendall-Mann is a nonparametric trend analysis (Gilbert, 1987) used to aid in determining the slope in groundwater quality data. It is particularly useful when the residuals from a regression analysis are not normally distributed, or for an unknown distribution. However, model projections indicate that asymptotic conditions are expected within 2003/2004. Shutdown of EW-15 is projected for the end of 2004.

6. 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, which did not detect any carbon tetrachloride, 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:

1) Continue the operation of EW-15. Periodically pulse pump EW-13 and EW-14 due to rebounding of carbon tetrachloride in nearby monitoring wells.

2) The monitoring well network is adequate and no modifications are necessary at this time.

3) Place the groundwater-monitoring program into a shutdown demonstration phase (quarterly monitoring of all wells) in August 2003 to develop a data set in anticipation of a shutdown petition in spring 2004.

3.2.2 Building 96 Air Stripping System

This section summarizes the operational data from the OU III Building 96 source control system of recirculation wells with air stripping treatment for 2002. The system began operation in February 2001. This summary is prepared annually and presents the operational data from January 1 through December 31, 2002. The analytical information from monitoring wells and characterization work is evaluated in detail.

3.2.2.1 System Description

The Building 96 groundwater treatment system consists of four recirculation treatment wells (RTW-1 through RTW-4) housed in individual treatment sheds. Construction details for the treatment system components are contained in as-built drawings available through BNL. The wells used in the system are referred to as recirculation treatment wells since water is withdrawn from, and recharged to, the aquifer in the same well. Contaminated groundwater is drawn from the aquifer, via a submersible well pump, into a lower well screen, which is set near the base of the contaminant plume. The groundwater then is pumped into a stripping tray adjacent to the well, and recharged back to the shallow portion of the plume through the upper screen after treatment.

The Building 96 system removes contaminants, from the groundwater (liquid phase) to the vapor phase via air stripping in a low profile stripping tray adjacent to each wellhead inside the treatment sheds. The vapor phase contaminants are then passed through a moisture-knockout drum in each treatment shed, and piped to Treatment Shed No. 3 where contaminated vapor streams from the four treatment sheds are combined in a common pipe via a manifold. The combined VOC contaminated vapor stream is passed through an electric reheat coil (duct heater) to lower relative humidity, and then through a series of Granular Activated Carbon (GAC) filters to remove VOCs. The clean air is discharged to the atmosphere.

Recirculation Treatment Wells

The primary component of the groundwater treatment system is the four recirculation treatment wells (RTW). RTW-1 is located in the area containing the highest VOC concentrations in the Building 96 area and the other three wells, RTW-2 through RTW-4 (from west to east), provide hydraulic control of the VOC plume. **Figure 3.2.2-1** shows the RTW locations.

Each treatment well is 8-inches in diameter with two separate 10-foot long, 304 stainless steel screens. The wells are constructed with a minimum three-inch filter pack. An inflatable packer separates the two well screens. It is inflated through an air line that runs to the wellhead and is fitted with a pressure gauge. The submersible pump is located below the packer to draw water in from the lower screen.

The groundwater around each treatment well is recirculated using a 1 hp stainless steel submersible pump operating on a 208 volt, 3-phase power supply. Each pump has a rated capacity between 20 and 30 gpm at a total discharge head (TDH) of 80 feet. The flow rate of each water pump can be controlled from the treatment sheds by adjusting the butterfly throttling valves. Each pump and inflatable packer assembly is supported in the well with a stainless steel cable. Discharge piping is 1-1/2 to 2 inches in diameter. **Table 3.2.2-1** shows the depths of the recirculation wells and pump settings. A summary of pumpage rates for 2002 is provided in **Table 2-3**.

Table 3.2.2-1. OU III Building 96 Recirculation Well Construction Data

Well	Well Depth (bls)	Influent Screen Depth (bls)	Effluent Screen Depth (bls)	Pump Intake Setting (bls)
RTW-1	61	48-58	25-35	52
RTW-2	61	48-58	25-35	52
RTW-3	61	48-58	25-35	52
RTW-4	61	48-58	25-35	52

bls = below land surface.

Air Treatment Facility

Several components comprise the air treatment system. Air lines run below grade from each treatment shed to Treatment Shed No. 3 carrying VOC laden air. Each air line joins to a common pipe header, which is connected to a duct heater. After the air passes through the duct heater it flows through two vapor phase GAC filter vessels, piped in series, before it is released.

The airflow to the stripping tray at each well can be controlled by adjusting the blower effluent damper at the individual treatment sheds, or by adjusting the gear operated butterfly valves in Treatment Shed No. 3. The air pipe and valve configuration enables increased airflow to wells exhibiting higher VOC concentrations, which results in higher removal efficiencies. Airflow meters are located on the influent line to each blower, with a fifth airflow meter located on the discharge line from the GAC filter vessels. After the stripping tray, air piping is connected to a knockout drum inside each treatment shed to collect moisture.

Condensate may accumulate in the below grade air lines and condensate pumps are employed to remove standing water. The pumps are installed in the air lines prior to the duct heater and are located in Treatment Shed No. 3. This system removes condensate from the air lines, allowing for unobstructed airflow from Treatment Sheds No. 1, 2, and 4. The pumps are operated by an adjustable timer and can also be triggered manually. Condensate removed from the air lines is pumped into the top of the RTW-3 air stripper tray for treatment and subsequent recharge.

Air leaves the duct heater and travels through two vapor phase GAC filter vessels, piped in series, to remove VOCs from the air stream. Each filter vessel contains 13,600 lbs of GAC. The GAC filters are located outside of Treatment Shed No. 3.

3.2.2.2 Groundwater Monitoring

Well Network: The monitoring network of 17 wells was designed to monitor the PCE plume originating in this source area, and the effectiveness of the groundwater remediation system (**Figure 3.2.2-1**).

Sampling Frequency and Analysis: The wells are sampled quarterly, and samples are analyzed for VOCs (see **Table 1-6**).

3.2.2.3 Monitoring Well Results

Complete VOC results are provided in **Appendix C** (located on the accompanying CD-ROM). VOC concentrations exceeding NYS AWQS during 2002 are summarized in **Table 3.2.2-2**. Additional characterization of the plume, consisting of fifteen temporary, geoprobe boreholes was conducted from August 2002 through March 2003. This activity is discussed in greater detail in Section 3.2.2.3.1.

The fourth quarter 2002 plume is shown on **Figure 3.2.2-2**. The monitoring data was supplemented with geoprobe data to obtain a comprehensive depiction of the plume. VOC trends are summarized in **Figure 3.2.2-3**.

3.2.2.3.1 Geoprobe Investigation

Geoprobe sampling was performed in several phases during 2002 to determine the extent of contamination remaining in the source area and to define the westward extent of the plume. Twelve additional Geoprobe wells were installed as shown on **Figure 3.2.2-2** (Note: 3 additional Geoprobes were installed in March 2003 and are also shown on the map**)**. The Geoprobes were sampled for VOC's, at four-foot intervals from the water table to depths ranging from 80 to 100 feet bls. The data are presented on **Table F-11** in **Appendix F** (located on the enclosed CD-ROM)

High concentrations of VOC's remain within the saturated silty zone (approximately 30-40 feet bls), upgradient of RTW-1 as shown in **Figure 3.2.2-4**. The highest concentration observed was at location 85-313 with 3,718 µg/L TVOCs. Based on the results of geoprobes installed to the west of RTW-1, there appears to be some westward migration of the plume as shown in **Figure 3.2.2-2**. Concentrations to the southwest of RTW-1 ranged up to 849 µg/L TVOCs.

3.2.2.4 Systems Operations

Operating Parameters

The influent, midpoint and effluent air samples from the carbon vessels were sampled monthly and analyzed for volatile organic compounds by EPA method TO-14A. These samples monitor the efficiency of the GAC units and demonstrate when a carbon change-out is required. The air sampling frequency was changed to quarterly beginning in April 2002 based on the consistency of the air sampling results in 2001. Air sampling results are included in **Table F-12** in **Appendix F** (located on the accompanying CD-ROM).

Influent and effluent water samples are collected monthly from each of the four recirculation wells; all samples are analyzed for volatile organic compounds by EPA method 524.2. These samples determine the well's removal efficiency and performance. Based on these results operational adjustments can be made to optimize the system's performance.

System Operations

The following summarizes the system's operations for 2002. BNL performs daily checks on the system and undertakes system sampling. BNL's PE Division carries out routine and non-routine maintenance. Details of these activities are given in the system's operation and maintenance manual. The daily operations and maintenance logs are available in the project files.

January-September 2002:

On January 31, 2002, the flow rate in RTW-1 was increased from approximately 15 gallons per minute (gpm) back to the designed rate of 30 gpm. The flow rate had been reduced on July 13, 2001, as a precaution against potential spreading of the plume until recently collected data could be reviewed. Upon review of this Geoprobe data, it was determined that the RTW-1 flow rate could be returned to the designed flow rate.

October 2002:

Influent and effluent water and air samples from the treatment system were collected on October 1, 2002. The effluent air samples were well below the DAR-1 Air Toxics Assessment limits. Effluent water samples were at or lower than one half the drinking water standard or non-detectable. The average system flow rate for October 2002 was approximately 94 gpm.

November 2002:

Influent and effluent water and air samples from the treatment system were collected on November 1, 2002. The effluent air samples were much lower than the DAR-1 Air Toxics Assessment limits. Effluent water samples were at or lower than one half the drinking water standard or non-detectable. The average system flow rate for November 2002 was approximately 89 gpm.

December 2002:

The system was down from December 5th through the 9th, due to excessive condensate accumulation in the air-lines. Two of the condensate pump impellors were replaced and the system was re-started. Influent and effluent water and air samples from the treatment system were collected on December 2, 2002. The effluent air samples were below the DAR-1 Air Toxics Assessment limits. Effluent water samples were at or lower than one half the drinking water standard or non-detectable. The average flow rate for December 2002 was approximately 79 gpm.

During 2002, approximately 45 million gallons of groundwater were pumped and treated by the Building 96 system.

3.2.2.5 Systems Operational Data

Recirculation Well Influent and Effluent

During 2002, BNL noted a significant overall decrease in TVOC concentrations in the influent of all four wells. **Table F-13** in **Appendix F** (located on the accompanying CD-ROM) lists the influent and effluent TVOC concentrations for each of the four recirculation wells.

Throughout 2002, effluent concentrations in all recirculation wells were, at or below, one half the drinking water standard, or non-detectable.

Cumulative Mass Removal

Mass-balance calculations were made to determine the mass of VOCs removed from the aquifer by the pumping wells, during this period of operation. For each RTW, the gallons of water pumped during each month were used in combination with the influent TVOC concentrations to calculate the pounds removed. The pumpage and mass removal data are summarized in **Table F-14** in **Appendix F**. To date, the system removed approximately 46 pounds of VOCs. **Figure 3.2.2-5** plots the cumulative total pounds of TVOCs removed vs. time.

Air Treatment System

Air samples were collected monthly from the GAC vessels before treatment (influent), between the two vessels (mid-point), and after the second vessel (effluent). The findings are utilized to monitor the efficiency of the GAC units and to determine when a carbon change-out is required (**Table F-12** in **Appendix F**). Airflow rates, measured for each air-stripping unit inside the treatment building, show that they typically range between 250 and 450 cfm for each of the four wells. Assuming a total airflow rate of 1200 cfm, all compounds detected in the carbon effluent during the operating year were much lower than the New York State DAR-1 Air Toxics Assessment limits for the worst-case potential impacts to the public.

Although the concentrations in the GAC air effluent have been well within the DAR-1 Toxics Assessment, the presence in the midpoint and effluent of benzene compounds not present in the influent or the groundwater is a concern. As long as the concentrations remain below the DAR-1 levels the situation only requires monitoring. The system was designed such that the carbon would not have to be changed out during its operational life.

3.2.2.6 System Evaluation

<u>Building 96 Model Assessment</u>

- **Figure 3.2.2-6** is a model predicted cumulative mass removal curve for the Building 96 system by pumping well through the end of 2007 under the existing pumping scheme. This projection suggests that the RTW–2, RTW-3 and RTW-4 will reach a very low and asymptotic contaminant removal rate by the end of 2003. This is consistent with the monitoring well data for that area.

- Monitoring well data in the vicinity of RTW-1 shows little reduction in aquifer contamination concentration. According to the AG&M modeling (1999) (which assumed both a continuing source scenario and no continuing source), the concentration in the RTW-1 area is predicted to be less than 2,000 μg/L TVOC and 1,000 μg/L TVOC, respectively after one year of treatment (**Figure 3.2.2-7**). Under a continuing source assumption, the model predicted that RTW-1 could operate up to 2-3 years before meeting its cleanup objectives. According to **Figure 3.2.1-11**, after 2 years of treatment the measured concentrations in the RTW-1 area are as high as 3,718 μg/L TVOC (in Geoprobe well 85-313) which is screened near the shallow silt layer thought to contain a residual source of some type. This suggests a continuing source upgradient of RTW-1. An evaluation will be performed to assess its significance and to assure it presents no significant risk to the OU III cleanup goal.

- The monitoring data show a "crescent" pattern of contamination in the RTW-1 area with the largest prong of contamination in a southwest direction. This pattern is generally consistent with the AG&M (1999) predictions. However, the 1999 modeling predicted concentrations on the order of 30 μg/L, not the 850 μg/L observed in the southwest prong.

- There is a question that the nearby carbon tetrachloride well EW-15 may capture this contamination in the southwest prong. Modeling performed as part of the 2002 Annual report predicts that EW-15 in the carbon tetrachloride treatment system will not capture the southwest prong of contamination from the RTW-1 area **(Figure 3.2.1-11)**. Even if EW-15 were to continue pumping, it would not capture the contamination. However, it is predicted to pass very close. Continued monitoring will be required. This contamination will not be treated by RTW-2, 3, or 4 but is expected to travel to the OU III Middle Road system where it will be captured in about 2014 (**Figure 3.2.1-12**).

- RTW-1, 2, 3, and 4 should go through a pulsed operation period for the remainder of FY 2003. However, an engineering study on the source term and alternative technologies will be considered. Direct in situ treatment technologies (e.g. in site chemical oxidation, alcohol or cosolvent flushing, surfactant injection, steam injection, molasses) will be evaluated.

The performance of the OU III Building 96 Air Stripping system can be evaluated based on the four major decisions identified for this system after applying the DQO process.

1. Is the BNL Groundwater Contingency Plan triggered?

No. There were no unusual detections of PCE, 1,1,1-TCA or any other contaminants in wells associated with this monitoring network during 2002 that triggered the BNL Groundwater Contingency Plan.

2. Have the source control objectives been met?

While the plan was to remove 50 pounds of VOCs and 46 have been removed to date, relatively high concentrations (much higher than expected) are migrating around the west side of RTW-1. **Figure 3.2.2-8** shows the actual removal of VOC mass over time versus the model predictions. Source remediation, as measured by mass removal, is continuing as predicted. The change in the plume distribution from 2000 to 2002 is shown in **Figure 3.2.2-9**.

Concentrations throughout most of the plume have declined significantly since the pre-design characterization. This is attributable to the operation of the system. The average concentration of TVOCs in plume core wells over time is shown in **Figure 3.2.2-10**. However, according to the Geoprobe data, a portion of the aquifer upgradient of RTW-1, in the silty layer, continues to show elevated VOC concentrations up to 3,718 µg/L. This is a persistent area of contamination that appears to be a continuing source.

3. Have asymptotic conditions been met?

Yes. Based on the Mann-Kendall test (**Figure 3.2.2-10**), asymptotic conditions have been met for the mean TVOCs in core wells (Note: based on the last 18 months of data).

3.2.2.7 Recommendations

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

1) Beginning in May 2003, the Building 96 system has been operating in a “pulse” mode in order to determine if significant TVOC concentrations rebound in the re-circulation and/or monitoring wells once the local hydraulics have stabilized. In this case the term “pulsed” operation, refers to discontinuous operation of the system consisting of; activation for two weeks, then deactivation for 6 weeks, followed by operation for two weeks, and so on. Therefore, the system was deactivated in May 2003, for a period of approximately 6 weeks at the end of which the monitoring wells will be sampled. The system will then be reactivated and influent system samples will immediately be collected to determine if significant TVOC concentrations rebound in the subsurface. The system will remain operational for a two-week period with samples being collected at the end of each week. After the two weeks, the system will again be de-activated for approximately 6 weeks. If significant TVOC concentrations return in the monitoring wells and system influent after system deactivation, the system will be “pulsed” through October 2003. During each subsequent “pulsed” operation of the system, system samples will be collected at start-up and shutdown. The monitoring wells will continue to be sampled quarterly.

2) Four additional monitoring wells will also be installed upgradient and west of the existing system to monitor the TVOC concentrations present in those areas.

3) Monitoring wells will continue to be monitored at a quarterly frequency over the next year as the system nears shutdown.

4) An engineering study on the source term and alternative technologies will be performed. Direct in situ treatment technologies (e.g. in situ chemical oxidation, alcohol or cosolvent flushing, surfactant injection, steam injection, molasses) should be screened for applicability. The study will also consider the risk to obtaining the OU III cleanup goals if this source area is treated no further. An evaluation will be performed to determine whether there is need for continued operation of the system. The results of this evaluation, as well as any further considerations for future system operation, will be provided under a separate cover.

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3.2.3 Middle Road Pump and Treat System

This section summarizes the operational data from the Middle Road groundwater pump and treat system for 2002, and presents conclusions and recommendations for future operation. This system began operating on October 23, 2001. The analytical data from the monitoring wells is also evaluated in detail. In addition, a monthly DMR is submitted to EPA and NYSDEC for treated effluent water from the air-stripping tower.

3.2.3.1 System Description

Recovery Wells

Six groundwater extraction wells, RW-1 through RW-6, hydraulically control the VOC plume (**Figure 3.2.3-1**). Groundwater currently is extracted at an average flow rate of approximately 600 gpm although rates vary during the system's life, based on operational monitoring data. Each well is 8-inches in diameter with a 30 to 40 foot long, 304 stainless-steel screen, and a minimum 3-in. filter pack surrounding it. The slot sizes for each well screen vary from 10 to 20 slot, based on the results of sieve analyses from the pre-design characterization. The wells vary in depth from 130 to 268 feet bls.

VOC concentrations in groundwater along BNL's Middle Path are stratified vertically and horizontally. The six recovery wells are screened at the depths showing the highest VOC concentrations. The pipe and valve configuration enables pumping rates to be increased at wells exhibiting higher VOC concentrations, and recovery wells to be added, if required. The extraction wells are sampled monthly.

Groundwater is extracted by stainless-steel submersible pumps operating on a 480 volt, 3-phase power supply. The pumps have check valves at the discharge. The discharge piping is 3-inch carbon steel pipe up to a pitless adapter, and then 4-inch PVC piping to the well house. **Table 3.2.3-1** shows the depths of the extraction wells and the pump settings.

Table 3.2.3-1. Middle Road Extraction Well Construction Data

Well #, (Site Id)	Screen Interval (Feet bls)	Pump Setting (Feet bls)
RW-1, (113-23)	90-130	110
RW-2, (113-24)	170-200	185
RW-3, (113-25)	228-268	248
RW-4, (113-26)	150-180	165
RW-5, (113-27)	150-180	165
RW-6, (106-66)	188-218	205

Well House

The well house is situated along Middle Path in the center of the southern portion of the site to the west of the wells. Each of the six pump discharge lines is reduced from 4-inch to 3-inch diameter just before it enters the well house. Inside the well house, each pump discharge line contains a gate valve to isolate the line, a propeller-type flow meter, a check valve, and a butterfly valve to control flow. High and low-level pressure switches and a sampling port also are located on each line before the gate valve. After the butterfly valve, the piping manifolds into a 10-inch discharge line that conveys the water to the treatment facility.

Treatment Facility

The groundwater treatment facility consists of a treatment control building and an air- stripping tower, and is located just northwest of Rochester Street and Princeton Avenue. The facility is designed for limited automatic operation, defined as automatic equipment shutdown with manual restart. Any alarm condition will signal a common trouble alarm at BNL's Central Chilled Water Facility requiring a physical inspection of the main control panel to determine the source of the alarm. The treatment building also houses a 150-gallon riser drain tank used to temporarily capture drained water from the tower's influent line if the air-stripping tower is shut down during cold weather. Two re-injection pumps send the drained water back into the stripping tower's influent line when the system is placed back in operation.

Air-Stripping Tower

The packed air-stripping tower removes VOCs from the groundwater to meet the discharge criteria. The stripping tower is 6 feet in diameter and 52 feet tall. It is equipped with a minimum of 39 feet of 2-inch plastic packing, configured in two separate beds. The tower's internals include five influent spray nozzles, water distribution trays for the two media beds, packing support/air distributor for the two media beds, a mist eliminator, screened air exit, and water redistribution rings. The 39-foot height of the packing media is based on the requirements to remove TCA. The efficiency of removing other VOCs of interest is greater than the required minimum, and effluent concentrations are lower than NYSDEC permitted levels. A centrifugal blower supplies air to the tower at an average flow rate of 3,200 scfm, providing an air to water ratio of 34:1 at the maximum water flow rate of 700 gpm.

Recharge Basin

The water discharged from the air-stripping tower flows by gravity through 10-inch diameter PVC piping to either of two recharge basins. A buried house trap in the piping has a 30-inch water seal to prevent air, under pressure in the stripping tower, from discharging through this line. The discharge piping splits to convey the water to either the OU III recharge basin, the HP recharge basin, and/or the RA V recharge basin. A gate valve in the line to each basin controls the flow to the basin.

The OU III basin can receive a continuous flow of greater than 850 gpm; this figure includes a sufficient factor of safety to account for variations in subsurface soil and fouling of the basin over time. The existing HP recharge basin provides backup for the discharge facilities during maintenance of the primary OU III basin.

A discharge pump station distributes the flow of water into both the OU III and RAV recharge basins. The pump station balances the flow between the two basins, therefore managing the flow of groundwater recharge.

3.2.3.2 Groundwater Monitoring

Well Network: The Middle Road Monitoring Program consists of a network of 26 monitoring wells located along the road between the Princeton Avenue fire break road and the OU III South Boundary Pump and Treat System (**Figure 3.2.3-2**). The wells are designated as follows:

- Plume Core – utilized to monitor the high concentration or core area of the plume. In addition, plume core wells will be used to provide data for measuring the performance of the system.

- Plume Perimeter – used to define the extent of the plume both horizontally and vertically.

- Bypass Detection –used to determine whether the plume capture performance objective is met.

Sampling Frequency and Analysis: The 26 Middle Road wells are monitored quarterly and the samples are analyzed for VOCs. Several wells that also are part of the OU III HFBR Tritium Monitoring Program are also monitored for tritium (**Table 1-6**).

3.2.3.3 Monitoring Well Results

The complete VOC results are shown in **Appendix C** (located on the enclosed CD-ROM). VOC results exceeding the NYS AWQS are summarized in **Table 3.2.3-2**.

The highest plume concentrations are found in the vicinity of extraction wells RW-2 and RW-3, based on influent data for these wells and available monitoring well data. TVOC concentrations in monitoring wells east of RW-3 are below 100 µg/L. Results for key monitoring wells are as follows:

- The highest TVOC concentration detected was in bypass detection well 113-17 at 2,948 µg/L. TVOC concentrations have increased in this well during 2002 (**Figure 3.2.3-3**). The VOCs in this bypass well were present prior to the operation of the pump and treat system and is expected to be captured by the OU III South Boundary System.

- Plume core well 105-23 is located approximately 2,000 feet upgradient of RW-1 near Princeton Avenue; concentrations of VOCs have decreased from 1,794 µg/L during 2001 to a low of 420 µg/L in the fourth quarter of 2002 (**Figure 3.2.3-3)**.

- TVOC concentrations in plume core wells further to the east along Princeton Avenue are generally below 100 µg/L in 2002, TVOC concentrations decreased in well 105-44 from 423 µg/L in 2001 to 75 µg/L in the fourth quarter of 2002 (**Figure 3.2.3-3)**.

Figure 3.2.3-4 shows the vertical distribution of contamination running along an east-west line through the extraction wells; the location of this cross section is given in **Figure 3.2-1**. VOC contamination in the western portion of the remediation area (RW-1 through RW-3) extends into the Upper Magothy Aquifer, as does the screen on well RW-3.

3.2.3.4 Systems Operations

The influent and effluent to the air stripper tower are sampled twice a month. Individual extraction wells are sampled monthly. All samples are analyzed for VOCs. In addition, the pH values of the influent and effluent samples are recorded weekly. The effluent sampling parameters for pH and VOCs follow the requirements of 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 samples from the treatment system during this period of operation were below equivalency permit levels (**Table 3.2.3-3**).

Table 3.2.3-3. OUIII Middle Road Air Stripping Tower: SPDES Equivalency Permit Levels January 1, - December 31, 2002

Parameters	Permit Limit (µg/l)*	Max. Observed Value (µg/L)
pH (range)	6.5 - 8.5	6.8 - 7.8
Carbon Tetrachloride	5.0	ND
Chloroform	7.0	ND
1,1-Dichloroethane	5.0	ND
1,2-Dichloroethane	5.0	ND
1,1-Dichloroethylene	5.0	0.33 J
cis-1,2-Dichloroethylene	5.0	ND
trans-1,2-Dichloroethylene	5.0	ND
Tetrachloroethylene	5.0	0.29 J
1,1,1-Trichloroethane	5.0	ND
Trichloroethylene	5.0	ND

*** Maximum effluent allowed by Requirements Equivalent to a SPDES Permit.**
ND - Not detected above the method detection limit of 0.50 µg/L
J - Estimated value, below the method detection limit.

System Operations

The following summarizes the systems operations for 2002. BNL's PE Division, in addition to routine and non-routine maintenance work, made routine maintenance checks daily on this system. Details are provided in the operation and maintenance manual for this system. The historical Operating Parameters Data Sheets are available in the system project files while the current month's data can be found in the treatment system buildings. The following paragraphs summarize the Middle Road system operations for 2002.

January – September 2002:

The OU III South Boundary and Middle Road Systems were placed offline from February 8th–12th, February 14th–15th, March 11th, and March 16th–19th, to allow for electrical connections to the new Western South Boundary Groundwater Remediation System.

On May 29, 2002, the Middle Road System was shut down after a malfunction was detected in the system programming. Re-programming of the system was completed on June 28, 2002, and the system was placed back on-line. Due to the system being off-line for the majority of the month, influent and effluent waters to the treatment system were sampled only once in June and the effluent met all equivalency permit requirements.

Extraction well RW-2 was off-line between June 28th and July 10th due to a faulty pressure switch.

October 2002:

The system pumped and treated approximately 25 million gallons of water in October. The average flow rate for the system was 557 gpm. Influent and effluent waters to the treatment system were sampled twice in October and the effluent met all equivalency permit requirements.

November 2002:

The Middle Road system pumped and treated approximately 26 million gallons of water in November. The average flow rate for the system was 602 gpm. Influent and effluent waters to the treatment system were sampled twice in November and the effluent samples met all equivalency permit requirements.

December 2002:

The system was placed off-line from December 18th to the 23rd, to allow for electrical connections to the new Chemical/Animal Holes Sr-90 Groundwater Treatment System. Approximately 23 million gallons of water were pumped and treated in December. The average flow rate for the system was 517 gpm. The influent and effluent waters to the treatment system were sampled twice in December and the effluent samples met all equivalency permit requirements.

Approximately 281 million gallons of water were pumped and treated in 2002 by the OUIII Middle Road System.

3.2.3.5 Systems Operational Data
System Influent and Effluent

All parameters in the permit equivalency conditions were within the specified ranges during 2002. The effluent data were either below the method detection limit, or below the regulatory limit specified in the permit equivalency conditions.

Figure 3.2.3-5 plots the concentrations of TVOC, TCA, and PCE in the influent to the system's air-stripper tower vs. time. The influent's overall water quality showed a significant and steady decrease in concentrations over the reporting period. The average concentration of TVOCs in the influent during 2002 was 93 µg/l (see **Table F-15, Appendix F**). The system influent also is sampled twice per month for tritium. Tritium was not detected in any sample during 2002. The results from sampling the influent and effluent are summarized in **Tables F-15** and **F-16**, 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. The average flow during 2002 was 572 gpm. (**Table 2-3,** and **Table F-17**). The cumulative total of VOCs removed since the system began start-up testing in October 2001 is approximately 223 pounds. The cumulative total of VOCs removed vs. time is plotted in **Figure 3.2.3-6**.

Air Discharge

Table 3.2.3-4, below, shows the air-emission data from the system for the OU III Middle Road tower over the operational period, and compares the values to levels stipulated in NYSDEC Air Guide 1 regulations. Emission rates are obtained through mass-balance calculations for all water treated during that time. The concentration of each constituent was averaged for 2002, and those values were used in determining the emission rate. All air emissions were below allowable levels.

Table 3.2.3-4. OUIII Middle Road Air Stripper: Air Emission Rates January 1, 2002 - December 31, 2002

Parameter	Allowable*	Actual***
Carbon Tetrachloride	**0.022 lb/hr**	**0.0017 lb/hr**
Chloroform	**0.0031 lb/hr**	**0.0002 lb/hr**
1,1 - Dichloroethane	**10 lb/hr****	**0.0000 lb/hr**
1,2 - Dichloroethane	**0.008 lb/hr**	**0.0000 lb/hr**
1,1 - Dichloroethylene	**0.034 lb/hr**	**0.0003 lb/hr**
cis-1,2-Dichloroethylene	**10 lb/hr****	**0.0002 lb/hr**
Trans-1,2-Dichloroethene	**10 lb/hr****	**0.0000 lb/hr**
Tetrachloroethylene	**0.387 lb/hr**	**0.0135 lb/hr**
1,1,1 - Trichloroethane	**10 lb/hr****	**0.0010 lb/hr**
Trichloroethylene	**0.143 lb/hr**	**0.0004 lb/hr**

*** - Emission Rate Potential (ERP) based upon NYSDEC Air Guide 1 Regulations.**
**** - 6 NYCRR Part 212 restricts emissions of VOCs to a maximum of 10 pounds per hour without controls.**
***** Actual Emission Rate reported as the average rate for January 1 through December 31, 2002.**

Extraction Wells

The six extraction wells are sampled monthly. Decreasing VOC concentrations were observed in all six extraction wells during 2002 (**Table F-18**, **Appendix F**). The highest concentrations have been seen in RW-1 and RW-2. The highest TVOC concentration was 489 µg/L in RW-2 during February 2002. TVOC concentrations in the westernmost three wells (RW-4, RW-5, and RW-6) were low in 2002 with individual VOCs remaining below NYS AWQS in all three wells during the fourth quarter.

3.2.3.6 System Evaluation

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.

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

No. There were no unusual or unexpected VOC concentrations observed in the monitoring wells associated with the OU III Middle Road Pump and Treat System during 2002.

2.Has the plume been controlled?

Yes. TVOC concentrations in plume perimeter wells remained stable at low concentrations during 2002 indicating that the plume is being controlled. High VOC concentrations in bypass wells were present in these wells before the system was operational and are expected given their proximity to the extraction wells. Groundwater elevation data are obtained form many of the OU III Middle Road monitoring program wells, in addition to wells located throughout the BNL on-site and off-site areas on a quarterly basis. Groundwater contour maps are generated using these data (**Figures 2-4** and **2-5**). The capture zone for the OU III Middle Road System is depicted in **Figure 3.0-1**. The capture zone is inclusive of the 50 µg/L isocontour, which is the capture goal of this system.

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

Yes. The system is operating as planned based on the mass removal of VOCs. Monitoring and extraction wells began showing decreasing concentration trends during 2002 and monitoring will continue.

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. Groundwater remediation due to this system is still in the early stages. Mann-Kendall tests were not performed at this time. Monitoring and extraction wells began showing decreasing concentration trends during 2002 and these trends are anticipated to continue.

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

No, see question 4a.

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

Four of the seventeen plume core wells contain TVOCs 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? Specifically, have MCLs been achieved by 2030?

No. MCLs have not been achieved for individual VOCs in plume core wells.

3.2.3.7 Recommendations

- Place wells RW-4 and RW-5 in stand-by mode beginning in October 2003 due to the low concentrations being detected in these wells. Quarterly sampling of these wells will continue and if significant rebound is observed in either the extraction or in adjacent monitoring wells (TVOC greater than 50 µg/L) an evaluation will be conducted on whether pumping should be resumed.

- Eliminate monitoring of wells 106-53, 106-54, and 106-59, as the screen intervals of these wells are redundant with others nearby.

- A baseline of over five years of groundwater data has been obtained from many of the OU III Middle Road Program wells. A routine operation and maintenance monitoring frequency will be implemented in the August 2003. Plume core and perimeter wells will be monitored on a semi-annual frequency (**Figure 3.2.3-2**). Bypass wells will continue to be sampled at a quarterly frequency.

- BNL was granted approval by NYSDEC to change influent/effluent sampling from twice a month to monthly. This modification was implemented in the Spring of 2003.

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 2002, and gives conclusions and recommendations for future operation. This system began operation on June 17, 1997. In addition to this report, a monthly DMR is submitted to the EPA and NYSDEC for treated effluent water from the air-stripping tower.

3.2.4.1 System Description

Recovery Wells

Seven groundwater extraction wells, EW-3 through EW-8 and EW-12, hydraulically control the OU III VOC plume at the southern site boundary (**Figure 3.2.4-1**). EW-12 began operation in December 1999. Groundwater is currently extracted at a total maximum flow rate of about 750 gpm. The actual rates vary during the extraction systems life, based on operational monitoring data. Each well is 8-inches in diameter with a 30 to 40 foot long, 20 slot, 304 stainless-steel screen, and they vary in depth from 190 to 250 feet.

VOC concentrations in groundwater along the site's southern property line are stratified vertically and horizontally. The seven recovery wells are screened at the depths showing the highest VOC concentrations. The pipe and valve configuration will enable pumping rates to be increased at wells exhibiting higher VOC concentrations, and recovery wells to be added, if required in the future. The extraction wells are sampled quarterly.

Groundwater is extracted by stainless-steel submersible pumps operating on a 480 volt, 3-phase power supply. The pumps have check valves at the discharge. The discharge piping is 3-inch carbon steel pipe up to a pitless adapter, and then 4-inch PVC piping to the well house. The depths of the extraction wells, and pump settings, are shown in **Table 3.2.4-1**.

Table 3.2.4-1 OU III South Boundary System Extraction Well Construction Data

Well #, (Site ID)	Screen Interval (Feet below grade)	Pump Setting (Feet below grade)
EW-3, (121-17)	150-190	170
EW-4, (121-16)	160-180 and 190-200	190
EW-5, (121-15)	160-200	180*
EW-6, (122-14)	160-200	180
EW-7, (122-13)	170-210	190
EW-8, (122-12)	190-210 and 230-250	220
EW-12, (122-30)	180-220	200

* = Pump intake was lowered from 180 to 190 feet below grade on January 17, 2003

Well House

The well house is situated along the southern site boundary to the west of the wells. Each of the seven pump discharge lines is reduced from 4-inch to 3-inch diameter just before it enters the well house. Inside the well house, each pump discharge line contains a gate valve to isolate the line, a propeller-type flow meter, a swing-type check valve, and a butterfly valve to control flow. High and low-level pressure switches and a sampling port also are located on each line before the gate valve. After the butterfly valve, the piping manifolds into a 10-inch discharge line that conveys the water to the treatment facility.

Treatment Facility

The groundwater treatment facility consists of a treatment control building and an air- stripping tower system, and is located just northwest of Rochester Street and Princeton Avenue. The facility is designed for limited automatic operation, defined as automatic equipment shutdown with manual restart. Any alarm condition will signal a common trouble alarm at BNL's Central Chilled Water Facility requiring physical inspection of the main control panel to determine the source of the alarm. The treatment building also houses a 110-gallon riser drain tank used to temporarily capture drained water from the tower's influent line if the air-stripping tower is shut down during cold weather. Two re-injection pumps send the drained water back into the stripping tower's influent line when the system is placed back in operation.

Air-Stripping Tower

The packed air-stripping tower removes VOCs from the groundwater to meet the discharge criteria. The stripping tower is 6 feet in diameter and 52 feet tall, and equipped with a minimum of 39 feet of 2-inch plastic packing, configured in two separate beds. The tower's internals include five influent spray nozzles, water distribution trays for the two media beds, packing support/air distributor for the two media beds, a mist eliminator, screened air exit, and water redistribution rings. The 39-foot height of the packing media is based on the requirements to remove TCA. The efficiency of removing other VOCs of interest are greater than the required minimum, and effluent concentrations will be lower than NYSDEC permitted levels. A centrifugal blower supplies air to the tower at a normal flow rate of 3,100 cfm, providing an air to water ratio of 27:1 at the maximum water flow rate of 850 gpm, and 31:1 at the more typical rate of 750 gpm.

Recharge Basin

The water discharged from the air-stripping tower flows by gravity through 10-inch diameter PVC piping to either of two recharge basins. A buried house trap in the piping has a 30-inch water seal to prevent air, under pressure in the stripping tower, from discharging through this line. The discharge piping splits to convey the water to either the OU III recharge basin, the nearby HP recharge basin, and/or the RAV Basin. A gate valve in the line to each basin controls the flow to the basin.

The OU III basin is sized to receive a continuous flow of more than 850 gpm; this value includes a sufficient factor of safety to account for variations in subsurface soil and fouling of the basin over time. The existing HP recharge basin provides backup discharge facilities during maintenance of the primary OU III basin.

3.2.4.2 Groundwater Monitoring

<u>Well Network</u>: The monitoring well network consists of 38 wells and was designed to monitor the VOC plume(s) in this area of the southern site boundary, as well as the efficacy of the groundwater remediation system (**Figure 3.2.4-2**).

<u>Sampling Frequency and Analysis</u>: The South Boundary wells are sampled and analyzed for VOCs at frequencies detailed in **Table 1-6**.

3.2.4.3 Monitoring Well Results

Appendix C has the complete groundwater monitoring results for 2002 (located on the enclosed CD-ROM). **Table 3.2.4-2** summarizes VOC results exceeding the NYS AWQS.

The south boundary segment of the OU III VOC plume continued to be bounded by the existing monitoring well network. VOC concentrations in the plume perimeter wells were less than 5 µg/L (**Figure 3.2.4-3**). VOCs were detected in the deep Upper Glacial aquifer in the vicinity of the site boundary as depicted in **Figures 3.2-2 and 3.2.4-4**.

The plume core wells continued to show the same trend of decreasing VOC concentrations that was observed following the start-up of the pump and treat system in 1997 with several exceptions. Instances in which TVOC concentration increases were observed are most likely due to slugs of contamination migrating to the site boundary area. The bulk of the VOC contamination in this area is currently located between EW-3 and EW-6 as can be seen in **Figure 3.2.4-4** which is a cross-section drawn along the south boundary and incorporating the extraction wells. The VOC concentration trends for specific key plume core wells are shown in **Figure 3.2.3-3**.

- Plume core well 114-07 is located just upgradient of EW-12. The original purpose of this well was to monitor VOC concentrations on the eastern plume perimeter, outside the capture zone of EW-8. Increasing VOCs in this well during 1998 prompted the addition of EW-12, which began pumping in December 1999. TVOC concentrations have continued to decrease, with 3 µg/L detected in the fourth quarter 2002. There were no VOCs exceeding NYS AWQS in 2002.

- Plume core well 122-22 is located just east of EW-8. A sharp drop in TVOC concentrations was observed during 1997 and 1998 from its pre start-up concentration of 1,617 µg/L. VOC concentrations have remained very low with one VOC exceedance of NYS AWQS (1,2 DCA) in 2001.

- Plume core well 122-19 is located directly downgradient of EW-8. TVOC concentrations that were as high as 367 µg/L in 1997 decreased to non-detectable levels by 2002.

- Plume core well 122-04 is between EW-7 and EW-8 and slightly upgradient. TVOC concentrations in this well displayed a dramatic decrease from 1998 to early 2000 during which they dropped to below 5 µg/L for seven consecutive quarters. The increasing trend begun in 2000 continued during 2001 with concentrations rising above 200 µg/L, in response to a slug of higher VOC concentrations reaching the site boundary. Concentrations decreased again in 2002 with TVOCs remaining below 30 µg/L.

- Plume core well 121-23 is immediately downgradient from EW-5. TVOC concentrations have fluctuated somewhat since 1998. The TVOC concentration spiked to 859 µg/L during the fourth quarter of 2002. Once again, the spikes in TVOC concentrations are the result of either higher concentration slugs of VOCs arriving at the site boundary or contamination being pulled back from the downgradient capture zone.

- Plume core well 121-13 is located 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. Concentrations stabilized between 30 µg/L and 50 µg/L during the last three quarters of 2001 and declined even further in 2002. Well 121-14 (which is located in the same cluster but screened deeper) showed a TVOC concentration spike up to 1471 µg/L during the fourth quarter of 2002. PCE is the primary compound in wells 121-13, 121-23, EW-4, and EW-5. This contamination is being captured by the treatment system.

- Plume core well 121-10 is situated upgradient of EW-3. TVOC concentrations decreased dramatically in 1998 from a high of 1,458 µg/L and have remained between 1 µg/L and 10 µg/L since the third quarter of 1999. No VOCs were reported above NYS AWQS in 2002.

- By-pass detection well 122-35, located south of EW-8, continued to show little to no detectable levels of VOCs. TVOC concentrations in well 122-34, clustered with 122-35, did not contain any VOCs above NYS AWQS in 2002.

3.2.4.4 Systems Operations

The system influent and effluent to the air stripper tower are sampled twice a month. The individual extraction wells are sampled on a quarterly basis. All samples are analyzed for VOCs. In addition, the influent and effluent samples are analyzed for pH values on a weekly basis. The effluent sampling parameters of pH and VOCs are done in accordance with SPDES equivalency permit requirements (**Table 3.2.4-3**). In addition, samples are analyzed for tritium with each system sampling event. In all samples, tritium continues to remain below detection limits. All effluent samples from the treatment system during this period of operation were below equivalency permit levels.

Table 3.2.4-3. SPDES Equivalency Permit Levels January 1 - December 31, 2002
OUIII South Boundary Air Stripping Tower

Parameters	Permit Limit (µg/L)*	Max. Observed Value (µg/L)
pH (range)	6.5 - 8.5	6.6 – 54x7.8
Carbon Tetrachloride	5.0	ND
Chloroform	7.0	ND
1,1-Dichloroethane	5.0	ND
1,2-Dichloroethane	5.0	0.71
1,1-Dichloroethylene	5.0	0.25 J
cis-1,2-Dichloroethylene	5.0	ND
trans-1,2-Dichloroethylene	5.0	ND
Tetrachloroethylene	5.0	ND
1,1,1-Trichloroethane	5.0	ND
Trichloroethylene	5.0	ND
1,2-Xylene	5.0	ND
Sum of 1,3 & 1,4 Xylenes	10.0	ND

***Maximum effluent allowed by Requirements Equivalent to a SPDES Permit.**
J = Estimated value below the method detection limit.
ND = Not detected above method detection limit of 0.50 µg/L.

System Operations

The following summarizes the systems operations for each month of 2002. BNL's PE Division, in addition to system sampling and routine and non-routine maintenance work, made routine maintenance checks daily on this system. Details are given in the operation and maintenance manual for this system. The daily operations and maintenance inspection logs are available in the project files and the treatment system buildings.

January – September 2002:

The South Boundary and Middle Road Systems were placed off-line from February 8–12, February 14th–15, March 11, and March 16–19, to allow for electrical connections to the new Western South Boundary Groundwater Remediation System.

Extraction well EW-8 was out of service from April 19 through May 28 due to pump motor failure. During the repair of EW-8, the pump was upgraded with a model capable of producing an increased flow rate of 110 gpm.

The OU III South Boundary system pumped and treated approximately 261 million gallons during the first three quarters of 2002 and all system effluent samples met equivalency permit requirements.

October 2002:

The quarterly extraction well sampling was performed on October 1, however, due to an intermittent outage, EW-5 was sampled on October 15th. On October 22, a faulty flow meter was replaced at well EW-4.

The South Boundary System pumped and treated approximately 29 million gallons of water in October. The average flow rate for the system was 653 gpm. Influent and effluent waters to the treatment system were sampled twice in October and the effluent met all equivalency permit requirements.

November 2002:

The South Boundary system pumped and treated approximately 29 million gallons of water in November. The average flow rate for the system was 675 gpm. Influent and effluent waters to the treatment system were sampled twice in November. All effluent samples met equivalency permit levels.

December 2002:

The system was placed off-line from December 18 to the 23, to allow for electrical connections to the new Strontium-90 Groundwater Pilot Treatment System. Extraction well EW-6 was found off-line on December 18 and remained off during December due to a faulty pump. The well was repaired the week of January 6, 2003.

Approximately 25 million gallons of water were pumped and treated in December. The average flow rate for the system was 551 gpm. The influent and effluent waters to the treatment system were sampled twice in December. All effluent samples met equivalency permit requirements.

Approximately 344 million gallons of water were pumped and treated in 2002 by the OU III South Boundary System.

3.2.4.5 Systems Operational Data

System Influent and Effluent

All parameters in the permit equivalency conditions were within the specified ranges during 2002. The effluent data were either below the method's detection limit, or below the regulatory limit specified in the permit equivalency conditions.

Figure 3.2.4-5 plots the concentrations of TVOC, TCA and PCE in the influent to the systems air-stripper tower vs. time. The overall influent water quality and the individual extraction wells show a general leveling off of concentrations. The average concentration of TVOCs in the influent for this operational period was 78.37 µg/l, a slight decrease compared to 101.44 µg/l for the same period last year. The system is sampled twice per month for tritium; it was not detected in any sample during 2002. System influent and effluent sampling results are summarized in **Tables F-19** and **F-20**, 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. Flow averaged 655 gpm from January 1, 2002 through December 31, 2002 (see **Tables 2-3** and **Table F-21**). The cumulative total of TVOCs removed by the treatment system vs. time is plotted in **Figure 3.2.4-6**. The cumulative total was approximately 219 pounds during this period of operation; altogether, the system removed approximately 1,927 pounds since it was started on June 17, 1997.

Air Discharge

Table 3.2.4-4, below, shows the air-emission data from the OU III South Boundary Tower for the operational period, and compares the values to levels stipulated in NYSDEC Air Guide 1 regulations. Emission rates are obtained through mass-balance calculations for all water treated during that time (**Table F-22**). The concentration of each constituent was averaged for the period, and that value was used in the calculation. All air emissions were below allowable levels.

Table 3.2.4-4. OUIII South Boundary Air Stripping Tower: Air Emission Rates January 1, 2002 - December 31, 2002

PARAMETERS	ALLOWABLE ERP*	ACTUAL***
Carbon Tetrachloride	**.022 lb/hr**	**.0024 lb/hr**
Chloroform	**.0031 lb/hr**	**.0005 lb/hr**
1,1 - Dichloroethane	**10 lb/hr****	**.0001 lb/hr**
1,2 - Dichloroethane	**.008 lb/hr**	**.0005 lb/hr**
1,1 - Dichloroethylene	**.034 lb/hr**	**.0014 lb/hr**
cis-1,2-Dichloroethylene	**10 lb/hr****	**.0002 lb/hr**
Trans-1,2-Dichloroethylene	**10 lb/hr****	**.0000 lb/hr**
Tetrachloroethylene	**.387 lb/hr**	**.0155 lb/hr**
1,1,1 - Trichloroethane	**10 lb/hr****	**.0043 lb/hr**
Trichloroethylene	**.143 lb/hr**	**.0006 lb/hr**

Actual Emission Rate reported as the average rate for the period of operation.
*** -** Emission Rate Potential (ERP) based upon NYSDEC Air Guide 1 Regulations.
** - 6 NYCRR Part 212 restricts emissions of VOCs to a maximum of 10 pounds per hour without controls
*** Actual Emission Rate reported as the average rate for January 1 through December 31, 2002.

Extraction Wells

In general, the extraction wells continued to show slowly decreasing VOC concentrations during 2002. This trend has continued since 1999 (**Figure 3.2.4-7**). The exception is EW-4, which displayed increasing VOC concentrations from 1999 into 2000 followed by a gradual decline. There was a slight increase in VOCs in this well in the second quarter of 2002. PCE is the primary contaminant in this well. **Table F-23, Appendix F** summarizes the data for the extraction wells.

3.2.4.6 System Evaluation

The pump and treat system continued to establish hydraulic control of contaminants originating from source areas in the central portion of the BNL site and continues to prevent further migration across the southern site boundary. Plume core and by-pass wells continued to show stable or decreasing VOC concentrations. The system operated at an average of 651 gpm during 2002 with all seven-extraction wells operational. There was some minor downtime due to electrical problems and the start-up of the OU III Western South Boundary system. No permit equivalencies were exceeded and no operating difficulties were experienced beyond normal maintenance. There have been no air emission exceedances.

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

1. Was the BNL Contingency Plan Triggered?

No. There were no unusual or unexpected VOC concentrations observed in the monitoring wells associated with the OU III South Boundary Pump and Treat System during 2002.

2. Has the plume been controlled?

Yes. Because the cleanup goals have not been met it must be verified that the plume is not growing. An analysis of the plume perimeter and bypass wells reveals that there have been no significant VOC concentration increases in these wells during 2002. In addition, groundwater level measurements indicate the presence of a cone of depression consistent with estimates prepared during the design. Therefore, we conclude that there has been no plume growth and the plume continues to be controlled.

Groundwater elevation data are obtained quarterly from many of the OU III South Boundary Monitoring program wells, in addition to wells located throughout the BNL on-site and off-site areas on a quarterly basis. Groundwater contour maps are generated using these data (**Figures 2-4** and **2-5**). The capture zone for the OU III South Boundary Pump and Treat System is depicted in **Figure 3.0-1**. The capture zone depicted is inclusive of the 50 µg/L isocontour, which is the capture goal of this system.

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

Yes. The OU III South Boundary System continues to be effective in removing VOCs from the deep Upper Glacial aquifer. Actual mass removal is within 250 pounds or 13% of what was predicted using the groundwater model (**Figure 3.2.4-9**). **Figure 3.0-3** compares the OU III plumes as modeled during the FS with the fourth quarter 2002 plume data. The plume data compares favorably with the modeled plume particularly with respect to some of the high concentration segments in the vicinity of the OU III southern site property boundary. If anything, the FS model predictions seem to be conservative. **Figure 3.2-4** compares the OU III plume from 1997 to 2002. The overall reduction in the high concentration areas of the plume near the south boundary is evident.

The OU III South Boundary system is planned to operate for 10 to 15 years; at the end of 2002, it had operated for approximately 5.5 years. Therefore, it is not expected to be approaching its cleanup goals. The system is removing contamination at the expected rate and hydraulic control of the plume was demonstrated; hence, it is operating as planned. However, the duration of operation could be closer to 15 years rather than 10 years. The duration of operation for the OU III South Boundary system is dependent upon the partition coefficient of the contamination, the rate of desorption (i.e., linear or non-linear) and the start-up and effectiveness of the Middle Road Groundwater Treatment System. The Middle Road system started operation approximately 4.5 years after the OU III South Boundary system. The contaminant travel time from Middle Road to the OU III South Boundary system is about 5-10 years. Therefore, the high concentrations observed in the vicinity of well 113-17 will likely determine the remaining 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 a declining one; however, there is significant variability in the mean from quarter to quarter. This is not indicative of poor performance, but rather, the capture of pulses or slugs of higher concentration contamination. The target contamination in this area is the result of periodic historical releases and not continuous sources of contamination. As a result, the nature of the plume is rather discontinuous and exists as a series of contamination pulses or slugs. This is the likely explanation of the significant variability in the mean from quarter to quarter. This variability makes it difficult to estimate the mass of contamination in the aquifer requiring treatment and the duration that treatment will be required.

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 showed a marked increase at the end of 2002 (**Figure 3.2.4-8).**

4b. Is the mean TVOC concentration in core wells less than 50 ug/L by 2025?

No. The mean plume core well TVOC concentration was approximately 200 µg/L in the fourth quarter of 2002. This was primarily due to a high concentration slug reaching the eastern portion of the OU III south boundary area.

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 by 2030?

No. MCLs have not been achieved for individual VOCs in plume core wells.

3.2.4.7 Recommendations

- A baseline of over five years of groundwater data has been obtained from many of the OU III South Boundary Program wells. A routine operations and maintenance monitoring frequency will be implemented in the fourth quarter of 2003. Plume core and perimeter wells will be monitored on a semi-annual frequency. Bypass wells will continue to be sampled at a quarterly frequency. This reduction in sampling frequency for plume core and perimeter wells was already implemented for many of the OU III South Boundary Program wells in 2001. In some cases shallow wells have been reduced to an annual sampling frequency. This frequency will be maintained during the O&M phase.

- Extraction well EW-12, which was installed in 1999 to address a slug of contamination that was to the east of the original capture zone of the South Boundary system, has now achieved VOC concentrations below NYS AWQS. This well will be placed in standby mode beginning October 2003. The well will be restarted should monitoring well data indicate that VOC concentrations are showing significant rebound.

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3.2.5 Western South Boundary Pump and Treat System

The Western South Boundary pump and treat system was designed to capture the VOCs in the Upper Glacial aquifer along the western portion of the BNL south property boundary. This system will capture the highest VOCs observed at the western south boundary and remediate 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

Two groundwater extraction wells, WSB-1 and WSB-2, provide hydraulic control of the VOC plume. Groundwater is extracted at a total maximum flow rate of 300 gallons per minute (gpm). The actual rates vary according to operational monitoring data. **Table 3.2.5-1** shows the depths of the extraction wells and pump settings.

Table 3.2.5-1. Extraction Well Construction Data

Well	Screen Interval (Feet below grade)	Pump Setting (Feet Below Grade)
(WSB-1, 126-12)	140-160	105
(WSB-2, 127-05)	150-170	95

Each wellhead is composed of a pitless adapter at the ground surface which is then piped to an enclosed reinforced concrete vault with the top slab one foot above grade. These vaults house the flow meters, pressure gauges, and electrical disconnects for the wells. The wells and vaults are located along the southern boundary of the site. Piping within the vaults is schedule 40 PVC, transitioning to Blue Brute PVC Class water pipe before exiting through the vault's wall. The pipes are 4-inch diameter, and join a 6-inch diameter pipe, at the start of the common force-main to the treatment facility.

The groundwater treatment facility consists of a treatment control building and an air-stripping tower located at the west end of Middle Path. The treatment facility is designed for limited manual operation, defined as automatic equipment shutdown with manual restart and automatic restart in the event of low power supply. Any alarm condition will signal an alarm at the Treatment Building and a common trouble alarm light on the building.

The stripping tower is 4 feet 6 inches in diameter and 33 feet tall, and is equipped with a minimum of 25 feet of 2-inch plastic packing. One centrifugal blower supplies air to the tower at a normal flow rate of 2,005 cfm, providing an air/water ratio of 50:1 at the maximum water flow rate of 300 gpm.

The water discharged from the air-stripping tower flows by gravity to the adjacent recharge basin to the west. The basin can receive a continuous flow of 300 gpm. However, scaling and silt in this area was heavier than expected and the basin requires periodic scraping throughout the year.

3.2.5.2 Groundwater Monitoring

Well Network: A network of seventeen wells is used to monitor this portion of the OU III plume. Their locations are shown in **Figure 3.2.5-1**.

Sampling Frequency and Analysis: The wells are sampled quarterly and analyzed for VOCs. Details are provided in **Table 1-6**.

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. Maximum TVOC concentrations during 2002 were in well 127-06 at 53 µg/L during the second quarter. VOC results exceeding NYS AWQS are summarized in **Table 3.2.5-2**. Fourth quarter well data is posted on **Figure 3.2-1**. The complete results are in **Appendix C** (located on the enclosed CD-ROM).

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. Groundwater monitoring for this system was initiated in 2002. There has not been a sufficient period of time to develop long term contaminant concentration trends.

3.2.5.4 Systems Operations

The extraction wells are currently sampled monthly. The influent and effluent of the air-stripper tower are sampled twice per month. All samples are analyzed for VOCs. In addition, the effluent sample is analyzed for pH monthly along with tritium. **Table 3.2.5-3** provides the effluent limitations for meeting the requirements of the SPDES equivalency permit.

Table 3.2.5-3. SPDES Parameter Effluent Concentrations for 2002

Parameter	Threshold Value* (µg/L)	Maximum Measured Value (µg/L)
pH	6.5-8.5	NS
Carbon Tetrachloride	5	<MDL**
Chloroform	7	<MDL
Dichlorodifluoromethane	5	<MDL
1,1-Dichloroethane	5	<MDL
1,1-Dichloroethylene	5	<MDL
Methyl Chloride	5	<MDL
Tetrachloroethylene	5	<MDL
Toluene	5	<MDL
1,1,1 Trichloroethane	5	<MDL
1,1,2 Tricholorethane	5	<MDL
Trichloroethylene	10	<MDL

* Maximum effluent concentration (µg/L) allowed – Equivalent to a SPDES Permit.
** Minimum Detection Limit (MDL) = 0.5 µg/L
NS Not Sampled

The following is a month-by-month summary of the system operations for 2002. BNL's Contractor performed routine maintenance checks on this system daily as part of the startup operation for the system.

Starting in early 2003 the daily system inspections will be performed by BNL's (PE) Water Treatment Shop and all system sampling will be conducted by EWMSD. Full details are recorded in the system's operation and maintenance log. The daily operations and maintenance inspection logs are available in the project files and the treatment facility.

January-September 2002:

From January to May the treatment system was under construction. Starting on May 12, 2002 the Western South Boundary System was started for the first time. During the startup phase of the system minor problems were corrected, such as faulty airflow gages, high water level sensors, and PLC programming glitches. For additional information please refer to the Western South Boundary Startup Report (BNL, 2002).

A total of 30,000,000 gallons of water was pumped and treated during the first three quarters of 2002.

October 2002:

The system operated normally, with no interruption. A total of 11,789,000 gallons were pumped and treated. The extraction wells and the air-stripper influent and effluent were sampled. All effluent discharges met the equivalency permit requirements.

November 2002:

The system operated normally, with only one minor interruption, on Nov. 11, 2002 due to a low blower pressure and low airflow. A faulty gauge was determined to be the problem. A total of 8,714,000 gallons were pumped and treated. The extraction wells, influent, and effluent were sampled in November 2002. All effluent samples met the equivalency permit's requirements.

December 2002:

The system experienced some problems during the month of December. On Dec. 12, 2002 the system was shut off to replace the blower pressure gauge and then restarted. On Dec. 16, 2002 the WSB-2 well shutdown due to a burned out fuse holder used for communications between the treatment building and the well. While the part was on order the system ran uninterrupted for the remainder of the month without WSB-2 on. A total of 7,588,000 gallons were pumped and treated. The air-stripper influent and effluent, and WSB-1 were sampled in December 2002. All effluent samples met equivalency permit requirements.

3.2.5.5 Systems Operational Data

Extraction Wells

During 2002, 74,287,000 gallons were pumped and treated by the OU III Western South Boundary system, with an average flow rate of 281 gpm. **Table 2-3** gives monthly pumping data for the two extraction wells. VOC concentrations for WSB-1 (126-12) and WSB-2 (127-05) are provided in **Table F-24** in **Appendix F** (located on the enclosed CD-ROM). TVOC levels in both wells demonstrated a decreasing trend with time during the first year of operation (**Figure 3.2.5-2)**.

System Influent and Effluent

TCA, DCE, chloroethane, chloroform, freon, and TCE influent concentrations to the air stripper tower versus time are illustrated in **Figure 3.2.5-3**. The concentrations of TCA and DCA steadily decreased over the first year of operation.

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 permit equivalency conditions.

Cumulative Mass Removal

The mass of TVOCs removed from the aquifer by the OU III Western South Boundary treatment system was calculated. Average flow rates for each monthly monitoring period were used, in combination with the TVOC concentration in the air-stripper's influent to calculate the pounds per month removed. The cumulative mass of TVOCs removed by the treatment system vs. time was then plotted (**Figure 3.2.5-4**). It shows that approximately 10 pounds of TVOCs were removed during 2002.

Air Discharge

Table 3.2.5-4 below presents the VOC air emission data for the year 2002 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 period. That value was converted from µg/L to pounds per gallon (lb/gal), which was multiplied by the average pumping rate (gallons per hour (gal/hr)) to compare with the regulatory value. All VOC air emissions were well below allowable levels.

Table 3.2.5-4. OU III South Boundary System Air Stripper VOC Air Emissions Data for 2002*

Parameter	Allowable ERP**	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
Carbon Tetrachloride	0.016	--	<0.0002	<0.0002	<0.0002
Chloroform	0.0086	--	0.00021	0.00016	0.00035
1,1 - Dichloroethane	10***	--	0.00008	0.00004	0.00008
1,2 - Dichloroethane	0.011	--	<0.0002	<0.0002	<0.0002
1,1 - Dichloroethene	0.194	--	0.00026	0.00015	0.00026
Chloroethane	10***	--	<0.0002	<0.0002	<0.0002
1,1,1 - Trichloroethane	10***	--	0.00042	0.00026	0.00045
Trichloroethene	0.119	--	0.00028	0.00015	0.00025

* Actual Emission Rate reported as the average rate (lb/hr) for each quarter.
** Emission Rate Potential (ERP) based on NYSDEC Air Guide 1 Regulations.
***6 NYCRR Part 212 restricts emissions of VOCs to a maximum of 10 pounds per hour without controls.
-- System not operating.

3.2.5.6 System Evaluation

The system has only been fully operational since September 2002. Based on groundwater elevation measurements and mapping it appears that hydraulic control of the plume has been achieved in this area (**Figure 3.0-1**). The BNL Groundwater Contingency Plan was not triggered during 2002 due to any unexpected monitoring well results. The decision rules developed, as part of the groundwater DQO process will be used to evaluate the system with continued operation time.

3.2.5.7 Recommendations

- Groundwater monitoring will continue in start-up phase mode (quarterly sampling) until May 2004.

- Complete the connection of wireless alarm communications to central on-site location.

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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 2002, and presents conclusions and recommendations for its future operation. The system began operation on September 27, 1999. This summary is prepared annually and presents the operational data from January 1 through December 31, 2002.

The OU III Industrial Park RA system was designed to contain and remediate the portion of OU III plume existing between BNL's southern boundary and the southern boundary of the Parr Industrial Park. **Figure 3.2-1** illustrates the extent of the OU III contaminant plume in the vicinity of the Industrial Park.

3.2.6.1 System Description

The OU III Industrial Park system consists of a line of seven in-well air stripping treatment wells. Each treatment well is constructed with two well screens separated by an inflatable packer. Contaminated groundwater is withdrawn from the aquifer via submersible pump through a lower screen (extraction screen) set at the base of the treatment well. The groundwater is pumped to a stripping tray located in a below ground 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 re-circulates 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 units in series to remove the VOCs. Treated air is then re-circulated back to the wellhead. The carbon units, system blower, and the system control panel are all housed in a one story, masonry treatment building.

The system treatment wells are referred to as "UVB" wells, which is a German abbreviation for vacuum extraction well. Groundwater is treated below grade within a well vault and returned to a contaminated segment of the aquifer (via the same well from which it is withdrawn). Therefore, a NYSDEC SPDES permit equivalent is not required. The simultaneous withdrawal and recharge of groundwater from a single well causes a flow cell to form near the treatment well. This localized change in the aquifer flow field takes the shape of a three-dimensional recirculation cell that is the mechanism by which hydraulic control is achieved.

The seven groundwater treatment wells are designated from west to east as UVB-1 through UVB-7 (**Figure 3.2.6-1**). Collectively, they hydraulically control and treat the off-site portion of the OU III VOC plume between the BNL southern boundary and the Parr Industrial Park. Each of the seven treatment wells are constructed with eight (8) inch diameter steel casing and two (2), 20 foot long, stainless steel screens separated by an inflatable packer. One, three (3) horsepower submersible well pump is installed below the packer in each well to draw water into the well through the lower screen.

Well casing, about 25 feet to 35 feet in length, separates the screen zones in each well. The well screens are strategically placed to intercept and contain the full vertical extent of the contaminant plume.

Therefore, screen zone depths differ from well to well based upon the plume configuration at each location. **Table 3.2.6-1** summarizes construction information for the recirculation wells.

Table 3.2.6-1. OU III Industrial Park System UVB Well Construction Data

Well	Well Depth (ft bls)	Grade at Well (ft msl)	Screen Depths Top / Bottom (ft bls)	Pump Intake Setting (ft bls)
UVB-1	243	83.0	165-185 / 220-240	229
UVB-2	218	79.5	140-160 / 195-215	204
UVB-3	220	74.0	142-162 / 197-217	179
UVB-4	193	72.0	125-145 / 170-190	184
UVB-5	203	71.0	125-145 / 180-200	179
UVB-6	215	82.0	140-160 / 192-212	214
UVB-7	228	82.0	150-170 / 205-225	219

ft bls = feet below grade.
ft msl = feet above mean sea level

The sizing of the groundwater treatment system was based upon a nominal hydraulic capacity of 60 gpm for each stripping tray with the capacity to operate at a maximum of 80 gpm. To permit independent flow rate control, variable frequency drives were used for the well pumps. Flow rates for each individual well can be controlled from a PLC located in the treatment and control building.

Air Treatment Facility

The air treatment system is a closed loop system that provides airflow to the UVB wells for the stripping process. The air treatment equipment, which consists of a blower, a dehumidification unit, a duct heater and two 13,600 pound GAC units, are housed in the treatment and control building. Individual air suction and return lines run underground from the building to each UVB well. A single blower provides the airflow for all seven wells. Like the submersible well pumps, the system blower has a variable frequency drive motor that is controlled from the PLC to regulate the output of the blower. The airflow to individual UVB wells can be controlled by adjusting the blast gates on the influent and effluent manifolds within the building, and by adjusting gear operated butterfly valves in the valve vault adjacent to each UVB well.

Contaminated air from the UVB wells is combined in a common header and passed through the dehumidification system and duct heater to remove moisture. Compressors, located on an exterior slab adjacent to the west wall of the building, circulate a chilled water-glycol solution through two banks of coils. As the contaminated air stream passes over the cold coils, moisture condenses out and collects in a drip pan. The drip pan drains via gravity to a sump where a sump pump transfers this condensate to the UVB-4 air-stripping tray for treatment.

Two (2) GAC filter vessels (piped in series) are utilized to remove VOCs from the air stream. After the air leaves the GAC filter units, it is re-circulated to the UVB wells and again used in the air stripping process. A clean air relief port allows removal of clean air from the air-piping loop if necessary.

3.2.6.2 Groundwater Monitoring

Well Network: The monitoring well network consists of 39 wells and is designed to monitor the VOC plume(s) 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 plume(s). The wells are located throughout the industrial park, and on Carleton Drive as shown in **Figure 3.2.6-2**. The wells were installed as single, doublets and triplets and are constructed of both two and four inch diameter PVC. Screen depths vary to capture contaminant concentrations at multiple levels, and to obtain water quality data above the treatment well effluent depth, at the effluent depth, and at the treatment well influent depth.

Sampling Frequency and Analysis: The wells were sampled quarterly, and the samples were analyzed for VOCs (**Table 1-6**).

3.2.6.3 Monitoring Well Results

The complete results are included in **Appendix C** (located on the enclosed CD-ROM). **Table 3.2.6-2** summarizes VOC detections exceeding the NYS AWQS.

VOC concentrations in the plume perimeter wells monitoring the width of the plume (000-245 and 000-272) continued to remain below NYS AWQS during 2002. Based on this data the plume is effectively bounded by the current well network. **Figure 3.2.4-3** shows the plume distribution based on fourth quarter 2002 data. The vertical extent of contamination is shown in **Figure 3.2.6-3**. The location of this cross section is illustrated in **Figure 3.2-1**.

The highest TVOC concentrations in the Industrial Park area observed were between remediation wells UVB-1 and UVB-3 in 2001. Increased concentrations were noted in several wells in the central and eastern portions of the system in 2002. The maximum concentration during 2002 was 1,262 μg/L during the first quarter in well 000-262, which is located between UVB-4 and UVB-5 in the center of the industrial park system.

- Plume core wells 000-253 (located just east of UVB-1), 000-256 (located between UVB-1 and UVB-2) and 000-259 (located between UVB-2 and UVB-3) generally showed stable or decreasing VOC concentrations during 2002 (**Figure 3.2.6-4**).

- There had been a steady decline in VOC concentrations in plume core well 000-112 (located immediately upgradient of UVB-1 and UVB-2) from 1999 through early 2002. Concentrations spiked upward in the second and third quarters of 2002 before dropping back down to 417 μg/L in the fourth quarter. These concentration changes are probably due to the inherent variability in the VOC plume distribution.

- Plume core well 000-262 (located between UVB-4 and UVB-5) displayed decreasing VOC concentrations during 2002 (**Figure 3.2.6-4**). This well peaked at 2,175 μg/L in 2001 and was at 578 μg/L in the fourth quarter of 2002.

- VOC concentrations in 000-268 (located between UVB-6 and UVB-7) spiked back up to 370 µg/L in the fourth quarter of 2002 after a steady decline during 2001. Again it appears that a higher concentration slug is migrating through this area.

- VOC concentrations in bypass monitoring wells located near Carleton Drive were stable during 2002. Well 000-431 and 000-432 were installed in 2002 as recommended in the 2001 Groundwater Status Report to supplement the Industrial Park bypass monitoring network. They serve as a bypass monitoring point downgradient of UVB-2. The wells were sampled in early 2003 and contained TVOCs at 32 µg/L and 5µg/L respectively. VOC contamination in the vicinity of 000-431 was present prior to the start-up of the system. This suggests that the system is effective in hydraulically controlling the plume.

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

3.2.6.4 Systems Operations

Operating Parameters

The influent and effluent of the carbon vessels are sampled once per quarter and analyzed for VOCs. These samples monitor the GAC units for a VOC break-through to determine when a carbon change-out is required. Since the system utilizes a closed-loop air system, no air equivalency permits are required for its operations.

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 well's removal efficiency and performance. Based on these results operational adjustments are made to optimize the system's performance.

System Operations

The following summarizes the systems operations for each month of 2002. BNL's PE Division carries out routine maintenance checks daily on the system, in addition to routine and non-routine maintenance. The EWMSD collects the samples. Details of these activities are given in the system's operation and maintenance manual. The daily operations and maintenance inspection logs are available in building the treatment system building.

January 2002:

The system was operational for the entire month of January with no shutdowns. The wells were operating at 60 gpm each. The stripper trays were sampled one time in January.

February 2002:

The system was operational the entire month of February with the exception of UVB-1, which was shut down from February 13 to 15, 19 to 22 and 26 to 28 for an electrical malfunction of the line filter. All other wells operated at 60 gpm.

March 2002:

The system was operational for the entire month of March with the exception of UVB-1 which was off the entire month due to an electrical problem. All other wells operated at 60 gpm.

April 2002:

The system was operational for the entire month of April with the exception of UVB-3, which was off April 23-24 due to an electrical problem. UVB-1 was also off the entire month due to an electrical problem. All other wells operated at 60 gpm.

May 2002:

The system was operational for the entire month of May with the exception of UVB-1, which was off the entire month due to an electrical problem. Well UVB-2 was shut down May 23 and 27 and re-started those same days. Well UVB-3 was found off May 24 for an over current fault and started the same day. All other wells operated at 60 gpm.

June 2002:

The system was operational for the entire month of June with the exception of UVB-1, which operated intermittently from June 1 to June 24 due to an electrical problem and began routine operation on June 24th. The system was shut down for electrical work on June 19 and re-started the same day for electrical work. All other wells operated at 60 gpm.

July 2002:

The system was off from July 2 through 8 and July 10-11 due to electrical problems. Well UVB-6 was off July 8 and 9 due to a problem with the flow meter. Well UVB-4 was off July 15-23 due to a electrical problem. All other wells operated at 60 gpm for the remainder of the month.

August 2002:

The system was off from August 5 through 12 due to a burned bearing in the blower unit. Well UVB-7 was off August 23 through 30 due to an electrical problem. All other wells operated at 60 gpm for the remainder of the month.

September 2002:

The system was off August 30 to September 3 due to a power surge. UVB-7 was shut down for repairs from September 8 through 30, and UVB-5 was also shut down for repairs from September 25 to October 2. All other wells operated at 60 gpm.

October 2002:

The system was operational the entire month with the exception of well UVB-5, which was off October 1, and 2 due to electrical problems. Well UVB-3 was also off from October 1 through 7 for developing. All other wells operated at 60 gpm.

November 2002:

The system was operational the entire month except for November 13 when it was found off due to an electric surge. The system was re-started that same day.

December 2002:

The system was operational the entire month with the exception of well UVB-6 which was turned off December 18 through December 30 to repair a leaking packer line. The system was also found off December 16 due to low blower discharge pressure and re-started that same day. All other wells operated at 60 gpm.

In 2002, 186,000,330 gallons of groundwater were pumped and treated.

3.2.6.5 Systems Operational Data

Recirculation Well Influent and Effluent

During 2002, influent TVOC concentrations in all wells remained stable (**Figure 3.2.6-5**). The corresponding effluent well concentrations (**Figure 3.2.6-6**) also showed decreasing and stable TVOC concentrations for the year. The concentrations in UVB-1 have decreased significantly since start-up.

During the fourth quarter of 2002, the average removal efficiency for TVOCs was 94.9% and overall for 2002, it was 92.6% (**Table F-25**, **Appendix F**). A summary of VOCs with concentrations above NYS AWQS in the effluent samples is provided as **Table 3.2.6.3**.

Cumulative Mass Removal

Calculations were performed to determine the VOC mass removed from the aquifer by the remediation wells during the year. The average estimated flow rates for each monthly monitoring period were used, in combination with the influent and effluent TVOC concentrations to calculate the pounds per month removed. **Table F-26** summarizes this data and is included in **Appendix F**. Flow averaged 54 to 60 gpm for the wells from January 1, 2002 through December 31, 2002. **Figure 3.2.6-7** plots the total pounds of TVOCs removed by the treatment system vs. time. 184 pounds were removed during this period, and a total of 632 pounds since the system started operations.

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 change-out is needed. In addition, airflow rates were recorded to correlate the flow with efficiency rates in individual recirculation wells.

Airflow rates are measured for each in-well air-stripping unit inside the treatment building. These rates averaged 557 cfm for the seven wells in the fourth quarter, and 560 scfm during 2002 (**Table F-27, Appendix F**).

3.2.6.6 System Evaluation

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no unusual or unexpected VOC concentrations observed in the monitoring wells associated with the OU III Industrial Park system during 2002.

2. If not has the plume been controlled?

Yes. Because the cleanup goals have not been met it must be verified that the plume is not growing. An analysis of the plume perimeter and bypass wells reveals that there have been no significant VOC concentration increases in these wells during 2002. In addition, groundwater level measurements indicate the presence of a cone of depression consistent with estimates prepared during the design. Therefore, we conclude that there has been no plume growth and the plume continues to be controlled.

Groundwater elevation data is obtained quarterly from many of the OU III South Boundary Monitoring program wells, in addition to wells located throughout the BNL on-site and off-site areas on a quarterly basis. Groundwater contour maps are generated using this data (**Figures 2-3** and **2-4**). The capture zone for the OU III Industrial Park System is depicted in **Figure 3.0-1**. The capture zone depicted is inclusive of the 50 µg/L isocontour, which is the capture goal of this system.

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

Yes. The treatment system is effectively removing contamination. The estimated duration (12 years) is significantly longer than what was specified in the design (7 years). The OU III Industrial Park System continues to be effective in removing VOCs from the deep Upper Glacial aquifer. Actual mass removal is within 10% of what was predicted using the groundwater model (**Figure 3.2.6-9**). **Figure 3.0-3** compares the OU III plumes as modeled during the FS with the fourth quarter 2002 plume data. **Figure 3.2-4** compares the OU III plume from 1997 to 2002. The overall reduction in the high concentration areas of the plume near the south boundary is evident.

The OU III Industrial Park system is planned to operate for 12 years; at the end of 2002, it had operated for approximately three years. Therefore, it is not expected to be approaching its cleanup goals. The system is removing contamination at the expected rate and hydraulic control of the plume was demonstrated; hence, it is operating as planned.

The trend in the mean of the TVOC concentrations in the core groundwater monitoring wells is a declining one (**Figure 3.2.6-8**).

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 2002 concentrations increased significantly from start-up therefore, the Mann-Kendall test was not applied to the data. Based on the current trend it will not be appropriate to apply the Mann-Kendall test for about five years.

4b. Is the mean TVOC concentration in core wells less than 50 ug/L by 2025?

No, the mean TVOC concentration in the plume core wells was just over 200 µg/L as of the fourth quarter 2002.

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

Nine of the nine plume core wells have TVOC concentrations exceeding 50 µg/L as of the fourth quarter 2002.

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

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

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

No. MCLs have not been achieved for individual VOCs in plume core wells.

3.2.6.7 Recommendations

The following change is recommended:

- A baseline of over four years of groundwater data has been obtained from many of the OU IIII Industrial Park Program wells. A routine operations and maintenance monitoring frequency will be implemented in August of 2003. Plume core and perimeter wells will be monitored on a semi-annual frequency. Bypass wells will continue to be sampled at a quarterly frequency. This reduction in sampling frequency for plume core and perimeter wells was already implemented for some of the shallow OU IIII Industrial Park Program wells in 2001.

3.2.7 Offsite Monitoring

The OU III Offsite Groundwater Monitoring Program consists of twenty wells that were installed primarily during the OU III RI. Three of the wells (000-97, 000-98, and 000-99) were installed as part of the Sitewide Hydrogeologic Characterization program. The wells installed during the OU III RI were meant to track the plume core or perimeter in off-site areas or to serve as sentinel wells for the leading edge of the plume. The three wells installed as part of the Sitewide Hydrogeologic Characterization are used as plume perimeter wells. Most of these wells will be folded into the groundwater monitoring programs associated with the Long Island Power Authority and Brookhaven Airport (LIPA and Airport) planned OU III off-site remediation systems as the systems come on line.

3.2.7.1 Groundwater Monitoring

<u>Well Network</u>: The network has 20 wells that monitor the off-site, downgradient extent of the OU III VOC plumes (**Figure 3.2.7-1**). Some wells downgradient of the leading edge of the plumes serve as sentinel wells. Their locations, which are screened in the deep portions of the Upper Glacial aquifer, were selected using BNL's Groundwater Model.

<u>Sampling Frequency and Analysis</u>: The wells are sampled quarterly, and samples are analyzed quarterly for VOCs with the exception of wells 800-21, 800-22, 800-23, 800-51, and 800-53 which are sampled semiannually (**Table 1-6**).

3.2.7.2 Monitoring Well Results

The complete results for the monitoring wells in this program can be found in **Appendix C**. The horizontal and vertical extents of the off-site segment of the OU III VOC plume are shown in **Figure 3.2-1** and **Figure 3.2-2**. Plume core well 000-131 continues to show a gradual decrease in TVOC concentrations (**Figure 3.2.3-3)**.

The leading edge of this plume continues to be located immediately south of Flower Hill Drive near the northern boundary of the Airport. The TVOC concentration in well 800-43 (located on Flower Hill Drive) remained at approximately 4 µg/L in each of the 2002 quarterly sampling rounds.

3.2.7.3 Groundwater Monitoring Program Evaluation

There were no unexpected results during 2001 that triggered the BNL Groundwater Contingency plan (BNL 2000c). The plume remained within the boundaries of the perimeter wells currently in place. Sentinel well 800-43 continued to show very low concentrations of VOCs, indicating that leading edge of the plume is in the vicinity of the northern boundary of the Airport. There is good agreement between the off-site segment of the OU III plume (**Figure 3.0-3**) and the FS modeled plume.

Many of the monitoring wells comprising this program will be absorbed into other programs over the next several years as OU III Offsite remediation systems are constructed and begin operation. Thus, monitoring of these wells provides us with data on the off-site OU III plumes in the interim.

3.2.7.4 Recommendations

The plume core and perimeter wells will be monitored semi-annually and sentinel wells annually for VOCs beginning in the fourth quarter of 2003. A sufficient data baseline has been developed for these wells and the reduction of sampling to semi-annually in core and perimeter wells will not compromise BNL's ability to monitor off-site VOCs. As wells are incorporated into both the LIPA and Airport Remediation System programs the sampling frequency will be elevated in all wells to quarterly for a two-year system start-up duration.

3.2.8 North Street Monitoring

The North Street (formerly known as OU I/IV) monitoring program addresses a VOC plume that is primarily south of the site boundary and the issue of potential 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 a precursor to groundwater remediation, groundwater characterization was performed and consisted of drilling 15 vertical profile borings and collecting and analyzing groundwater samples and analysis for VOCs and tritium from these temporary wells in 2001/2002.

Groundwater treatment will consist of two extraction wells operating at a combined pumping rate of 450 gallons per minute (gpm). This will capture the higher concentration portion of the VOC plume (i.e., TVOC concentrations greater than 50 to 60 µg/L) in the Upper Glacial aquifer and minimize the potential for migration to the Magothy aquifer. A 2004 start-up is anticipated for the treatment system. Details on the pre-design groundwater characterization and the planned groundwater treatment system can be found in the *North Street Remedial Action Work Plan* (BNL, 2002a).

This plume has been divided into segments for remediation purposes. The area north of Moriches-Middle Island Road will be addressed by the remediation system off of North Street while the Airport Recirculation System will handle the area to the south. The leading edge of the North Street plume extends south to the vicinity of the Airport. A groundwater remediation system (Airport System) is being 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). Pump and Recharge wells were selected for this application and will be sited to address the leading edge of the North Street plume. Details on the proposed remediation system and pre-design characterization activities can be found in the *OU III Aiport Groundwater Treatment System 90% Design Documents* (J.R. Holzmacher, 2002a). Construction of the system began in 2003.

3.2.8.1 Groundwater Monitoring

<u>Well Network</u>: A network of 23 wells monitors the downgradient portion of the OU IV, Former Landfill, Chemical/Animal Pits, and Glass Holes VOC plumes and the potential radiological contamination originating in these areas (**Figure 3.2.8-1**). Additionally, wells sampled under the OU III South Boundary and Industrial Park Programs are utilized for mapping this plume. Additional wells will be installed during 2003 in association with the construction of the groundwater treatment system.

<u>Sampling Frequency and Analysis</u>: The wells are sampled and analyzed quarterly for VOCs, and annually for gross alpha/beta, gamma spectroscopy, tritium, and Sr-90 (**Table 1-6**).

3.2.8.2 Monitoring Well Results

The primary VOCs associated with this plume are carbon tetrachloride, PCE, and TCA. **Figure 3.2-1** depicts the TVOC plume distribution and includes data from the 23 monitoring wells. The complete groundwater monitoring well data are included in **Appendix C**. Details of the pre-design groundwater characterization data can be found in the *North Street Remedial Action Work Plan* (BNL, 2002a). A hydrogeologic cross section running through the spine of the plume is provided in **Figure 3.2.8-2;** its location is shown on **Figure 3.2-1**.

Monitoring well 000-154 has 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, as illustrated in **Figure 3.2.8-3**. This high concentration area appears to have migrated south of 000-154 as evidenced by data from vertical profile 000-381 which contained 2,020 µg/L of TVOC in the deep Upper Glacial aquifer approximately 700 feet south of well 000-154 in 2001. The increasing concentrations in well 000-153 during 2002 (**Figure 3.2.8-3**) suggest that the leading edge of this higher concentration segment is approaching well 000-153. The delineation of this plume to 50 µg/L TVOC was achieved by the pre-design characterization as shown in **Figure 3.2-1**.

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

Tritium has been detected historically in well 000-153. The tritium concentration in this well in 2002 was 1,070 pCi/L. Tritium was detected in seven of the fifteen vertical profiles installed in 2001/2002. In six of the seven vertical profiles tritium was detected at concentrations less than 1,000 pCi/L. The highest tritium concentration was detected in temporary well 000-337 at 9,130 pCi/L. This location is approximately 300 feet north of well 000-153.

3.2.8.3 Groundwater Monitoring Program Evaluation

Construction of the OU III North Street and Airport Remediation Systems and installation of additional monitoring wells is scheduled for 2003. **Figure 3.2.8-4** compares the TVOC plume from 1997 to 2002. The following significant changes were observed in the plume over this period:

- The trailing edge of the plume has migrated south of the Former Landfill, Chemical/Animal Holes Areas.
- The high concentration area has moved south from well 000-154 and, based on the 2002 characterization data, appears to be approaching well 000-153.
- A small area of TVOC greater than 50 µg/L has migrated south of the site boundary and is crossing to the south of North Street. Due to the lack of recent well data the movement of this plume segment was estimated from groundwater modeling. This area of contamination will be monitored under the North Street East program.
- The leading edge of the plume, as defined by a TVOC of 5 µg/L, remains in the vicinity of Flower Hill Drive.

Figure 3.0-3 compares the observed plume in 2002 to the plume modeled in the OU III FS. There is good correlation between the observed and predicted plumes.

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

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no unusual or unexpected VOC or radionuclide concentrations in the monitoring wells associated with this program during 2002.

2. Does the existing contaminant plume represent a potential risk to downgradient receptors?

No. There have been no significant increases in the concentrations of contaminants during 2002 in the monitoring wells. The leading edge of the plume was defined at the northern boundary of the Airport at concentrations below the NYS AWQS for individual VOCs during the 2002 pre-design characterization work. There are no downgradient receptors within the Airport. Homes in the residential area overlying the plume have been connected to public water (with the exception of nine homes).

3. Is the planned remediation system adequate to intercept and treat the existing contamination to prevent impacts to potential downgradient receptors?

Yes. The remediation systems are being planned to intercept and treat the contamination as outlined in the OU III ROD. The combined North Street and Airport systems will prevent any impacts to potential downgradient receptors south of the leading edge of the plume, as currently defined.

4. Are there off-site radionuclides that would trigger additional actions?

No. Based on both monitoring well data and the extensive pre-design characterization in 2002 radionuclide contamination appears to be relegated to isolated occurrences of tritium, primarily in the deep Upper Glacial aquifer, at concentrations below the NYS AWQS of 20,000 pCi/L.

3.2.8.4 Recommendations

The monitoring well network will be enhanced during 2003 by establishing monitoring wells associated with both the North Street and Airport Remediation Systems. There are no recommendations for the monitoring well network other than those currently planned as part of these efforts. The current sampling frequency and analytes will be maintained in 2004.

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3.2.9 Central Monitoring

The OU III Remedial Investigation identified several low-level (less than 50 µg/L) source areas and non-point contaminant sources within the developed central areas of the BNL Site. Since these sources, which include spills within the Alternating Gradient Synchrotron (AGS) Complex, and the storage area for site maintenance equipment (Building 208) and others, are not large enough to warrant a dedicated monitoring program, they are monitored under the OU III Central project. In addition, this project includes wells 109-03 and 109-04, which are located near the BNL site boundary and serve as sentinel wells for the SCWA William Floyd Parkway well field.

3.2.9.1 Groundwater Monitoring

Well Network: The monitoring well network established to check the relatively low-level VOC contamination in the central areas of the site is comprised of 19 wells (**Figure 3.2.9-1**). The locations provide data on groundwater quality near the source areas that aid in defining the VOC plumes, which extend downgradient from this area of the site. This network also is supplemented by data from Environmental Surveillance (ES) program wells that monitor active research and support facilities (**Table 1-7**).

Sampling Frequency and Analysis: The wells are sampled and analyzed quarterly for VOCs, and semiannually for gross alpha/beta, gamma spectroscopy, tritium, and Sr-90 (**Table 1-6**).

3.2.9.2 Monitoring Well Results

VOC concentrations detected in most of the OU III Central wells are near or below NYS AWQS. The following wells displayed significant changes in VOC concentrations in 2002 or were otherwise noteworthy:

- Well 65-05 is screened in the shallow Upper Glacial aquifer and is located in the AGS area. TVOCs in well 65-05 increased during 1999 and 2000, peaking at a concentration of 123 µg/L in September 2000. Concentrations continued a decreasing trend in 2002 with a detection of 5 µg/L during the fourth quarter. Based on the occurrence of VOCs in this well, the contamination most likely is traveling as a slug from an unidentified small source to the north.

- Well 66-09 is located southeast of building 830 and screened in the shallow Upper Glacial aquifer. VOC concentrations, primarily TCA, significantly increased during late 2000 and early 2001, peaking at 112 µg/L TVOC in February 2001. A preliminary investigation identified several potential sources in building 830. Geoprobes installed in the area during the summer of 2001 revealed little or no VOC contamination (BNL, 2001). VOC concentrations have remained below NYS AWQS with the exception of a single detection of trichloroflouromethane at a concentration of 9 µg/L in the fourth quarter of 2002.

- Well 83-02 is located near the intersection of Brookhaven Avenue and Upton Road and is screened in the mid to deep Upper Glacial aquifer. This well consistently has contained 10 to 25 µg/L of chloroform since 1997. Potential sources of this contamination may be in the AGS area of the site.

- SCDHS wells 109-03 and 109-04 serve as sentinel wells for the SCWA William Floyd Well Field and are located near the eastern BNL site property boundary. Toluene was detected in well 109-03 (screened in deep Upper Glacial Aquifer) at 5.3 µg/L in a sample obtained on September 12, 2002 (see **Appendix C** on enclosed CD-ROM for data). There were no VOC detections in this well exceeding NYS AWQS or guidance values prior to this sampling event. The well was resampled on October 29, 2002 and sent to both GEL and STL labs. MTBE was detected at concentrations of 4.8 µg/L (GEL) and 7 µg/L (STL). Trace amounts of toluene (0.2 µg/L) were detected by both labs. The well was sampled again in December with no VOCs detected. The SCDHS sampled the well in early January 2003 and also did not detect any VOCs. Routine BNL monitoring detected MTBE at 67 µg/L in a sample collected on February 21, 2003. Benzene, m/p xylene and toluene were also detected at concentrations of 1.4 µg/L, 6.2 µg/L and 8.7 µg/L, respectively. BNL sampled the well again on April 3, 2003 and detected MTBE at 5 µg/L and toluene at 1 µg/L. The well was sampled by both BNL and SCDHS on April 23, 2003 and no VOCs were detected. Routine monitoring will continue for this well.

3.2.9.3 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?

Yes. The BNL Groundwater Contingency Plan was triggered by the detection of VOCs exceeding NYS AWQS in well 109-03, which serves as a sentinel well for the SCWA William Floyd Well Field. The SCDHS, EPA and NYSDEC were notified of the detection and resampling efforts were coordinated with the SCDHS. VOCs were detected by BNL in subsequent sampling events during early 2003. The latest results (April 23, 2003) from well 109-03 from both BNL and the SCDHS were non-detect for VOCs. The well will continue to be sampled at a quarterly frequency in 2003 and the regulatory agencies will be notified of any additional VOC detections.

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

No. As a follow up to VOC detections in well 109-03 a meeting was held between BNL and SCDHS to discuss potential impacts to the William Floyd Well Field. The draft SCDHS Source Water Assessment Report was reviewed and a determination made that the recent detections did not presently pose any immediate threat to the SCWA well field from BNL.

3. Are the performance objectives met?

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

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

Yes. **Figure 3.0-3** compares the observed OU III plume in 2001 with the FS groundwater model predictions for 2002. In the areas of the site where the wells of the OU III Central Monitoring Program are located the observed TVOC concentrations generally are in good agreement with the model predicted concentrations with respect to both the plume extent and contaminant concentrations.

3.2.9.4 Recommendations

Due to the recent VOC detections in well 109-03, the quarterly sampling frequency will be maintained for these SCWA well field sentinel wells.

3.2.10 Magothy

Additional characterization of the Magothy aquifer (partially characterized as part of the OU III RI and OU I/IV Groundwater Investigation) was undertaken and completed between April 2000 and August 2002. The characterization consisted of 22 vertical profile borings and 13 new monitoring well installations. The monitoring well locations are shown on **Figure 3.2.10-1**. The Magothy Aquifer Characterization Project was undertaken to 1) further define VOC impacts within the Magothy aquifer, 2) provide additional characterization data on tritium impacts in specific areas, 3) provide geologic information to assess subsurface controls on contaminant migration, 4) to provide for locations to monitor contamination within the Magothy aquifer over time, and 5) to determine the need for a remedy for Magothy aquifer contamination. A summary of the field investigation work and presentation of the findings is included in the *Magothy Aquifer Characterization Report* (BNL, 2003).

Monitoring of the 13 new wells will begin in 2003 and the data presented in the 2003 BNL Groundwater Status Report. Sampling will initially be conducted quarterly under a start-up phase.

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3.2.11 HFBR Tritium Monitoring

In late 1996, tritium was detected in monitoring wells near the High Flux Beam Reactor (HFBR). The source of the release was traced to the HFBR spent fuel pool. In response, the fuel rods were removed from the pool for off-site disposal, the spent fuel pool was drained and the HFBR was removed from service in 1997. Also, numerous monitoring wells were installed to characterize the tritium plume downgradient of the HFBR. In May 1997, operation of a three-well groundwater pump and recharge system began. This system was constructed on Princeton Avenue approximately 3,500 feet downgradient of the HFBR to capture any 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 drinking water standards (20,000 pCi/L) before reaching the site boundary. The extraction system was placed on stand-by status in September 2000 as the groundwater monitoring data demonstrated that plume growth was not occurring. Beginning in June 2000 and ending April 2001 20 low flow extraction events removed 95,000 gallons of tritiated water.

As described in the OU III ROD, the selected remedy to address the HFBR tritium plume includes implementing monitoring and low-flow extraction programs to prevent or minimize the plume's growth. This water was sent off site for disposal. The trigger level for low flow extraction has not been exceeded since the April 2001. Plume growth is defined as a detection of tritium above 25,000 pCi/L in monitoring wells at the Chilled Water Plant Road, or above 20,000 pCi/L in monitoring wells along Weaver Drive. Exceedances of these activities will necessitate implementing the specific contingencies described in the ROD, including possible reactivation of the Princeton Avenue pumping system.

Groundwater flow in the vicinity of the HFBR is variable due to BNL pumping and recharge operations in the area. In general, groundwater flow is toward the south or southeast (**Figures 2-4** and **2-5**). Evaluation of groundwater flow and quality data indicates that the downgradient portion of the tritium plume (south of Brookhaven Avenue) has shifted to the east since 1997 in response to changing flows to the HO recharge basin, the use of the OU III recharge basin, and the reduced pumping of BNL supply wells 10, 11 and 12.

3.2.11.1 Groundwater Monitoring

Well Network: A monitoring well network of 157 wells was designed to follow the extent of the plume, the source area, and the effectiveness of the groundwater remediation system (**Figure 3.2.11-1**). Due to the closeness of the HFBR to artificial pumping and recharge locations, the plume is subjected to changing hydraulic stresses, which have warranted an extensive monitoring network. Select wells are also analyzed for VOCs as part of the Carbon Tetrachloride and Middle Road programs (**Table 1–6**).

Sampling Frequency and Analysis: The wells associated with the high concentration portion of the plume were sampled for tritium monthly. Sampling details are contained in **Table 1-6**. The remaining wells were sampled quarterly.

3.2.11.2 Monitoring Well/Temporary Well/Geoprobe Data

The extent of the tritium plume is shown on **Figure 3.2.11-2.** This figure summarizes data collected during the fourth quarter of 2002, including monitoring well and geoprobe data. Data from the OU III HFBR Tritium Groundwater Monitoring program were supplemented with data obtained from 15 geoprobes during 2002. The geoprobes were installed along two east-west transects (just east of Bell Avenue and between Bell Avenue and Brookhaven Avenue) to track the high concentration segment of the plume (**Figure 3.2.11-3**). **Appendix C** has the complete set of monitoring well data.

During 2002 the high concentration segment of the plume was located between Brookhaven Avenue and Rowland Street. This segment was characterized by sampling temporary wells installed using geoprobes. The high concentration observed in 2002 was 254,000 picoCuries per liter (pCi/L) in geoprobe 85-326 located at the eastern end of Bell Avenue (**Figure 3.2.11-3**). A cross section along the Bell Avenue transect is provided as **Figure 3.2.11-4**. Tritium concentrations immediately south of the HFBR building demonstrate a tailing effect. Concentrations in well 075-43 were 22,600 pCi/L during the fourth quarter 2002. This is a significant reduction from the historic highs in this well that approached 2,500,000 pCi/L in 1999 (**Figure 3.2.11-5**).

Tritium concentration trend plots are shown for key wells located along the spine of the plume in **Figure 3.2.11-5**. The high concentration core of the plume passed through the vicinity of well 75-294 during the beginning of 2001 then through well 75-418 during the middle to latter part of 2001 north of Brookhaven Avenue, then the high concentration segment reached Bell Avenue in early 2003 as determined by the temporary well results. Tritium concentrations at Temple Place have remained below 750,000 pCi/L, the trigger level for low-flow remediation pumping, since April 2001. The vertical extent of contamination along the spine of the plume is depicted in cross section K-K' (**Figure 3.2.11-6**).

The fourth quarter 2002 HFBR tritium plume distribution is shown in **Figure 3.2.11-2**. The leading edge of the 20,000 pCi/L isocontour is estimated to be in the vicinity of the Chilled Water Plant Road in the mid to deep Upper Glacial aquifer. This estimate is based on an average groundwater velocity for this area of 1 ft/day. There were no detections of tritium in excess of 1,000 pCi/L during 2002 at or south of Weaver Drive.

Well 95-93 is screened in the deep Upper Glacial aquifer along the western portion of Weaver Drive. Tritium concentrations were detected above 1,000 pCi/L beginning in July 2000 and peaked at 5,500 pCi/L in April 2001. Concentrations decreased in this well during the last three quarters of 2001 and all of 2002. Concentrations during the last three quarters of 2002 were under 1,000 pCi/L. This tritium was originally detected in vertical profiles further north as part of the 1997 investigation, and appears to have been a small slug with concentrations less than 6,000 pCi/L.

Groundwater flow data indicate that the downgradient segment of the tritium plume has remained relatively stable during 2002 (**Figures 2-4** and **2-5)**.

3.2.11.3 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?

No. The BNL Groundwater Contingency Plan was not triggered during 2002. High tritium concentrations detected in vertical profiles, geoprobes and monitoring wells were consistent with our understanding of the HFBR Tritium plume.

2. Is the tritium plume growing?

No. Tritium above 25,000 pCi/L in wells at the Chilled Water Plant Road or above 20,000 pCi/L in wells along Weaver Drive was not observed. None of these criteria were approached during 2002 although there was a tritium concentration increase in Chilled Water Plant Road well 95-276 with 8,810 pCi/L observed in July. A comparison of the plume distribution between 1997 and 2002 is shown in **Figure 3.2.11-7**. This figure also illustrates that plume growth is not occurring.

<u>*3. Are observed conditions consistent with the attenuation model?*</u>

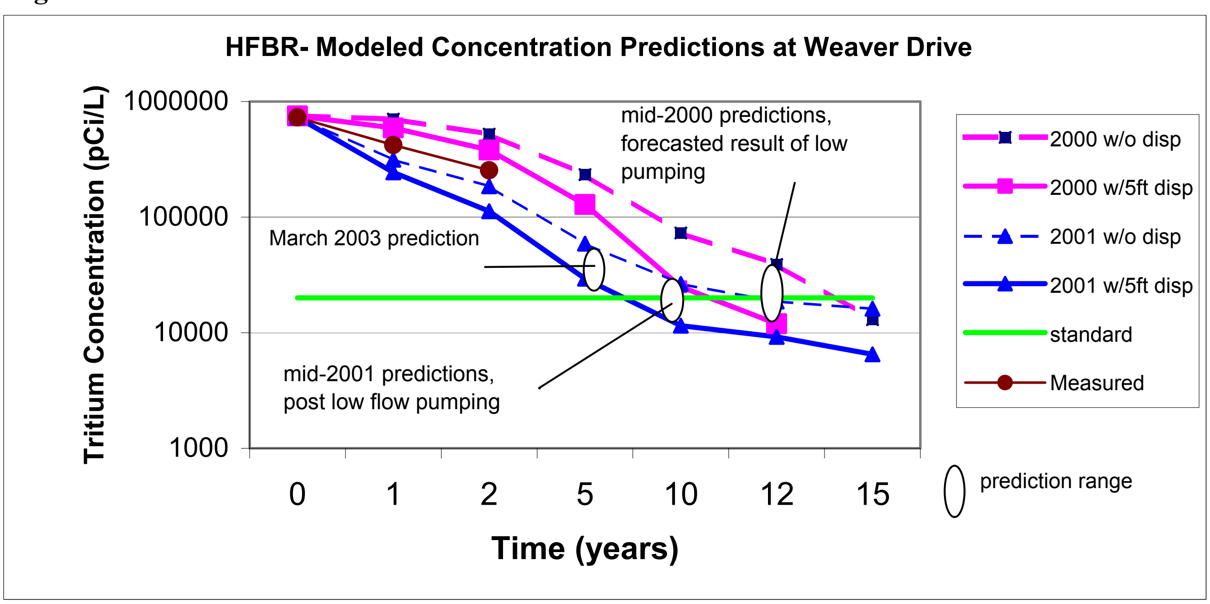
Yes. Since the HFBR tritium plume discovery in 1997, groundwater models have been used to assess the fate and transport of the plume and aid in making plume management decisions. The groundwater modeling objectives have evolved to support the remedial action process. The *Groundwater Flow and Tritium Transport Modeling Report* (AG&M, 1998) supported the initial plume characterization, aided in the design of the HFBR pump and recharge system (located at Princeton Avenue) and supported comparisons on remedial alternatives for the OU III FS. The *HFBR Groundwater Model Update Report* (BNL, September 2001a) addressed model calibration and the design and performance of a low flow pumping system. The *HFBR Groundwater Model Update report* estimated future tritium concentrations at the Weaver Road location. The 2002 BNL Groundwater Status Report is being used to document the latest model assessment, which examined fourth quarter 2002 monitoring data relative to earlier predictions. The objectives of this assessment are to:

- Assess if the plume is attenuating as predicted by the model; and
- Assess the likelihood the Weaver Road trigger will be exceeded thus prompting the need to reactivate the HFBR Pump and Recharge system at Princeton Avenue.

Model Forecast

Figure 3.2.11-8 summarizes model predictions of peak tritium concentrations with time. The square-marked lines illustrate the range in predictions performed as part of the low flow pumping planning process in 2000. The triangle marked lines illustrate the range of predictions performed as part of the 2001 low flow pumping evaluation. The circle marked line represents the peak tritium concentrations measured since the predictions. The estimated travel time of the slug to Weaver has varied depending on the latest groundwater velocity estimate and the date of the estimate. The ovals on the chart correspond to the estimated travel time to Weaver for a particular estimate and show the predicted range of tritium concentrations at Weaver.

Figure 3.2.11-8 Predicted vs. Actual Peak Tritium Concentrations with Time in the HFBR Plume



The September 2000 low flow pumping plan predicted that if the “hot spot slug” concentrations near Temple Place were reduced to 750,000 pCi/L, the concentration of the hot spot slug would attenuate down to about 22,000 to 39,000 pCi/L by the time it migrated to Weaver Drive around 2012. The low flow pumping was implemented from June 2000 through April 2001. Groundwater monitoring data were collected to characterize what remained of the hot spot slug after low flow pumping. These data determined that the peak concentration in the remaining slug was 730,000 pCi/L. The model was used to simulate the fate of what remained from the hot spot. These 2001 predictions indicated that the 730,000 pCi/L detection near the National Synchrotron Light Source (NSLS) in early July 2001 was still projected to decay and disperse to about 20,000 pCi/L (specifically 15,000 to 32,000 pCi/L) by the time it migrated to Weaver drive around 2009-2010. Note that the 2001 prediction had the slug arriving at Weaver Drive about 2-3 years earlier than the 2000 prediction and the predicted concentrations were somewhat higher. This is due to a higher groundwater velocity in the 2001 prediction compared to the 2000 prediction. Because the slug remnants are predicted to get to Weaver Drive faster than was planned in 2000, the concentrations are predicted to be somewhat higher.

For this report, the fourth quarter 2002 monitoring data were compared to the model prediction for December 2002. No parameter changes were made from those reported in the *HFBR Groundwater Model Update Report* (BNL, September 2001a). The measured extent of the tritium vs. the predicted extent as of December 2002 is shown in **Figure 3.2.11-9**.

<u>2002 Groundwater Status Report Model Update</u>

- The hot spot slug remnants continue to migrate at a rate somewhat greater than predicted by the model.

- The measured centerline of the plume is reasonably close to the predicted centerline. The direction of contamination migration is well simulated.

- The fixed groundwater monitoring system is well positioned to monitor the plume. One exception to this may be the area in the vicinity of Chilled Water Road where the wells are not present near the existing plume centerline nor the eastern perimeter to monitor shifts in the plume’s centerline axis.

- The model predicts that concentrations exceeding 20,000 pCi/L are currently in the vicinity of Weaver Drive. However, the monitoring data only shows concentrations as great as 4,710 pCi/L. An evaluation of the monitoring system at Weaver Drive in cross-section relative to the trajectory of the plume has been performed. It is concluded that the wells are screened at the proper horizon at Weaver. However, BNL will continue to monitor the appropriateness of this monitoring program. Therefore, the tritium concentration in the vicinity of Weaver Drive is attenuating more rapidly than predicted.

- The tritium being measured south of Rowland in fourth quarter 2002 was not from the remnants of the hot spot that was low flow pumped, but rather from the tritium that was released from the HFBR pre-1995. This is the remnant of tritium that was characterized in 1997. The tritium detected at Weaver in fourth quarter 2002 was probably located in the vicinity of Bell Avenue in 1997.

- The HFBR pump and recharge wells, which are currently in standby mode, are still optimally positioned to address any high concentrations that might arrive at Weaver.

- The model does not include the tailing effect of tritium from beneath the reactor. This effect is caused by the release of trtium from the unsaturated zone during periods of natural water table rise. The monitoring data indicate that this tailing effect is still occurring.

According to the model, it appears likely that the remnants of the hot spot will reach Weaver in about the late 2005 time frame and will be between 30,000 to 60,000 pCi/L. It seems prudent to continue quarterly monitoring and implement Contingency 1, the pump and recharge system, as necessary. However, because the model has been under predicting concentrations in the near field and over predicting in the far-field, the need for re-implementing any contingency should only be done based on careful review of the actual monitoring data. Should it be necessary, the duration of operation of the HFBR pump and recharge system contingency is expected to be less than one year. In conclusion, the observed conditions are reasonably consistent with the attenuation model.

4. Is the tritium plume migrating toward the zone of influence of BNL water supply wells 10, 11 and 12?
No. Tritium was not detected above 1,000 pCi/L in any of the monitoring wells located upgradient of the HFBR. These wells are sited to serve as sentinel wells for any northward migration of tritium towards the supply wells. No tritium was detected in the supply wells.

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

No. There were no detections in plume perimeter wells during 2002 indicating that tritium had moved beyond the current monitoring network. Temporary well data south of Brookhaven Avenue did indicate that the plume was shifted slightly east of the downgradient-monitoring network. Additional temporary and permanent wells are needed to ensure that the downgradient segment of the plume is adequately monitored in the future and to track the high concentration segment.

3.2.11.4 Recommendations

The following are recommendations for the HFBR groundwater monitoring program.

1) Several temporary wells will be installed in 2003 to track the high concentration portion of the plume as per the HFBR Tritium Low Flow Pumping Evaluation Report (BNL 2001b).

2) Three temporary wells will be installed in 2003 to characterize the deeper tritium detected in 2002. One will be installed on Bell Avenue at the location of geoprobe 85-236. Two temporary wells will be installed immediately east of well 95-276 to assess the location of the 20,000 pCi/L plume leading edge in the vicinity of the Chilled Water Road/Weaver Drive. (Note: these were installed in early 2003).

3) The data will be evaluated to determine if additional wells are necessary in the Chilled Water Road and Weaver Drive areas. Based on the high concentration segment of the tritium plume having migrated south of Brookhaven Avenue, the frequency of monitoring for wells located to the north of this area should be reduced from monthly to quarterly beginning in August 2003. This includes monitoring wells 75-43, 75-224, 75-225, 75-230, 75-231, 75-236, 75-237, 75-242, 75-244, 75-296, 75-297, 75-298, 75-299, 75-414, 75-415, 75-416, 75-417, 75-418, 75-419, 75-285, 75-286, 75-287, 75-288, 75-289, 75-558, 85-286, 85-287, 85-288, and 85-289.

4) Based on the relative stability of groundwater flow directions in the tritium plume path the sampling frequency for western perimeter wells 75-47, 75-48, 75-75-87, 75-210, 75-211, 75-208,

75-209, 75-292, 85-39, 85-40, 85-41, 85-65, 85-66, 85-73, 85-74, 85-75, 85-87, and 85-78 will be reduced from quarterly to semi-annually (second and fourth quarters) beginning in August 2003.

5) Up to five monitoring wells will be installed in 2003 along in the vicinity of Bell Avenue to enhance the monitoring network near the leading edge of the higher tritium concentrations.

3.2.12 BGRR/Waste Concentration Facility Strontium-90 Monitoring

The OU III Brookhaven Graphite Research Reactor (BGRR)/Waste Concentration Facility (WCF) project monitors the extent of strontium-90 plumes in groundwater. Some of the wells included in the OU III BGRR/WCF network also are monitored as part of the OU III AOC 29 HFBR and Building 801 (see Section 4.13) programs. These wells are sampled concurrently for both programs to avoid duplication of effort.

The analytical results show separate areas of elevated strontium-90, one emanating from the WCF area and extending approximately 1,500 feet south, an area south of the BGRR Below Ground Ducts (BGD), an area south of the Pile Fan Sump (PFS) and HFBR stack, and another beginning south of the BGRR Building 701 area and extending south for approximately 600 feet (**Figure 3.2.12-1**). Variability in groundwater flow directions due to changes in pumping and recharge patterns in the plume vicinity over time have resulted in spreading of the contamination.

3.2.12.1 Groundwater Monitoring

Well Network: A network of 61 monitoring wells was designed to monitor the Sr-90 plumes associated with the BGRR, WCF, and Pile Fan Sump areas (**Figure 3.2.12-2**). Fourteen wells monitored under this program also are sampled under the AOC 29 HFBR Tritium program; sampling events are coordinated between the two programs to eliminate any duplication of effort. The 14 wells, which were originally installed as part of the AOC 29 HFBR program, are utilized either as sentinel wells or to bound the Sr-90 plumes to the east.

Sampling Frequency and Analysis: The wells are monitored semiannually, and the samples are analyzed for Sr-90 (**Table 1-6**).

3.2.12.2 Monitoring Well/Geoprobe Data

The BGRR/WCF strontium-90 plumes consist of two areas of strontium-90 contamination. The first extends from just south of building 701 in the area of the Below Ground Ducts (BGD) to just north of Brookhaven Avenue (**Figure 3.2.12-1**). Contamination in this lobe migrates from the water table in the vicinity of the BGD to the mid Upper Glacial aquifer as it travels downgradient. The southern extent of the plume is estimated to be located north of Brookhaven Avenue based on the absence of strontium-90 in the sentinel wells installed immediately south of Brookhaven Avenue in 2002. **Figure 3.2.12-3** plots the trends in strontium-90 for key wells. The variability in concentrations for several wells including 75-190 and 75-198 are reflective of either the contamination migrating as discreet slugs and/or the shifting of the plume laterally in response to changing groundwater flow direction.

The second plume segment extends from just south of the WCF area to south of Cornell Avenue. An overall eastward shift of this plume has been observed since 2000 and is reflected in the increasing strontium-90 concentrations in perimeter well 65-39. Strontium-90 was not detected during the first sampling event for this well in 1997, but subsequently concentrations have increased to 44 pCi/L in October 2002.

There are three areas of high strontium-90 concentrations (greater than 50 pCi/L) within the plumes. The first is in the vicinity of the BGD where a geoprobe groundwater sample in August 2001 detected levels of strontium-90 at 540 pCi/L. Concentrations greater than 50 pCi/L extend south of this area to well 75-190, which is located just south of Cornell Avenue. Samples were obtained during 2002 from a characterization beneath Building 701/702. Two of the twenty-seven samples exceeded the NYS DWS for strontium-90 of 8 pCi/L, with a concentration of 12 pCi/L detected in each. The groundwater investigation consisted of 27 samples taken at 26 geoprobe boring locations (**Figure 3.2.12-4**); details on the sample data can be found in the BGRR Characterization Report (BNL 2003). Additional pre-design characterization of the strontium-90 plumes is planned for calendar year 2003, with design and construction of a groundwater remediation system planned for calendar years 2004 and 2005.

Another area of high strontium-90 concentration exists immediately south of the WCF area and extends southward by approximately 200 feet. The highest strontium-90 concentration observed in well 65-175 during 2002 was 599 pCi/L in December; it has peaked at 821 pCi/L in November 2000 but declined during 2002 (**Figure 3.2.12-3**).

A third area of high strontium-90 concentrations is in the vicinity of the HFBR stack. A geoprobe sampled in 2001 detected 392 pCi/L of strontium-90. There are currently no monitoring wells in this immediate area.

The highest concentration detected in the PFS area was 565 pCi/L in April 1997 from a geoprobe located approximately 45 feet downgradient from the PFS.

3.2.12.3 Groundwater Monitoring Program Evaluation

The OU III BGRR/WCF Strontium-90 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?

No. There were no detections in BGRR Strontium-90 program wells that triggered the BNL Groundwater Contingency Plan during 2002.

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

Yes. The extent of the strontium-90 plumes are adequately monitored with the current network however, several zones of higher concentrations may require additional wells.

- The area downgradient of the BGD.

- The extent of the high strontium-90 concentrations detected in the vicinity of the HFBR stack during geoprobe characterization. Additional characterization will be performed during the BGRR groundwater remediation pre-design study in 2003.

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

No. The nearest operating groundwater remediation systems are the Carbon Tetrachloride and Building 96 Systems which are located more than 2,000 feet south of this area and will not be affected by strontium-90 contamination in the foreseeable future. Strontium-90 plume impacts would have to be evaluated should the need for g-2 tritium plume remediation or additional HFBR tritium remediation occur.

4. Is the strontium-90 plume (s) migrating toward BNL supply wells 10,11, and 12?

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

3.2.12.4 Recommendations

The following are recommendations for the BGRR groundwater monitoring program:

- The BGRR/WCF/PFS and HFBR stack areas will be characterized in 2003 to determine the areas of highest strontium-90 contamination (hot spots) and to identify potential extraction well locations for the design of the Strontium-90 treatment system.

- Maintain the southerly groundwater flow direction by managing the pumping of BNL supply wells 10, 11, and 12.

- Submit a Groundwater Characterization Report for the Building 701 below ground structures, building 702 pile, and remaining soils.

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3.2.13 Chemical/Animal Holes Strontium-90 Groundwater Monitoring

Waste, glassware containing chemical and radioactive waste and animal carcasses containing radioactive tracers were disposed of in shallow pits directly east of the Chemical/Animal Holes area between 1960 and 1966. Used glassware continued to be disposed in shallow pits directly north of this area from 1966 through 1981. Remediation of the Chemical/Animal Holes area, including waste excavation, treatment, and disposal, was completed in September 1997.

Two distinct strontium-90 plumes were identified in this general area during the OU I RI/FS. The larger of the two is associated with the Chemical Holes and the other with the Former Landfill. The Chemical Holes plume is approximately 650 feet long and 90 feet wide, with a maximum thickness of 15 feet (**Figure 3.2.13-1**).

The OU III ROD specified the selected remedy for the Chemical Holes area to consist of:

1. Groundwater extraction;
2. Strontium-90 treatment using ion-exchange;
3. Onsite discharge of treated water.

A pilot study was initiated in February 2003 for the Chemical Holes area plume to evaluate the effectiveness of extraction and treatment of strontium-90 before implementation of the remedy. Based upon the results of the pilot study, the treatment remedy for strontium-90 plumes may be modified.

3.2.13.1 Groundwater Monitoring

Well Network: A network of 36 monitoring wells are positioned to monitor the strontium-90 plume downgradient of the Former Landfill and Chemical/Animal Pits. Twelve of these wells were installed in late 2002. The new wells were sampled along with the 24 existing wells (**Figure 3.2.13-2**). Additional (sentinel) wells, screened in the middle Upper Glacial aquifer, are sited along Middle Path to signal early warning of the plume's migration. The locations for the sentinel wells were selected with help from BNL's Groundwater Model (Geraghty and Miller 1996).

Sampling Frequency and Analysis: The Chemical/Animal Holes wells are monitored semiannually, and samples are analyzed semiannually for Sr-90, and annually for VOCs (**Table 1-6**). Plume core and perimeter wells 106-16, 106-17, 106-48 and 106-49 were sampled quarterly for strontium-90 in 2002 in anticipation of the pilot study beginning in early 2003.

3.2.13.2 Monitoring Well Results

Figure 3.2.13-1 shows the strontium-90 plume distribution. The plume depiction is derived from fourth quarter monitoring well data including the twelve new wells sampled in December 2002. The highest strontium-90 concentration observed during 2002 was 1,130 pCi/L in well 106-16, that is located immediately south of the Animal Pits and historically has shown the highest concentrations in this area (**Figure 3.2.13-3**). The sharp increase in strontium-90 can be correlated with the excavation of the Animal Pits area in 1997.

A high concentration plume segment of greater than 100 pCi/L strontium-90 extends from approximately 75 feet northwest of well 106-16 to approximately 75 feet south of the Princeton Avenue firebreak road. The leading edge of the plume, as defined by the NYS DWS of 8 pCi/L, is approximately 240 feet south of this firebreak road.

A second, smaller plume occurs south of the Former Landfill. The trailing edge of the plume exceeding 8 pCi/L is estimated to be approximately 80 feet south of the Princeton Avenue firebreak road.

The monitoring wells in this program also are analyzed annually for VOCs. The data are summarized in section 3.2.9 of this report; the complete results are in **Appendix C**.

3.2.13.3 Groundwater Monitoring Program Evaluation

The OU III Chemical/Animal Holes Strontium-90 Monitoring Program can be evaluated in the context of the three basic decision rules identified for this program after applying the groundwater DQO process.

1. Was the BNL Contingency Plan Triggered?
No. There were no unexpected strontium-90 concentrations detected during 2002 under the groundwater monitoring program.

2. Are the strontium-90 plumes targeted for monitored natural attenuation attenuating as planned?

Natural attenuation and groundwater monitoring are planned for the strontium-90 plume originating from the Former Landfill area. Sentinel wells situated along the Middle Road will continue to be monitored on a semi-annual basis.

3. Is the high concentration strontium-90 plume to be addressed by the upcoming pilot study still located in the pilot study area?

Yes. Data indicate that the high concentration portion of the plume is still in the pilot study area. The pilot study has an extraction well placed in the segment of the plume with the highest concentration of strontium-90. Additional extraction wells may be installed to facilitate remediation if necessary. The high concentration segment is anticipated to remain within the pilot study area.

3.2.13.4 Recommendations

The following are recommendations for the OU III Chemical/Animal Holes groundwater monitoring program:

1) All 24 wells in the groundwater monitoring program will be sampled on a semi-annual basis and analyzed for strontium-90 in 2003. Specific wells will be sampled on a more frequent basis as part of the Strontium-90 Pilot Study.

2) The installation of an additional sentinel monitoring well is recommended to monitor the leading edge of the strontium-90 plume downgradient of the Former Landfill area. This well would be located along Middle Path to the west of existing well 106-62.

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 western sections of the BNL site. Tritium, gamma spectroscopy, and strontium-90 are analyzed annually from wells in these programs. The sampling will continue, in conjunction with the OU III South Boundary and Western South Boundary programs, to eliminate additional costs of collecting samples. The south boundary of the eastern portions of the site are monitored for radionuclides as part of the OU I South Boundary, EDB, and OU V Sewage Treatment Plant groundwater monitoring programs.

3.2.14.1 Groundwater Monitoring

Well Network: A network of 31 monitoring wells incorporates wells also sampled under the OU III South Boundary and OU III Western South Boundary programs. Their 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 will be sampled annually for tritium, strontium-90, and gamma spectroscopy (**Table 1-6**).

3.2.14.2 Monitoring Well Results

The radionuclide analytical results for the wells can be found in **Appendix C**. All detections are summarized in **Table 3.2.14-1**. There were only 2 detections (both of which were below NYS AWQS) during 2002, in deep Upper Glacial well 122-25.

3.2.14.3 Groundwater Monitoring Program Evaluation

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

1. Was the BNL Contingency Plan Triggered?

No. There were no unexpected results during 2002 that triggered 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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3.3 Operable Unit IV

3.3.1 Air Sparge/Soil Vapor Extraction (AS/SVE) Remediation System

In 1977, a 23,000 to 25,000 gallon mixture of Number 6 fuel oil and mineral spirits was released from a ruptured pipe used to transfer the contents from an underground storage tank (UST) to above ground storage tanks at the Central Steam Facility (CSF). The primary chemical contaminants in the OU IV plume near the 1977 spill site were TCA, PCE, DCE, TCE, toluene, ethylbenzene, and xylenes. In addition, several small spills of Number 6 fuel oil from the CSF fuel unloading area were documented between 1988 and 1993; it also is suspected that small volumes of solvents, such as PCE, were released to the ground near the CSF.

Air sparge (AS) with soil vapor extraction (SVE) was selected as the remedy for soil and groundwater contaminated with VOCs underlying OU IV. Three areas of soil and/or groundwater contamination were addressed in the remedial design.

The AS/SVE system operation began in November 1997. The performance goals for soil cleanup were achieved in 1998, while those for groundwater were met in August 2000. Subsequently, a formal petition for shutdown was submitted to the EPA and NYSDEC and approval was received in January 2001. The system was shutdown on January 10, 2001. However, following the shutdown, groundwater results were received for well 076-04 showing a rebound in several VOC parameters (indicative of fuel oil). This well is located in the area where the original fuel oil/solvent spill occurred and it had shown VOC levels below MCLs for nearly two years previously. As a result of this finding, pulsing of the AS/SVE system was activated on a weekly basis in February 2001. The system was pulsed for one day (approximately 24 hours) each week and focused on the sparge and extraction well in the vicinity of well 076-04. During the following months, analytical results from the monthly sampling showed a decreasing trend in VOC concentrations.

In addition, the supplemental action recommended in the 2000 BNL Groundwater Status Report was accomplished during July 29 to July 31, 2001. The objective of this action was to further reduce any residual VOCs, primarily ethylbenzene, xylenes and trimethylbenzenes, through enhanced biodegradation processes using an oxygen releasing compound (ORC). A slurry of a mixture of magnesium peroxide powder and water was injected under pressure at seven locations around well 076-04 into the water table. The system was shutdown on August 08, 2001 and further monitoring was continued as per *OU IV Remediation Area 1 Proposed Supplemental Remedial Effort - Work Plan, (BNL, May 2001c)*. A *Petition For Closure and Termination of Formal Post Closure Monitoring of OU IV Air Sparge/Soil Vapor Extraction Remediation System* was submitted in June 2002. BNL is currently awaiting regulatory approval for system closure.

3.3.1.1 Groundwater Monitoring

Well Network: A network of 21 wells was designed to monitor the effectiveness of the groundwater remediation system and extent of the VOC plume associated with the 1977 spill (**Figure 3.3.1-1**). During planning for placing the wells, the proximity of the RA V and HO Recharge basins was considered, along with their associated effects on local patterns of groundwater flow. Sixteen of the wells sampled under this program also monitor radionuclide contamination originating from Building 650's Sump Outfall Area. The two programs coordinate sampling to eliminate any duplication of effort.

<u>Sampling Frequency and Analysis</u>: The wells are sampled quarterly, and samples are analyzed for VOCs and SVOCs (**Table 1-6**). Some wells also are used for the OU IV AOC 6 (Building 650 Sump Outfall) program, and are analyzed semiannually for gross alpha/beta, gamma spectroscopy, Sr-90, and tritium.

3.3.1.2 Monitoring Well Results

Quarterly sampling of monitoring wells continued in 2002 as BNL awaited a decision from the regulatory agencies on system closure. The complete groundwater data are given in **Appendix C**. There were several detections of VOCs exceeding the NYS AWQS in wells 76-04 and 76-06. 1,2,4-trimethyl benzene was detected in 76-04 at 6 µg/L (fourth quarter) and in 76-06 at 6 µg/L (third quarter). 1,3,5-trimethyl benzene was detected in 76-06 at 10 µg/L (second quarter), 9 µg/L (third quarter), and 5 µg/L (fourth quarter). m/p xylene was detected in well 76-04 in the fourth quarter sample.

VOCs were not detected above NYS AWQS in the remainder of the wells in the monitoring program except for wells 76-19 and 76-185. These wells are located outside the area of influence of the AS/SVE system. The source of contamination in these wells is the Central Steam Facility.

3.3.1.3 Remediation System Evaluation

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

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

No. There were no unexpected VOC concentrations in groundwater during 2002.

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

Yes. The cleanup goals for this system have been met as per the *OU IV AS/SVE Operations, Maintenance and Monitoring Plan (BNL, 1999b).* Formal petition for system closure was submitted in the report titled *Petition For Closure and Termination of Formal Post Closure Monitoring of OU IV Air Sparge/Soil Vapor Extraction Remediation System (BNL, June 2002).*

<u>*3. Are additional enhancements (that is, ORC) necessary or is further operation of the AS/SVE system required?*</u>

No. VOC concentrations have remained below NYS AWQS with several exceptions (as noted previously) since the implementation of the ORC in August 2001. Neither the further operation of the AS/SVE system nor additional ORC enhancements is required.

3.3.1.4 Recommendations

The following are recommendations for the OU IV AOC 5 groundwater monitoring program.

- Conduct quarterly monitoring of wells 76-06, 76-19, and 76-23 for VOCs, beginning in August of 2003 for an additional period of one year. Monitoring of these wells will continue at a semi-annual frequency for up to 5 years beginning in 2004. Well abandonment will be initiated following approval for closure.

- Terminate monitoring for all OU IV AOC 5 wells that are below NYS AWQS including 76-02, 76-04, 76-05, 76-08, 76-178, 76-179, 76-180, 76-185, 76-186, 76-18, 76-21, 76-380, 76-07, 76-09, 76-181, 76-182, 76-183, 76-184, and 76-24.

- Monitoring wells containing VOCs from source(s) in the Central Steam Facility area (76-18, 76-19, and 76-380) will continue to be monitored under the BNL Facility Monitoring Program.

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

The Building 650 (Sump Outfall) Strontium-90 Monitoring Program monitors a strontium-90 plume emanating from contaminated soil within an area known as the Building 650 Sump Outfall Area. This area is a natural depression at the terminus of a discharge pipe from the building. The pipe conveyed discharges from the decontamination of radioactively contaminated clothing and equipment that was conducted on an outdoor pad at Building 650, beginning in 1959.

Remediation of the contaminated soils associated with the Building 650 sump outfall and the pipe leading to the outfall were excavated in 2002.

3.3.2.1 Groundwater Monitoring

Well Network: A monitoring network was designed to clarify the extent of strontium-90 contamination originating from the area of the Building 650 Sump Outfall. The network consists of 29 wells (five of which are used for the OU IV AOC 5 program) located to define the limits of strontium-90 contamination and serve as an early warning system for the downgradient migration of the plume (**Figure 3.3.2-1**).

Sampling Frequency and Analysis: The wells are monitored semiannually, and the samples analyzed for gross alpha/beta, gamma spectroscopy, tritium, and strontium-90 (**Table 1-6**).

3.3.2.2 Monitoring Well Results

The complete results from radionuclide sampling can be found in **Appendix C**. The overall extent of the strontium-90 plume originating from the Building 650 sump outfall did not change significantly during 2002 although it continues to migrate to the southwest (**Figure 3.3.2-2**). The highest strontium-90 concentrations were detected in well 76-13 at 27 pCi/L in August 2002. In general, the concentrations in wells associated with the Building 650 sump outfall remained relatively stable during 2002. The slow and steady increase in strontium-90 concentrations in well 76-263 continued during 2002. It appears that the center-line of the plume may be located just to the west of well 76-24 and is approaching 76-263 but remaining below the NYS DWS of 8 pCi/L.

Strontium-90 concentrations in well 76-28 remained at or below detectable levels during 2002 after showing significant increases in 2000 and 2001 (**Figure 3.3.2-3**). This well is located immediately north of Building 650, adjacent to a former decontamination pad. Contaminated soils were removed from the area of the former decontamination pad in 2002.

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 strontium-90 concentrations in groundwater during 2002.

2. Were performance objectives met?

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

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

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

3.3.2.4 Recommendations

The following are recommendations for the OU IV AOC 6 Strontium-90 monitoring program:

1) Continue to monitor well 76-28 to determine if remediation of the Building 650 decon pad has removed the source of this contamination.

2) Following the soil excavation work in the area of the Building 650 sump outfall a low spot has created a situation where precipitation runoff is collecting in the low lying area. The standing water will be pumped from this area and well 76-18 abandoned to prevent any migration of standing water into the monitoring well.

3.4 Operable Unit V

3.4.1 Sewage Treatment Plant Monitoring Program

Historically, Brookhaven's sewage treatment plant (STP) received discharges of contaminants from routine operations. Releases of contaminants, in particular VOCs, metals and radionuclides, to groundwater occurred via the STP sand filter beds and discharges to the Peconic River. The OU V project monitors the identified groundwater contamination in the area of the STP, eastern site boundary, and off-site.

3.4.2 Groundwater Monitoring

<u>Well Locations</u>: A monitoring network of 34 wells was designed to follow groundwater contamination in the vicinity of the STP, at the boundary, and off-site (**Figure 3.4-1**). Sentinel wells were installed downgradient of the leading edge of the off-site VOC plume. BNL's Groundwater Model was used to aid in placing these wells.

<u>Sampling Frequency and Analysis</u>: Wells are sampled semiannually, and samples are analyzed for VOCs, Pesticides/PCBs, water quality parameters, metals, and tritium (**Table 1-6**).

3.4.3 Monitoring Well Results

The OU V wells were sampled during two rounds in 2002. **Appendix C** contains the complete data. There were no significant changes to the VOC plume in 2002 as compared to 2001(**Figure 3.4-2**). The highest TVOC concentration was 12 µg/L in well 61-05 located near the eastern site property boundary. The vertical distribution of VOC contamination is shown in the cross section in **Figure 3.4-3**. In general, decreasing VOC concentrations continued in plume core wells (**Figure 3.4-4)**. The only individual VOCs detected at levels exceeding NYS AWQS were TCE and 1,2-dichloropropane. TCE was detected at 5.5 µg/L (NYS AWQS of 5 µg/L) in downgradient plume core well 000-122 during the first quarter of 2002. TCE was detected in well 61-05 at concentrations of 6.4 and 6.5 µg/L, respectively, during the 2002 sampling rounds. 1,2-Dichloropropane has been detected in shallow off-site sentinel well 600-25 at concentrations ranging between 1.4 and 2 µg/L (NYS AWQS of 1 µg/L) since sampling of this well began in 1998. During 2002 the concentrations were 1.4 µg/L and 1.7µg/L. There appears to be an off-site source for this contamination based on the shallow depth of the well and its location approximately 4,000 feet southeast of the BNL site boundary.

Several wells detected estimated concentrations of pesticides just above detectable limits during the August 2002 sampling round. There have been sporadic detections of pesticides historically in off-site wells. These detections are most likely the result of agricultural spraying of farms in the nearby vicinity.

Aluminum, iron, manganese, sodium, and thallium were detected in monitoring wells for the OU V program at concentrations above the applicable NYS AWQS levels. Aluminum was detected in 11 wells above the NYS AWQS of 200 µg/L. The highest concentration was 1,160 µg/L detected in well 061-03 during the first quarter sampling event. Iron was detected in 17 wells above the NYS AWQS of 300 µg/L. The highest concentration of iron was 31,500 µg/L detected in well 050-02 during the third quarter sampling event. Manganese was detected in 7 wells above the NYS AWQS of 300 µg/L. The highest concentration of manganese was 1,100 µg/L detected in well 50-02 during the second quarter sampling event. Sodium was detected in 2 wells above the NYS AWQS of 20,000 µg/L. The highest concentration of sodium was 25,700 µg/L detected in well 50-02 during the second quarter sampling event. Thallium was detected in 2 wells above the NYS AWQS of 0.5 µg/L. The highest concentration was 4.76 µg/L during the second quarter.

Hexavalent chromium was detected in five monitoring wells at concentrations ranging from 3 µg/L to 6 µg/L. However, total chromium was reported in these wells at concentrations ranging from non-detect to 2.36 µg/L, all of which were significantly below the associated hexavalent chromium levels. The hexavalent chromium methodology is subject to interferences, which can cause false positive results. The total chromium methodology is not subject to many of these interferences and is, therefore, a more accurate measure of the chromium present in the groundwater. Since the concentration of total chromium reported in these samples is below the hexavalent chromium values and well below the 50 µg/L NYS AWQS value, hexavalent chromium is not deemed to be an issue in these wells.

Tritium has historically been detected at low concentrations in monitoring wells 49-06, 50-02 and 61-05 (**Figure 3.4-5**). Historical trends for tritium in wells 50-02 and 61-05 are plotted in **Figure 3.4-6**. Tritium concentrations were barely above detectable levels in well 61-05, and at a high concentration of 2,300 pCi/L in well 50-02; this is almost ten times lower than the NYS DWS of 20,000 pCi/L.

Gross alpha and gross beta levels were consistent with established background levels for the site.

3.4.4 Groundwater Monitoring Program Evaluation

1. Was the BNL Groundwater Contingency Plan Triggered?

No. There were no unexpected VOC concentrations in groundwater during 2002.

2. Were the performance objectives met?

No. The performance objective for this program is to attain drinking water standards for VOCs in groundwater in the Upper Glacial aquifer within 30 years. These standards continue to be exceeded in two of the monitoring wells. **Figure 3.4-7** compares the plume distribution between 1997 and 2002. The leading edge of the plume is now estimated to be located between the LIE and South Street.

3. Is the extent of the plume still defined by the existing monitoring well network?

The leading edge of the plume is located to the southeast of well 000-122 (south of the LIE). Currently, two well clusters serve as sentinel wells for this plume along North Street and Wading River Road.

3.4.5 Recommendations

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

- Although there are presently sentinel wells south of the leading edge of the VOC plume, additional wells are recommended because the plume is narrow and there is potential for it to bypass the existing wells. A hydrogeologic evaluation, including some updated modeling, is recommended to re-evaluate the monitoring network with respect to the signed ROD requirements. This will determine whether any modifications to the monitoring well network are warranted.

- The contaminants of concern for the OU V STP are VOCs and tritium. Six years of semi-annual monitoring have resulted in only minor detections of radionuclides (other than tritium), pesticides, and metals. Therefore, it is recommended that these parameters be dropped from the sampling program beginning in August 2003. VOCs and tritium will continue to be monitored at a semi-annual frequency.

3.5 Operable Unit VI

3.5.1 EDB Monitoring Program

The OU VI EDB Program monitors the extent of an ethylene dibromide (EDB) plume in groundwater currently extending from 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. A groundwater remediation system to address the off-site EDB plume is being designed, and system construction is planned to begin in late 2003.

Pre-design groundwater characterization work was performed in 2001 and consisted of installing five vertical profiles. There is detailed information and data obtained during this investigation in the *OU VI EDB Plume Groundwater Remediation System 90 Percent Design Documents* (J.R. Holzmacher, 2002b).

3.5.2 Groundwater Monitoring

Well Locations: A network of 27 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**). Additional monitoring wells will be installed as part of the construction of the pump and treat system in 2003.

Sampling Frequency and Analysis: The wells are monitored quarterly, and analyzed for EDB. Samples are analyzed annually for VOCs, tritium and gross alpha/beta (**Table 1-6**).

3.5.3 Monitoring Well/Characterization Results

Appendix C contains the complete results of the quarterly sampling program. The distribution of the EDB plume is shown for the fourth quarter of 2002 in **Figure 3.5-2**. The leading edge of the plume is presently downgradient of monitoring wells 000-283 and 000-284. The installation of additional sentinel wells to monitor the leading edge of the plume is scheduled for 2003. The plume is located in the deep Upper Glacial aquifer and is generally moving horizontally as depicted in **Figure 3.5-3**. The highest EDB concentration observed during 2002 was 4.6 µg/L in well 000-284. The Federal Drinking Water Standard for EDB is 0.05 µg/L. A summary of all EDB detections exceeding the Federal Drinking Water Standard in 2002 is provided in **Table 3.5-1**.

The southward migration of the plume can be observed by analyzing the trends in **Figure 3.5-4**. EDB shows decreasing trends for wells north of the current plume's core position. In contrast, EDB is increasing in the wells currently in the plume core area. Comparing the plume's distribution from 1997 to 2002 in **Figure 3.5-5** also illustrates plume movement.

The wells are sampled annually for VOCs in addition to EDB. There were several detections above detection limits but none exceeded NYS AWQS in any of the wells (**Appendix C**).

The wells are sampled annually for radionuclides. There were no detections observed in 2002.

3.5.4 Monitoring Program Evaluation

The plume is migrating as predicted by groundwater modeling. Installing new monitoring wells during system construction in 2003 will address the current gap in the data at the leading edge of the plume. The groundwater remediation system will be constructed in late 2003 and is scheduled to be operational in 2004.

3.5.5 Recommendations

- The EDB Monitoring Program will be enhanced with additional wells in 2003 to more precisely monitor the high concentration area of the EDB plume and sentinel wells downgradient of the plume edge. No additional modifications to the monitoring program are warranted at this time.

- Eliminate annual sampling for gross alpha/beta. The only detections over the past several years have been barely above background levels and well below NYS AWQS.

3.6 Site Background Monitoring

Background water quality has been monitored since 1996. 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 2002 program included ten wells located in the northwestern portion of the BNL property and adjacent off-site areas (**Figure 3.6-1**). Background quality is defined as the quality of groundwater that is completely unaffected by BNL's operations.

Sampling Frequency and Analysis: The samples were analyzed for VOCs (**Table 1-6**).

3.6.2 Monitoring Well Results

The complete groundwater data is provided in **Appendix C**. There were detections of trace amounts of several VOCs in the site background wells. All VOC detections were below NYS AWQS. The highest concentration detected was m/p xylene at 1.7 µg/L in well 034-02.

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 2002. Based on these results there has not been any impact to BNL groundwater quality from upgradient contaminant source(s).

3.6.4 Recommendations

No modifications are recommended to this monitoring program.

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4.0 ENVIRONMENTAL SURVEILLANCE PROGRAM SUMMARY

BNL's Environmental Surveillance (ES) Program monitors the groundwater quality at 13 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 eleven research and support facilities are monitored in accordance with DOE Order 5400.1. This Order requires BNL 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 2002, 130 groundwater surveillance wells were monitored in approximately 280 individual samplings. Potential threats to groundwater quality at each of the monitored research and support facilities are described below. **Table 1-7** summarizes ES Groundwater Monitoring Program's wells by project. The monitoring wells' screened depths and specific analytical requirements are provided in **Table 1-8**. Analytical results from groundwater samples collected in 2002 can be found in **Appendix D** located on the accompanying CD-ROM.

4.1 Alternating Gradient Synchrotron (AGS) Complex

Activated soils have been created near a number of AGS experimental areas as the result of secondary particles (primarily neutrons) produced at beam targets and beam stops. Radionuclides, such as tritium and sodium-22, have been produced by the interaction of these secondary particles with the soils that surround these experimental areas. To prevent rainwater from leaching these radionuclides from the soils and transporting them to the groundwater, impermeable caps have been constructed over these soil activation areas.[1] BNL uses approximately 50 groundwater monitoring wells to evaluate the impact of current and historical operations at the AGS's beam stop and target areas. The locations of permanent monitoring wells are shown on **Figure 4-1**.

During 2002, 49 monitoring wells were used to evaluate groundwater quality near areas of potential soil activation within the AGS Complex (e.g., 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). Since 1999, BNL's improved monitoring program has detected three tritium plumes that originated from activated soil shielding. These plumes originated from the g-2/VQ12 experimental area, the former U-Line beam stop, and the former E-20 Catcher. The subsequent installation of impermeable caps over these soil activation areas has resulted in a reduction of tritium levels to less than the 20,000 pCi/L drinking water standard in the Former U-Line and E-20 Catcher areas. As discussed below, tritium concentrations well above 20,000 pCi/L continue to be detected downgradient of the g-2/VQ12 soil activation area (see **Section 4.1.5**).

Historical surface spills and discharges of solvents to cesspools and recharge basins near the AGS have contaminated soils and groundwater with volatile organic compounds (VOCs). VOC contamination is monitored under the ER OU III Central groundwater monitoring program (see **Section 3.2.10**).

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[1] Assessment and design criteria for potential soil activation areas are described in the SBMS Accelerator Safety Subject Area.

4.1.1 AGS Building 912

Building 912 consists of five interconnected structures that house four experimental beam lines (A, B, C, and D Lines) consisting of magnets, instrumentation, high voltage electrostatic devices, beam targets, radiation shielding, cooling water systems and experimental detectors. A typical beam line contains bending and focusing electro-magnets along with their associated electrical power supplies, cooling water systems and vacuum pipes.

Beam loss and production of secondary particles at proton target areas results in the activation of adjacent equipment, floors, and probably the soils beneath the building's floor. The highest levels of soil contamination 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 located to the north of the AGS complex. Therefore, it is believed that the potentially activated soils underlying the beam targets and stops are adequately protected from surface water infiltration.

4.1.1.1 Groundwater Monitoring

Well Network: Seventeen shallow Upper Glacial aquifer wells are located 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 areas. The downgradient wells are positioned to be directly downgradient of significant beam stop and target areas within Building 912.

Sampling Frequency and Analysis: During 2002, Building 912 wells that were used to help track the g-2/VQ-12 tritium plume were sampled quarterly, whereas the remainder of the wells were sampled semiannually. The groundwater samples were analyzed primarily for tritium (**Table 1-7**).

4.1.1.2 Monitoring Well Results

Other than tritium contamination that is traceable to the g-2/VQ12 magnet source area, groundwater surveillance data for 2002 do not indicate that appreciable levels of tritium are being released from potentially activated soils located beneath the experimental floor of Building 912. The g-2 tritium plume has been tracked from the VQ-12 magnet source, beneath a portion of Building 912, to an area located just to the southwest of the Waste Concentration Facility (**Figure 4-1**). Elevated levels of tritium from this plume were detected downgradient of Building 912, primarily in well 065-122. Furthermore, low levels of tritium that are traceable to the former U-Line target and stop area have been detected in upgradient wells 054-69 and 055-14. In areas not impacted by the g-2 tritium plume or former U-Line experimental areas, tritium was either not detectable or was only observed at trace levels. As described in Section 4.1.5, BNL is preparing an Engineering Evaluation/Cost Analysis (EE/CA) for the g-2 Tritium Plume to evaluate the adequacy of the corrective actions taken to date, and the need for further actions. During 2002, BNL conducted additional characterization work designed to obtain the necessary plume concentration and position data required to prepare the EE/CA.

4.1.1.3 Groundwater Monitoring Program Evaluation

As noted above, in areas not impacted by the g-2 tritium plume or former U-Line experimental areas, tritium was either non-detectable only observed at trace levels. These results indicate that the building and associated stormwater management operations are effectively preventing rainwater from infiltrating activated soils located below the experimental hall.

4.1.2 AGS Booster

The AGS Booster is a circular accelerator with a circumference of nearly 660 feet, and is connected to the northwest portion of the main AGS ring and the 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. The Booster accelerates protons and heavy ions prior to injection 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 constructed at the 10/11 o'clock portion of the Booster.

The AGS Booster beam scraper is an area where the interaction of secondary particles and soil surrounding the Booster tunnel can result in production of tritium. Although internal shielding around the beam scraper was designed to keep secondary particle interactions with the soil to very low levels, a landfill-type geomembrane cap was constructed over the scraper region to provide an extra level of protection.

4.1.2.1 Groundwater Monitoring

Well Network: Two shallow Upper Glacial aquifer monitoring wells (064-51 and 064-52) are located approximately 250 feet downgradient of the beam scraper (**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: During 2002, the Booster area wells were monitored semiannually, and the samples were analyzed for tritium (**Table 1-7**).

4.1.2.2 Monitoring Well Results

During 2002, only a trace amount of tritium was detected downgradient of the Booster, with the November sample from well 064-52 having a tritium concentration of 445 pCi/L. This trace level may be related to tritium that may have been released during temporary disturbance of the Booster cap in 1999 (see below).

4.1.2.3 Groundwater Monitoring Program Evaluation

The low-levels of tritium detected during 2001-2002 may be related to a short-term uncovering of activated soil shielding near the Booster Beam Stop during the construction of the tunnel leading from the Booster to the new NASA Space Radiation Laboratory (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. (Note: 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.)

4.1.3 E-20 Catcher

The E-20 beam catcher was used from 1984 to 1999. It is located at the 5 o'clock position of the AGS ring (**Figure 4-1**). The E-20 Catcher is a minimum aperture area of the AGS ring, and is used to pick up or "scrape" protons that move out of acceptable pathways. The E-20 Catcher was subject to injection, transition, ejection, and losses studies, and picked up about 80 to 90 percent of all of these losses.

Like other beam loss areas within the AGS complex, the E-20 Catcher is an area where the soils surrounding the AGS tunnel became activated by the interaction with secondary particles. In late 1999, tritium and sodium-22 were detected in two wells located 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, four Geoprobe wells were installed in January 2000. Tritium and sodium-22 levels in the temporary wells were found to exceed the drinking water standards, 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 to prevent rainwater infiltration and the continued leaching the radionuclides out of the soils and into groundwater. A permanent cap was constructed by October 2000, and an additional downgradient well was installed to allow for improved long-term monitoring.

4.1.3.1 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, 064-56 and 064-80. These wells are located approximately 100 feet downgradient of the source area (**Figure 4-1**).

Sampling Frequency and Analysis: During 2002, the E-20 Catcher wells were monitored semiannually, and the samples were analyzed for tritium (**Table 1-7**).

4.1.3.2 Monitoring Well Results

Following the installation of the cap in 2000, tritium and sodium-22 concentrations were found to be below applicable drinking water standards during 2001, with a maximum tritium concentration of 2,070 pCi/L, and a maximum sodium-22 concentration of 163 pCi/L. Monitoring conducted during 2002 continued to show that tritium concentrations were decreasing, with a maximum concentration of only 774 pCi/L detected in well 064-80.

4.1.3.3 Groundwater 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 soils that surround that portion of the AGS tunnel.

4.1.4 Building 914

Building 914 houses the transfer line between the main 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 structure, soil activation is likely to be limited to the areas below the floor of the building. As with other beam loss areas within the AGS complex, soil activation could result in the introduction of tritium and sodium-22 to the groundwater below the facility. Water infiltration through potentially activated soils is likely to be minor, because the soils are isolated beneath the floor of the building, and portions of the transfer tunnel are covered with a soil-crete mixture.

4.1.4.1 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 2002, the Building 914 area wells were monitored semiannually, and the samples were analyzed for tritium (**Table 1-7**).

4.1.4.2 Monitoring Well Results

During 2002, tritium was not detected in any of the Building 914 area monitoring wells.

4.1.4.3 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 soils located below the building.

4.1.5 g-2 Beam Stop and VQ-12 Magnet Area

The g-2 experiment started operations in 1997. The beam line has a beam stop that is composed of iron. The iron beam stop is covered by soil. Like other beam loss areas within the AGS complex, the g-2 Beam Stop is an area where the soils surrounding the stop may become activated by the interaction with secondary particles. To prevent rainwater from infiltrating the soils surrounding the beam stop, BNL installed a gunnite cap over the stop area prior to the start of beam line operations.

In November 1999, monitoring wells located 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-December 1999 revealed a narrow plume of tritium approximately 20-30 feet wide and 250-300 feet long, with a maximum tritium concentration of 1,800,000 pCi/L and sodium-22 concentration of 60 pCi/L (or 15% of the 400 pCi/L drinking water standard for sodium-22).

Following the discovery, an investigation into the source of the contamination revealed that the tritium originated from activated soil shielding located adjacent to the g-2 experiment's VQ-12 Magnet. In December 1999, an impermeable cap was installed over the VQ12 soil activation area to prevent rainwater infiltration and the continued leaching the radionuclides out of the soils and into groundwater. In September 2000, the activated soil shielding and the associated tritium plume were designated as new sub-Area of Concern 16T. Following this designation, DOE agreed to prepare an Engineering Evaluation/Cost Analysis (EE/CA) to evaluate the adequacy of the corrective actions taken to date, and the need for further actions. During 2001, BNL conducted additional characterization work designed to obtain the necessary plume concentration and position data required to prepare the EE/CA.

4.1.5.1 Groundwater Monitoring

Well Network: A total of 27 wells are used to monitor the g-2 Beam Stop and the tritium plume that originates from the VQ12 magnet area (**Figure 4-1**). Groundwater quality downgradient of the g-2 Beam Stop is monitored using three downgradient wells, and the tritium plume originating from the VQ12 magnet area is monitored using 23 downgradient wells.

Sampling Frequency and Analysis: During 2002, the g-2 beam stop wells were monitored semiannually, and tritium plume wells were monitored quarterly. All samples were analyzed for tritium, and select samples from the tritium plume were analyzed for sodium-22 (**Table 1-7**).

4.1.5.2 Monitoring Well Results

g-2 Tritium Plume: Samples collected during 2002 from wells located approximately 150 feet downgradient of the VQ12 area indicate that tritium continues to be released to the groundwater (**Figure 4-3**). The highest tritium concentrations were measured in July 2002, when 3,440,000 pCi/L were detected in a sample from monitoring well 054-07 (which is located immediately west of Building 912A). In the area to the east of Building 912, tritium concentrations decreased from a maximum of 58,900 pCi/L (in well 065-122) in April to 12,500 pCi/L (in well 065-123) in October. **Figure 4-2** shows the position of the g-2 tritium plume. The two segments of the plume are representative of two distinct periods of tritium release (also referred to as slug releases). The leading segment of tritium contamination was released in 1999 prior to the installation of the cap over the VQ12 area, and the second slug is related to tritium released in 2001-2002. The leading hypothesis at this time for the second release is that a natural rise in the water table may have released residual tritium from the unsaturated soil into the groundwater. It is believed that this tritium was mobilized to the soils close to the water table before the cap was put in place in December 1999. Inspections of the cap and review of its design have concluded that the cap over the VQ12 area has not failed and is properly positioned. The cap appears to be effective in preventing the infiltration of rainwater into the activated soil-shielding zone.

Because of the continued release of tritium from the VQ12 area, BNL and the regulatory agencies decided that additional monitoring data would be needed to better evaluate the vadose zone release hypothesis before finalizing the Engineering Evaluation/Cost Analysis (EE/CA) and submitting the Action Memorandum. In early 2003, BNL will collect additional groundwater samples using permanent and temporary wells, and BNL will also investigate other potential water pathways that could mobilize tritium from the vadose zone. These include stormwater running into cable trenches that run close to the VQ12 soil activation area, perched zones in the subsurface soils and nearby sheet piling that extends into the groundwater.

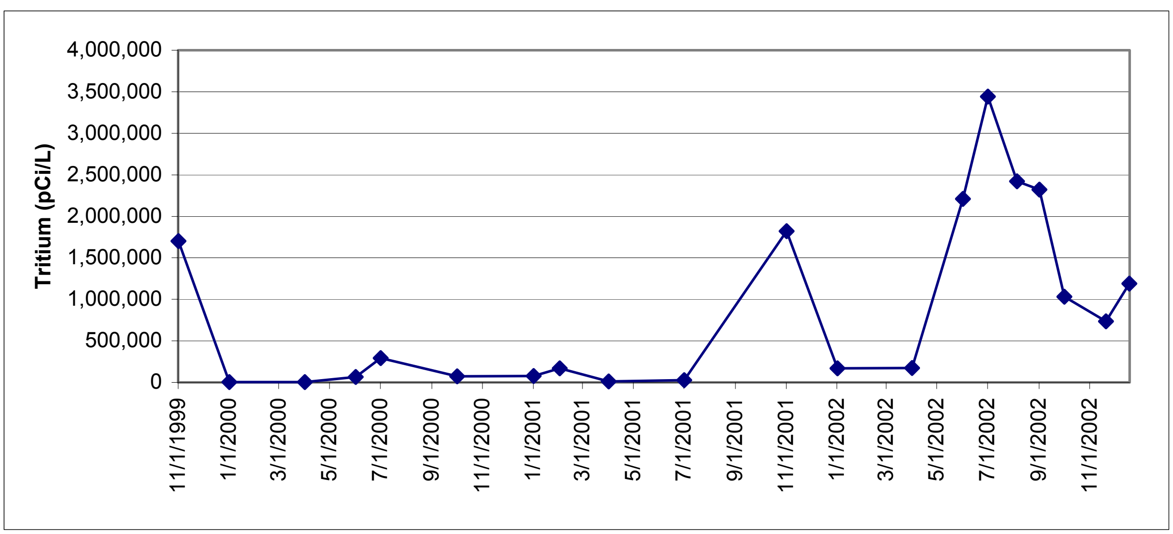

Figure 4-3. Maximum tritium concentrations detected downgradient of the VQ12 source area, in permanent and temporary wells located along the west side of Building 912A.

g-2 Beam Stop: During 2002, tritium was not detected in any of the three monitoring wells located downgradient of the g-2 beam stop.

4.1.5.3 Groundwater Monitoring Program Evaluation

It is likely that the continued presence of high levels of tritium in groundwater directly downgradient of the source area is due to the release of residual tritium from the vadose zone following a natural fluctuations in water table position. BNL and the regulatory agencies determined that additional monitoring of the permanent wells would be required before completing the g-2 tritium plume EE/CA and Action Memorandum.

Monitoring of wells downgradient of the g-2 beam stop indicates that cap is effective in preventing rainwater from infiltrating the activated soil shielding.

4.1.6 J-10 Catcher

In 1998, BNL established a new beam stop at the J-10 (12 o'clock) section of the AGS Ring (**Figure 4-1**). The J-10 stop serves as the preferred repository for any beam that might be lost in the AGS Ring. Activation products are likely to be produced in the soils surrounding the tunnel adjacent to 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 above. The ability of rainwater to infiltrate potentially activated soils surrounding the J-20 is likely to be significantly reduced because the AGS tunnel has been covered by layers of sand, Styrofoam and soil-crete. In an effort to further reduce the potential for surface water to infiltrate activated soils, BNL constructed a gunnite cap over remaining exposed soil areas overlying the J-10 region prior to its operation.

4.1.6.1 Groundwater Monitoring

Well Network: The monitoring well network for the J-10 beam stop consists of one upgradient (054-62) and two downgradient wells (054-63 and 054-64).

Sampling Frequency and Analysis: During 2002, the three J-10 beam stop wells were monitored semiannually, and the samples were analyzed for tritium.

4.1.6.2 Monitoring Well Results

Low levels of tritium (up to 987 pCi/L) were detected in both samples from downgradient well 054-64. Prior to the beginning of beam-scraping activities at J-10 in December 1999, low levels of sodium-22 had been detected in this area, and trace levels of tritium were detected in 2001. It is likely that the trace levels of tritium and sodium-22 are related to historical low-level activation of soils along this section of the beam line.

4.1.6.3 Groundwater Monitoring Program Evaluation

Available data suggests that the engineered controls in place at J-10 are providing effective control in preventing rainwater infiltration into the activated soil shielding. Low levels of sodium-22 have been detected in this area of the AGS Ring even before beam-scraping activities at J-10 began in December 1999. Therefore, the low-levels of tritium and sodium-22 may be related to historical low-level activation of soils along this section of the beam line.

4.1.7 Former U-Line Target and Beam Stop Areas

The U-Line target area was in operation from 1974 through 1986. During its operation, a 28 GeV 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 located in a ground-level tunnel covered with an earthen berm. Internal shielding was stacked around the horns. Although the U-Line target has not been in operation since 1986, the associated tunnel, shielding and overlying soils remain in place. The former U-Line 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 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 drinking water standards. In early 2000, BNL installed four Geoprobe wells downgradient of the former U-Line beam stop, which is located 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 stop soil activation area to prevent additional rainwater infiltration and the continued leaching the radionuclides out of the soils and into groundwater. By October 2000, a permanent cap was constructed over the U-Line stop area, and two additional permanent wells were installed to provide improved long-term monitoring of this source area.

4.1.7.1 Groundwater Monitoring

Well Network: The former U-Line area is monitored by one upgradient and seven downgradient wells. Three of the downgradient wells monitoring the target area, whereas the beam stop is monitored using four downgradient wells (**Figure 4-1**).

Sampling Frequency and Analysis: During 2002, the former U-Line area wells were monitored semiannually, and the samples were analyzed for tritium (**Table 1-7**).

4.1.7.2 Monitoring Well Results

U-Line Target Area: The highest tritium concentration during 2002 was 7,450 pCi/L in Well 054-129 located approximately 200 feet downgradient of the target area.

U-Line Beam Stop Area: During 2002, the maximum observed tritium concentration was 5,650 pCi/L in downgradient well 054-168.

4.1.7.3 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 drinking water standard. Furthermore, the significant decrease in tritium concentrations observed in wells located downgradient of the U-Line beam stop since 2000, indicate that the impermeable cap has been effective in stopping rainwater infiltration into the residual activated soils surrounding the beam stop.

4.2 Brookhaven LINAC Isotope Producer (BLIP) Area

When the BLIP is operating, the LINAC delivers a 200 MeV beam of protons that impinge on a series of eight targets located within the BLIP target vessel. During irradiation, the BLIP targets are located at the bottom of a 30-foot underground tank. The targets rest inside a water-filled 18-inch diameter shaft that runs the length of the tank, and are cooled by a 500 gallon closed loop primary cooling system. During irradiation, several radionuclides are produced in the cooling water, and activation of the soils immediately outside of the tank occurs due to the creation of secondary particles produced 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 vessel's outer wall is used as secondary containment system for the primary vessel. The BLIP target vessel system conforms to Suffolk County Article 12 requirements, and is registered with SCDHS. The BLIP facility also has a 500 gallon-capacity UST used 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. Elevated levels of tritium (11,400 pCi/L) and sodium-22 (at 38 pCi/L) were also detected in shallow groundwater samples collected from a temporary well that was installed 150 feet downgradient of the BLIP. Due to the activation of soils and the detection of tritium and sodium-22 in groundwater, the BLIP facility has been designated as AOC 16K under the Environmental Restoration program.

Starting in 1998, BNL made improvements to the stormwater management program at BLIP in an effort to prevent rainwater infiltration of the activated soils below the building. The BLIP building's roof drains were redirected away from the building, paved areas were resealed, and an extensive gunnite (cement) cap was installed on three sides of the building. In May-June 2000, BNL undertook additional protective measures by injecting a colloidal silica grout into the activated soils. The grout reduces the permeability of the soils, thus further reducing the potential of rainwater leaching radionuclides out of the soil and into groundwater.

4.2.1 Groundwater Monitoring

Well Network: The monitoring well network for the BLIP facility consists of two upgradient and five downgradient wells. These wells were installed as 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 2002, most of the BLIP area wells were monitored quarterly. All samples were analyzed for tritium, and select samples from several wells were analyzed for sodium-22 (**Table 1-7**).

4.2.2 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 soils 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 in late May-early June 2000 (**Figure 4-4**). Samples collected in early July indicated tritium and sodium-22 concentrations of 5,700 pCi/L and 57 pCi/L, respectively. By early October, 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. In accordance with the BNL Groundwater Contingency Plan, BNL and DOE notified the regulatory agencies of this situation and increased the groundwater sampling frequency to bi-weekly. At the request of the agencies, the well sampling frequency was increased to weekly starting December 1, 2000. The maximum sodium-22 concentration was 299 pCi/L detected in well 064-67 on December 1, 2000. By December 21, 2000, tritium concentrations dropped to below the 20,000 pCi/L drinking water standard in wells located approximately 40 feet downgradient of BLIP, and weekly sampling of the wells was discontinued by the end of January 2001.

During 2001 - 2002, tritium concentrations in wells located 40 feet downgradient of BLIP did not exceed the 20,000 pCi/L standard (**Figure 4-4**). During 2002, the maximum tritium concentration was 15,100 pCi/L detected in well 064-67. As the slug of tritium released during the Viscous Liquid Barrier (VLB) grout project continued to migrate downgradient, tritium concentrations in well 064-50 increased, and reached a maximum of 60,800 pCi/L in July 2001. During the remainder of 2001 and 2002, tritium concentrations in well 064-50 fluctuated. Concentrations declined to less than 20,000 pCi/L by November 2001, increased to a maximum of 44,100 pCi/L in April 2002, then steadily declined to less than 5,000 pCi/L by July 2002 (**Figure 4-5**).

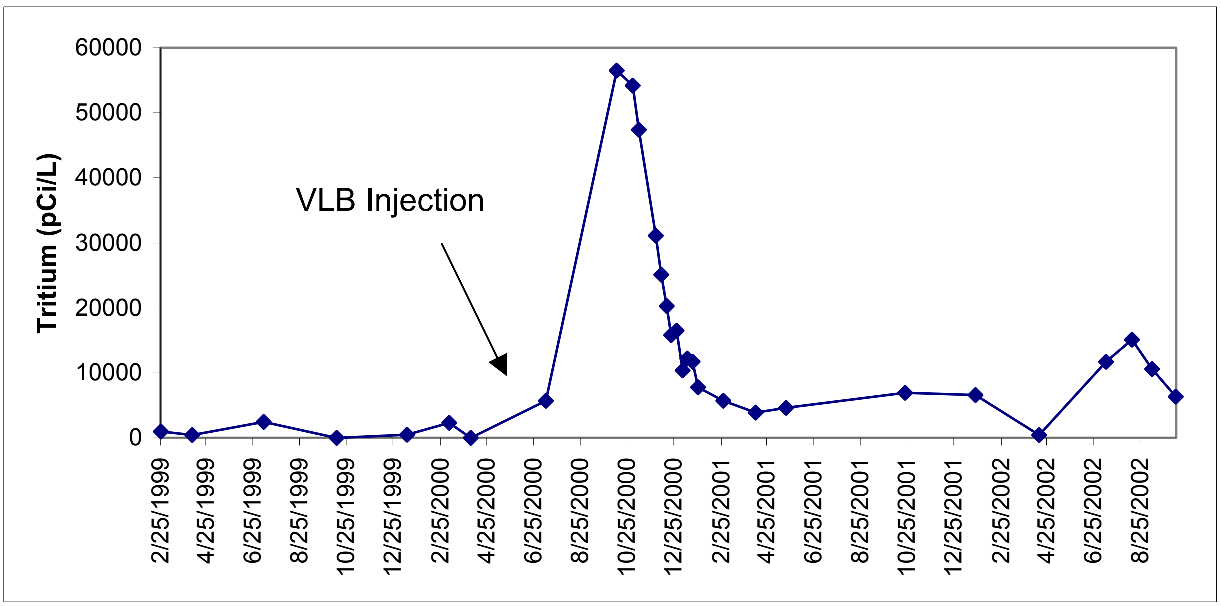

Figure 4-4. Maximum tritium concentrations detected in wells located approximately 40 feet downgradient of the BLIP target vessel.

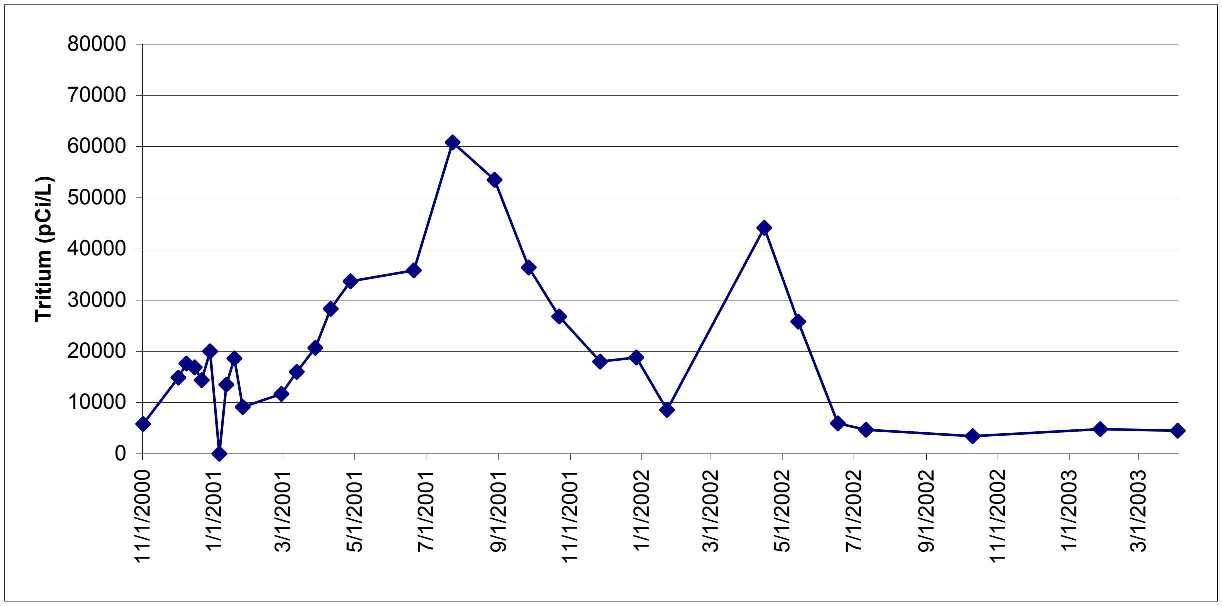

Figure 4-5. Maximum tritium concentrations detected in wells located approximately 150 feet downgradient of the BLIP target vessel.

4.2.3 Groundwater Monitoring Program Evaluation

Following the detection of elevated tritium concentrations in October 2000, BNL conducted a review of the grouting process. Findings of this review suggested that that grout displaced residual vadose zone soil pore water that was contaminated with tritium. The pattern of decreasing tritium concentrations in wells directly downgradient of BLIP indicate a short-term (pulsed) tritium release and that the tritium released as a result of the grout injection has dissipated quickly in the aquifer.

4.3 Relativistic Heavy Ion Collider (RHIC)

Beam line interaction with the RHIC collimators and beam stops will produce secondary particles that will interact with some of the soils surrounding the 8 o'clock and 10 o'clock portions of the RHIC tunnel, and the W-Line stop. These interactions will result in the production of tritium and sodium-22, which could be leached out of the soils by rainwater. Prior to the start of RHIC operations, BNL installed impermeable caps over these beam loss areas to reduce the potential impact to environmental quality.

4.3.1 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 4-6**). As an extension to the groundwater monitoring program, surface water samples are also collected from the Peconic River both upstream and downstream of the beam stop area to ensure that potentially activated groundwater is not being discharged into the Peconic River stream bed during high water table conditions.

Sampling Frequency and Analysis: During 2002, groundwater samples were collected from the thirteen RHIC monitoring wells on a semiannual schedule, and the samples were analyzed for tritium (**Table 1-7**). Routine analysis for sodium-22 was dropped from the groundwater surveillance program 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 also collected semiannually, and analyzed for tritium.

4.3.2 Monitoring Well Results

As in past years, no tritium was detected in any of the groundwater samples. Furthermore, no tritium was detected in the surface water samples collected from the Peconic River both upstream and downstream of the beam stop area.

4.3.3 Groundwater Monitoring Program Evaluation

Groundwater and surface water monitoring data continue to demonstrate that the impermeable caps that were constructed over the RHIC beam stop and collimator areas have been effective in preventing rainwater infiltration into potentially activated soils.

4.4 Brookhaven Medical Research Reactor (BMRR)

The BMRR is a 3 MW light water reactor that was used for biomedical research. Research operations at the BMRR stopped in December 2000, and BNL is preparing plans to permanently decommission the facility.[2]

The BMRR's primary cooling water system consists of a recirculation piping system that contains 2,550 gallons of water containing high levels of tritium (tritium concentration in 1997 was 465 µCi/L). Unlike the High Flux Beam Reactor, the BMRR does not have a spent fuel storage canal or pressurized imbedded piping systems that contain radioactive liquids. Historically, fuel elements that required storage are either stored within the reactor vessel, or were transferred to the HFBR spent fuel canal. The primary system's piping is fully exposed within 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 process supply well 105 or the BNL Chilled Water System. This secondary water was discharged to recharge basin HP located 800 feet to the south of the Medical Department complex, and was monitored as part of the SPDES program.

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 drinking water standard of 20,000 pCi/L. The tritium 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 (non-radioactive) cooling water until 1997. The infiltration of this water may have promoted the movement of residual tritium from the soils 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 soils.

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[2] All spent fuel is scheduled to be removed from the BMRR by early 2003. Drainage of the primary cooling water will be completed sometime following fuel removal.

4.4.1 Groundwater Monitoring

Well Network: The monitoring well network for the BMRR facility consists of one upgradient and three downgradient wells (**Figure 4-7**). Samples collected from four groundwater monitoring wells are used to verify that the engineered and administrative controls described above are effective in preventing additional impacts to groundwater quality.

Sampling Frequency and Analysis: During 2002, the BMRR wells were monitored semiannually, and the samples were analyzed for tritium (**Table 1-7**).

4.4.2 Monitoring Well Results

Monitoring results for sampling conducted during 2002 indicates that tritium concentrations continued to be well below the drinking water standard of 20,000 pCi/L. Detectable levels of tritium were observed in all three downgradient wells, with the maximum value of 4,680 pCi/L in Well 084-27 (**Figure 4-8**).

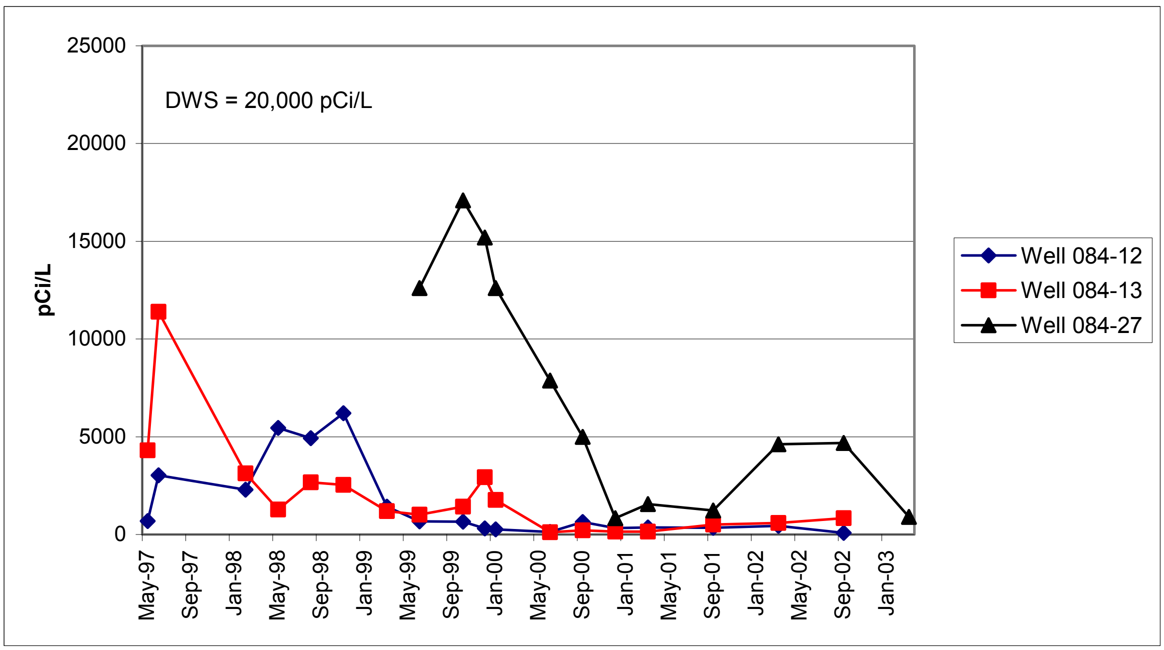


Figure 4-8. Tritium concentrations downgradient of the BMRR from 1997 through 2002.

4.4.3 Groundwater Monitoring Program Evaluation

Compared to the initial monitoring results from 1997, tritium concentrations in groundwater have shown a steady decline. Discontinuing the use of the BMRR's floor drains has apparently helped to reduce the movement of residual tritium from the soils surrounding the floor drain piping system to the groundwater.

4.5 Sewage Treatment Plant

The STP processes sanitary sewage for BNL facilities. The STP processes an average of 0.72 million gallons per day (MGD) during non-summer months and approximately 1.25 MGD during the summer months. Treatment of the sanitary waste stream includes: primary clarification to remove settleable solids and floatable materials; aerobic oxidation for secondary removal of the biological matter and nitrification of ammonia; secondary clarification; sand filtration for final effluent polishing; and, ultraviolet disinfection for bacterial control prior to discharge into the Peconic River. By regulating the oxygen levels during the treatment process, nitrogen can be biologically removed by using nitrate bound oxygen for respiration. This discharge is regulated under a NYSDEC SPDES permit (NY-0005835).

Wastewater from the STP's clarifier is released to the sand filter beds, where the water percolates through three 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% 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 to the east of the sand filter bed area. The hold-up ponds are used for the emergency storage of 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 are equipped with fabric reinforced (hypalon) plastic liners that are heat-welded along all seams. The first lined hold-up pond was constructed in 1978, and has a capacity of approximately four million gallons. A second four million gallon capacity lined pond was constructed in 1989, for a combined capacity of nearly eight million gallons. The combined capacity of the hold-up ponds provides the Laboratory with the ability to divert all sanitary system effluent for approximately twelve days. 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 are now used as secondary containment.

4.5.1 Groundwater Monitoring

Well Network: The STP's groundwater monitoring program is designed to provide a secondary means of verifying that STP operations are not impacting environmental quality. Six wells are used to monitor groundwater quality in the filter bed area and three wells are monitored in the holding pond area (**Figure 4-9**).

Sampling Frequency and Analysis: During 2002, the nine STP wells were monitored semiannually, and samples were analyzed for VOCs, anions, metals, tritium, gross alpha, gross beta, and gamma emitting radionuclides (**Table 1-7**).

4.5.2 Monitoring Well Results

Radiological Analyses: Radioactivity levels in samples collected from the STP wells during 2002 were consistent with ambient (background) levels from naturally occurring radionuclides. The exception was a trace level of tritium (626 pCi/L) detected in one sample from well 039-89. During 2001, this same well had a tritium concentration of 1,420 pCi/L. This well is located downgradient of the holding ponds. Because the ponds have not been used recently to hold tritiated waste water and the wells are also located downgradient of the filter bed area, it is likely that the tritium originated from past water releases to the filter beds.

Non-radiological Analyses: During 2002, all water quality and most metals concentrations were below the applicable New York State Ambient Water Quality (NYS AWQS). Sodium was detected at concentrations slightly above the NYS AWQS of 20 mg/L in three filter bed area wells. Wells 039-07, 039-08 and 039-86 had maximum sodium concentrations of 28 mg/L, 32.2 mg/L and 32.8 mg/L, respectively. Nitrates were detected in most filter bed area wells, with a maximum concentration of 8.3

mg/L detected in monitoring well 039-08. The NYS AWQS for nitrate is 10 mg/L. No volatile organic compounds were detected in any of the monitoring wells.

4.5.3 Groundwater Monitoring Program Evaluation

Monitoring results for 2002 indicate that STP operations are not impacting groundwater quality, and that BNL's administrative and engineered controls designed to prevent the discharge of chemicals and radionuclides to the sanitary system have been highly effective.

4.6 BNL Shotgun Range

The BNL shotgun range is utilized for trap and skeet target shooting by the Brookhaven Employees Recreation Association (BERA), and has been in operation since 1974. The shotgun range is located in an isolated, wooded area north of the new Waste Management Facility (**Figure 4-10**). Although most of the shot falls within the cleared range, shooting from several of the trap line positions results in the deposition of some of the shot into the nearby wooded areas.

From 1974 until 2000, the types of shotgun shells used at the facility typically contained lead pellets. It is estimated that as many as 30,000 shotgun rounds per year have been used at the range. At an average of 1.125 oz. per round, as much as 2,100 pounds of lead may have been deposited on the surface of the range annually. To prevent additional deposition of lead, in early 2000 BNL implemented a rule that allows only steel shot to be used at the range.

4.6.1 Groundwater Monitoring

Well Network: The monitoring well network for the Shotgun Range consists of one upgradient and two downgradient wells (**Figure 4-10**).

Sampling Frequency and Analysis: During 2002, the Shotgun Range wells were monitored one time, and the samples were analyzed for metals (**Table 1-7**).

4.6.2 Monitoring Well Results

During 2002, the groundwater monitoring wells at the Shotgun Range were sampled in March. As in past years, all metals concentrations were below the applicable NYS AWQS, and were consistent with established background levels.

4.6.3 Groundwater Monitoring Program Evaluation

Groundwater monitoring data collected since 2000 indicate that Shotgun Range operations have not impacted groundwater quality. Starting in 2003, routine groundwater surveillance program for the range be suspended. The wells will be maintained for the collection of routine water level measurements, which are used to assess site-wide groundwater flow patterns, and for potential future water quality sampling.

4.7 BNL Live Fire Range

The BNL Live-Fire Range consists of a six-position, 100-yard, bermed outdoor small arms and grenade range. The primary use of the current facility is to allow members of the BNL Police Group to practice and qualify in the use of firearms and to gain experience in the use of smoke and CS gas grenades. Federal law enforcement agencies and BERA also occasionally use the range.

The present BNL Live-Fire Range was constructed in 1986, and is located immediately to the north of the BNL Sewage Treatment Plant (**Figure 4-9**). The eastern half of the range is located within 200 feet of the Peconic River. BNL utilized this same location as a practice range from 1963 until the present facility was constructed in 1986. The small arms and grenade ranges are co-located, side-by-side, and have a combined area of 87,516 square feet. The bullet stop (i.e., rear berm) of the live fire range is an earthen berm, and is screened for lead on an annual basis. The bullets are known to have a typical penetration depth of approximately two to three inches into the berm. The soil of the rear berm is screened to a depth of approximately one foot. The lead shot recovered during the screening process and the spent brass cartridges are disposed of off-site via a commercial waste handler as scrap metal. The grenade range is essentially an open field surrounded by earthen berms.

4.7.1 Groundwater Monitoring

Well Network: Groundwater quality at the Live-Fire Range is evaluated using two downgradient wells (**Figure 4-9**).

Sampling Frequency and Analysis: During 2002, the Live-Fire Range wells were monitored one time, and samples analyzed for metals (**Table 1-7**).

4.7.2 Monitoring Well Results

During 2002, all metals concentrations were below the applicable NYS AWQS and are consistent with established background levels.

4.7.3 Groundwater Monitoring Program Evaluation

Groundwater monitoring data collected since 2000 indicate that Live-Fire Range operations have not impacted groundwater quality. Starting in 2003, routine groundwater surveillance program for the range be suspended. The wells will be maintained for the collection of routine water level measurements, which are used to assess site-wide groundwater flow patterns, and for potential future water quality sampling.

4.8 Motor Pool and Facility Maintenance Area

The Motor Pool (Building 423) and Site Maintenance facility (Building 326) are attached structures located along West Princeton Avenue (**Figure 4-11**). 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 the historical use of USTs for the storage of gasoline, diesel fuel and waste oil, hydraulic fluids used for lift stations, and 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 with 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-capacity USTs used for the storage of unleaded gasoline, one 260 gallon-capacity above ground storage tank used for waste oil, and one 3,000 gallon-capacity UST for Number 2 fuel oil.

In March 2002, an inactive 275 gallon-capacity UST that was used for diesel fuel was removed. Following the removal of the tank, it was discovered that the tank had several small holes and that fuel oil had leaked into the surrounding soils. Approximately twenty cubic yards of soil were removed. Although the endpoint sample had a petroleum smell, analysis of the sample did not detect any of the target compounds of concern. As an additional verification step, BNL collected groundwater samples in July from three of the existing groundwater monitoring wells located downgradient of the spill area (102-05, 102-06 and 102-10). Analysis of the groundwater samples did not indicate the presence of petroleum in groundwater except for low levels of methyl tertiary butyl ether (MTBE), a compound found in gasoline.

The Motor Pool facility has five vehicle lift stations. The hydraulic fluid reservoirs for the lifts are located above ground. In February 1998, it was discovered that hydraulic fluid was leaking from one of the lift stations (BNL Spill Number 98-14). The lift was excavated and soils below the lift were contaminated with hydraulic oil. Approximately 50 cubic yards of the most contaminated soils were removed. In response to a NYSDEC request to evaluate whether the spill affected groundwater quality, BNL installed a monitoring well (102-09) inside the building, directly downgradient of the spill area. Hydraulic oil products were not detected in groundwater samples collected during 1999. Based upon these findings, the hydraulic fluid spill was removed from the NYSDEC's Active Spill List.

The only known environmental concern associated with the Site Maintenance facility (Building 326) was the December 1996 discovery of a historic oil spill directly south of the building. During the removal of an underground propane tank, the surrounding soils were contaminated with petroleum hydrocarbons (BNL Spill Number 96-54). The site was excavated to the extent that the footings of the building were almost undermined. Although approximately 60 cubic yards of contaminated soil were removed, there was clear evidence that contaminated soils remained. In an effort to investigate the potential impact to groundwater quality, four wells were installed. Although groundwater monitoring detected the presence of the solvent TCA at concentrations above NYS AWQS, petroleum hydrocarbons were not detected in groundwater downgradient of the spill site. Based upon these findings, the oil spill was removed from the NYSDEC's Active Spill List.

4.8.1 Groundwater Monitoring

<u>Well Network</u>: The Motor Pool facility's groundwater monitoring program for the underground storage tank area is designed to confirm that the engineered and institutional controls in place are effective in preventing contamination of the aquifer. Two wells (102-05 and 102-06) are used to monitor for potential contaminant releases from the UST area (**Figure 4-11**).

Groundwater quality downgradient of Building 423 and Building 326 is monitored using four wells (102-10, 102-11, 102-12, and 102-13). The program is designed to periodically assess existing solvent contamination that resulted from historical vehicle maintenance operations, and to confirm that the current engineered and institutional controls are effective in preventing additional contamination of the aquifer.

<u>Sampling Frequency and Analysis</u>: During 2002, the UST area wells were monitored semiannually, and the samples were analyzed for VOCs and SVOCs. The wells were also checked for the presence of floating petroleum hydrocarbons on a semiannual basis (**Table 1-7**). Most of the Building 423/326 area wells were monitored annually, and the samples were analyzed for VOCs and SVOCs.

4.8.2 Monitoring Well Results

Underground Storage Tank Area: During 2002, MTBE was the only chemical related to gasoline detected in groundwater downgradient of the gasoline UST area (**Figure 4-12**). MTBE was detected in the July sample collected from well 102-06 at a concentration of 3.4 µg/L. The NYS AWQS for MTBE is 10 µg/L. Low levels of MTBE have been detected in these wells since the start of routine monitoring in 1997. The solvent TCA was detected in both wells, but at concentrations well below the NYS AWQS of 5 µg/L. The presence of these chemicals could be related to small-scale spillage of gasoline during refueling operations and/or historical parts degreasing operations at the Motor Pool facility. Wells 102-05 and 102-06 were also tested semiannually for the presence of floating petroleum hydrocarbons. As in previous years, no floating product was observed.

Building 423/326 Area: As in previous years, VOCs continue to be detected in wells located downgradient of the Building 423/326 area at concentrations that exceed NYS AWQS (**Figure 4-13**). During 2002, TCA was detected in all four wells at concentrations ranging from 4.5 µg/L to 34.5 µg/L and 1,1-dichloroethane (DCA) was detected in Well 102-12 at concentrations up to 6.2 µg/L. The NYS AWQS for TCA and DCA is 5 µg/L. The gasoline additive MTBE was detected in all four wells, with a maximum observed concentration of 40.8 µg/L. The NYS AWQS guidance value for MTBE is 10µg/L. It is believed that the TCA, DCA and MTBE originate from historical vehicle maintenance/part degreasing operations.

4.8.3 Groundwater Monitoring Program Evaluation

Analysis of groundwater samples collected at the Motor Pool facility during calendar year 2002 indicates that releases from historical operations continue to impacted groundwater quality. Monitoring of the leak detection systems and the wells located downgradient of the Motor Pool's underground storage tank area indicate that the tanks and associated distribution lines are not leaking. Furthermore, recent evaluation of current vehicle maintenance operations indicates that all waste oils and used solvents are being properly stored and recycled.

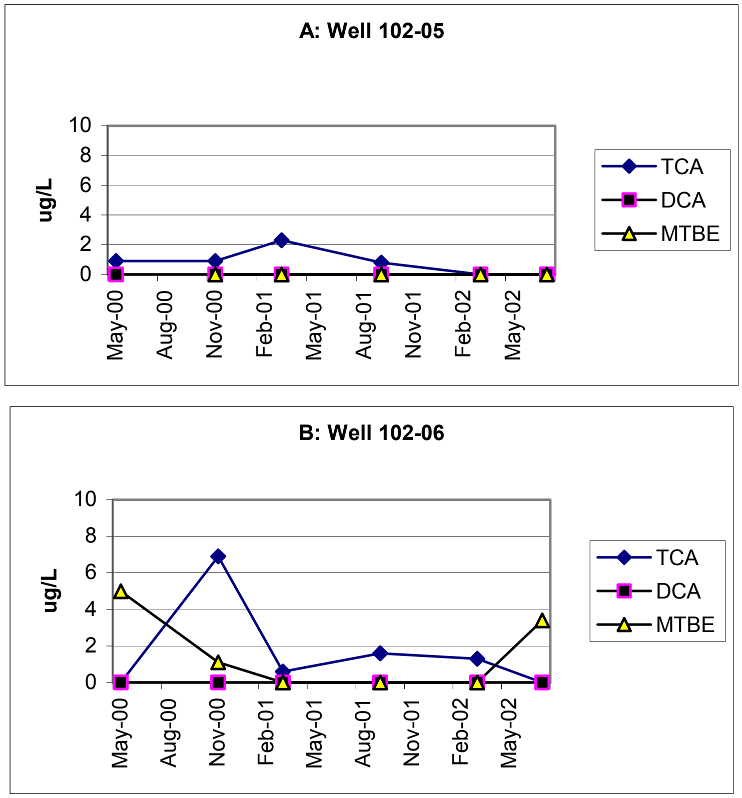
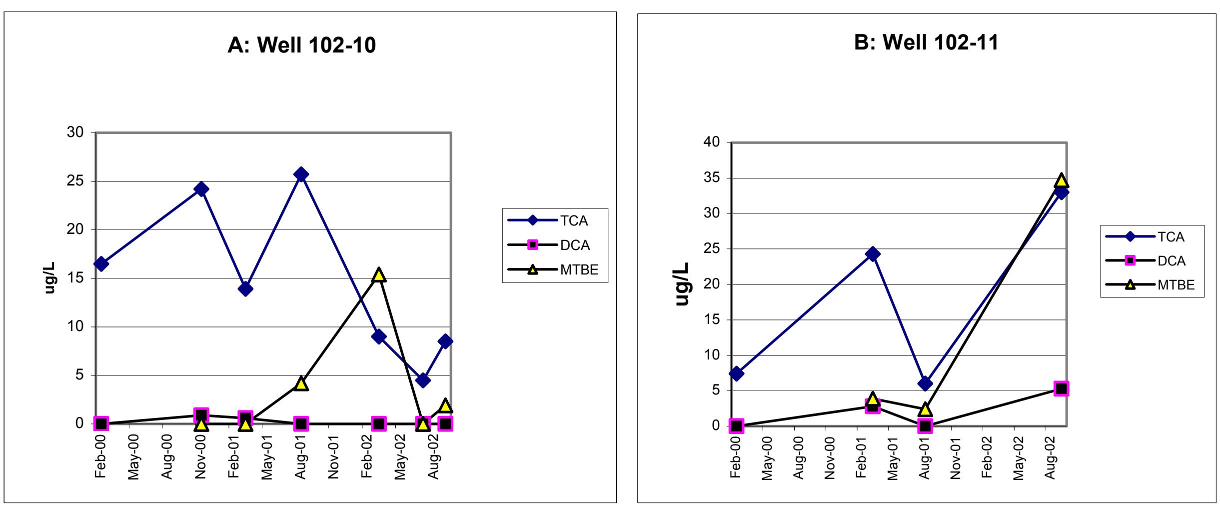
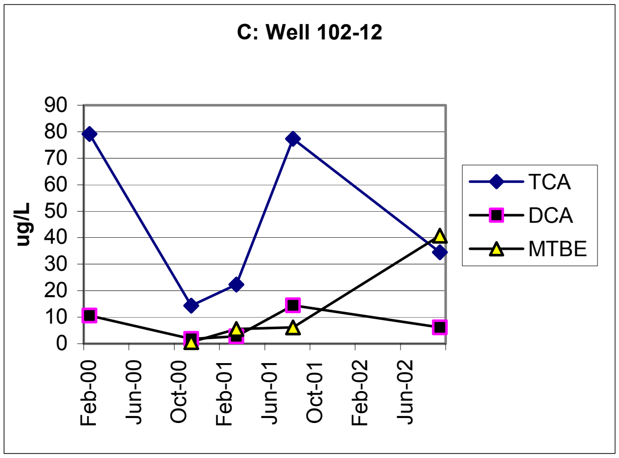


Figure 4-12. VOC concentration trends in well located downgradient of the gasoline UST area.





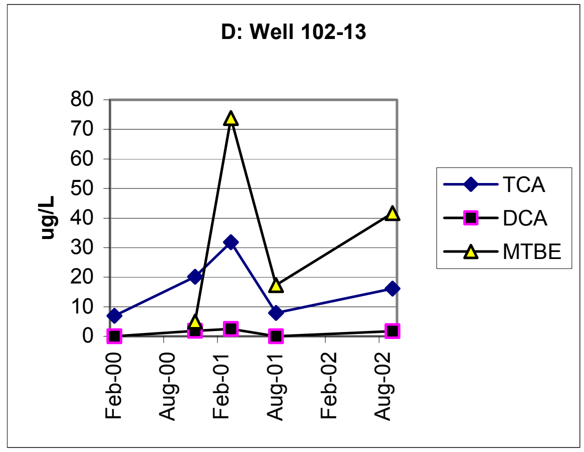


Figure 4-13. VOC concentration trends in wells located downgradient of Building 323/326.

4.9 On-Site Service Station

Building 630 is a commercial automobile service station, which is privately operated under a contract with BNL. The station, which was built in 1966, 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 two 8,000 gallon-capacity and one 6,000 gallon-capacity tanks for the storage of gasoline, and one 500 gallon-capacity 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 present tank inventory includes three 8,000 gallon-capacity USTs used for the storage of unleaded gasoline, and one 500 gallon-capacity UST used for waste oil. The facility also has three 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 underground storage tank that was used as part of an experiment conducted in the 1950s. In April 1998, BNL removed an underground storage tank from an area located approximately 200 feet to the northwest (upgradient) of the Service Station. Although there are indications that the tank was releasing small quantities of carbon tetrachloride prior to the tank removal, the detection of a significant increase in carbon tetrachloride concentrations in groundwater suggests 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.

4.9.1 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 4-14**).

Sampling Frequency and Analysis: During 2002, most of the Service Station facility wells were monitored six times by the Environmental Surveillance and Environmental Restoration programs, and the samples were analyzed for VOCs (**Table 1-7**). The wells were also sampled once for SVOCs, and checked semiannually for the presence of floating petroleum hydrocarbons on a semiannual basis.

4.9.2 Monitoring Well Results

During 2002, carbon tetrachloride continued to be observed in Service Station monitoring wells (see Section 3.2.1). The maximum carbon tetrachloride concentration was 1,940 μg/L observed in well 085-16 during January 2002. Carbon tetrachloride concentrations decreased during the year, with concentrations dropping to less than 262 μg/L by December. These concentrations are considerably less than those observed in CY 2000, when carbon tetrachloride concentrations in Service Station area wells approached 4,400 μg/L. The NYS AWQS for carbon tetrachloride is 5 μg/L.

In addition to the carbon tetrachloride contamination described above, groundwater quality has been impacted by a variety of petroleum and solvent related VOCs that are primarily the result of historical Service Station operations. The highest levels of VOCs are detected in downgradient well 085-236 (**Figure 4-15**). During the first half of 2000, high levels (>100 μg/L) of petroleum related compounds such as xylene, ethylbenzene were detected in wells 085-17, 085-236 and 085-237. From mid-2000 through mid-2002, individual VOC concentrations generally decreased to less than 10 μg/L. A slight increase in PCE and xylene concentrations was observed in samples collected from well 085-236 in September and December 2002. During this time, PCE reached a maximum of 24.7 μg/L and total xylene concentrations reached a maximum of 46.1 μg/L. Although the gasoline additive MTBE continues to be detected in wells 085-236 and 085-237, MTBE levels decreased from a maximum concentration of 64 μg/L in 2001, to a maximum concentration of 32 μg/L in 2002. The NYS AWQS guidance value for MTBE is 10 μg/L. Monitoring wells 085-17, 085-236 and 085-237 are located downgradient of southern end of the Service Station building, and it is likely that the PCE and petroleum related chemicals detected in groundwater are due to historical discharges to the former service bay floor drains. No SVOCs or floating petroleum was detected in the monitoring wells during 2002.

4.9.3 Groundwater Monitoring Program Evaluation

In addition to the release of carbon tetrachloride from an upgradient source, historical operations at the Service Station have impacted groundwater quality. Available information indicates that the Service Station's underground storage tanks and associated distribution lines are not leaking and that all waste oils and used solvents are being properly stored and recycled. Therefore, it is believed that the petroleum hydrocarbon related compounds and solvents detected in groundwater originate from historical vehicle maintenance and fuel dispensing operations prior to improved chemical storage and handling controls implemented in 1989.

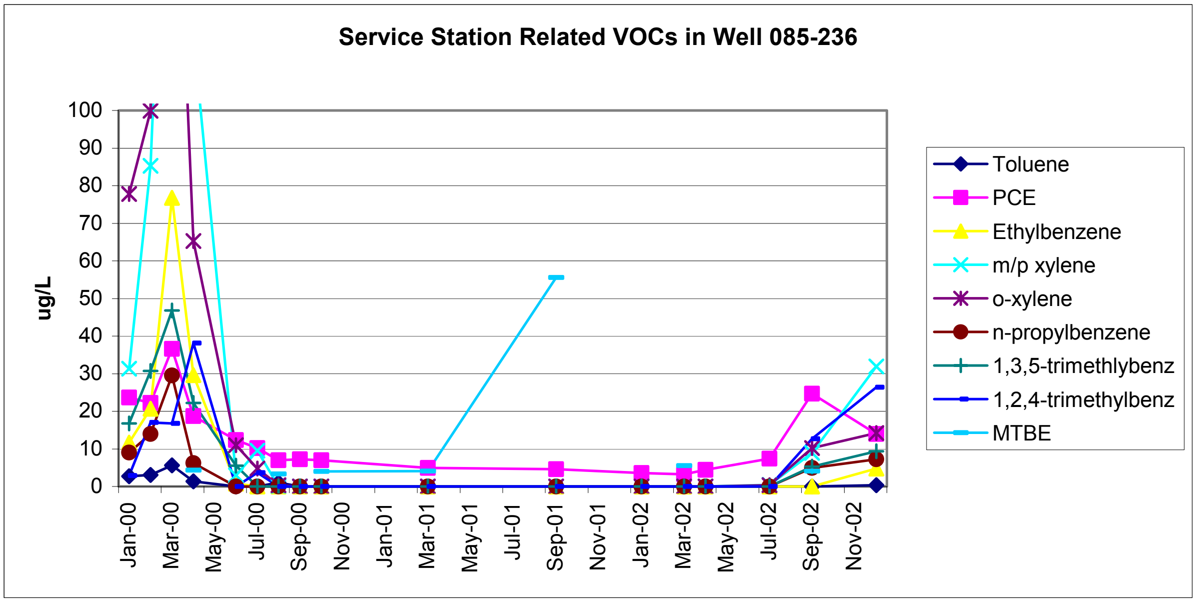


Figure 4-15. Service Station related VOC concentration trends monitoring well 085-236.

4.10 Major Petroleum Facility (MPF) Area

The MPF is the holding area for fuels used at the Central Steam Facility (**Figure 4-16**). Fuel oil for the Central Steam Facility is held in a network of seven above ground storage tanks, two of which are currently inactive. The tanks, which have a combined capacity to contain up to 2.3 million gallons of #6 fuel oil and 60,000 gallons of #2 fuel oil, are connected to the Central Steam Facility (CSF) by above ground pipelines that have secondary containment and leak detection devises. All fuel storage tanks are located in bermed containment areas that have a capacity to hold >110% of the volume of the largest tank located within each bermed area. The bermed areas have bentonite clay liners consisting of either Environmat (consisting of bentonite clay sandwiched between geotextile material) or bentonite clay mixed into the native soils to form an impervious soil/clay layer. As of December 1996, all fuel unloading operations were consolidated in 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 Control and Countermeasures Plan and a Facility Response Plan have been developed for the facility.

4.10.1 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 4-16**).

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. In early 2002, the NYSDEC expanded the required list of analyses to include VOCs, including testing for MTBE (**Table 1-7**). Although MTBE is a common gasoline additive, it can apparently be introduced to fuel oil as a contaminant during the refining process.

4.10.2 Monitoring Well Results

In April 2002, BNL sampled the MPF wells and tested the samples for SVOCs and VOCs in accordance with the new permit requirements. As in the past, no SVOCs were detected, and no floating product was observed. However, VOCs were detected in two wells (076-19 and 076-380) at concentrations exceeding the NYS AWQS of 5 ug/L. The compounds detected in well 076-380 were: 1,2-dichloroethene *(total)* at 300 ug/L, tetrachloroethylene at 36 ug/L, and trichloroethylene at 8.3 ug/L. The compound 1,2-DCE was also detected in nearby well 076-19 at a concentration of 16 ug/L. (Please note that 1,2-dichloroethene is a breakdown product of the common degreasing agent tetrachloroethylene.) Following the receipt of the analytical data for well 076-380, BNL upper management, DOE, and regulatory agencies were notified of the findings in accordance with the BNL Groundwater Protection Contingency Plan (Level 2 response), and a technical team was established to evaluate the source of the contamination.

BNL increased the sampling frequency for well 076-380, as well as several nearby monitoring wells. Evaluation of these monitoring data indicates that 1,2-DCE contamination extends as far south as well 076-185. In May 2002, 1,2-DCE was detected in well 076-185 at a concentration of 26.6 ug/L. This is a shallow well that is located approximately 350 feet south of wells 076-380 and 076-23. During the remainder of the year, 1,2-DCE concentrations in well 076-380 increased to a high of 566 ug/L in June, then steadily decreased to non-detectable levels by October (**Figure 4-17**). Tetrachloroethylene concentrations also dropped to non-detectable levels by October, however, trichloroethylene concentrations increased slightly to 20 ug/L.

4.10.3 Groundwater Monitoring Program Evaluation

Based upon an evaluation of groundwater flow directions and modeling, it is likely that the VOC contamination originates from historical spills near the CSF (Building 610) area. The historical nature of this spill is supported by: 1) degreasing agents such as tetrachloroethylene have not been used at the CSF in many years; 2) tetrachloroethylene has been detected in well 076-19 since the early 1990s; and 3) the presence of 1,2-dichloroethene, which is a breakdown product of tetrachloroethylene. A number of historical spill sites near the Building 610 were identified in the late 1990s, and the most contaminated soils were subsequently excavated in accordance with regulatory requirements. In an effort to identify the source of the contamination, in early 2003 BNL will install four temporary Geoprobe wells downgradient of the suspected source areas near Building 610.

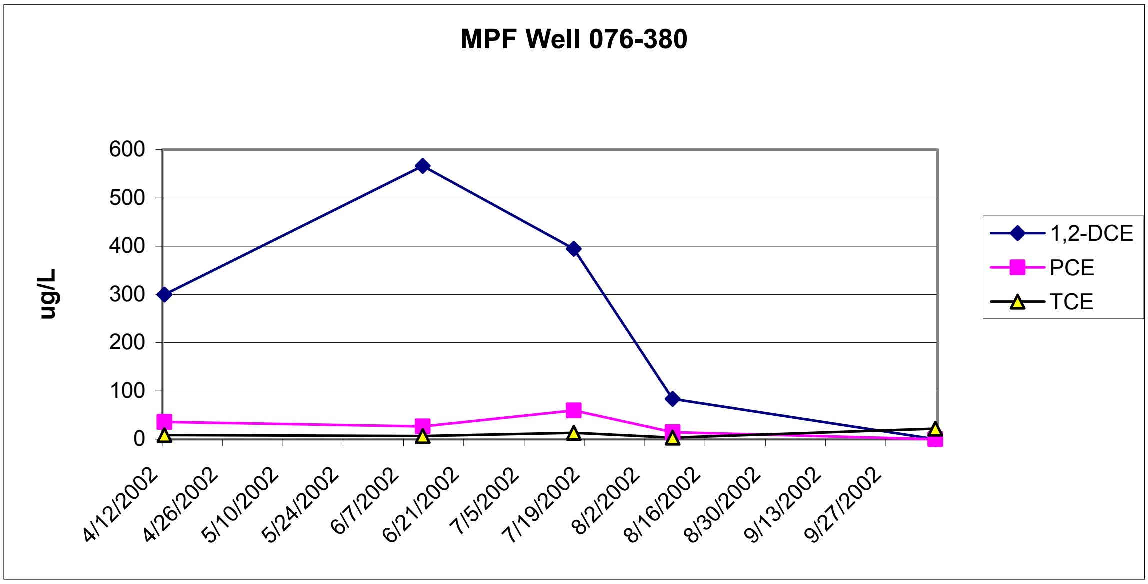


Figure 4-17. VOC concentrations in MPF well 076-380 during 2002.

4.11 New Waste Management Facility (WMF)

BNL has established a groundwater monitoring program at WMF to evaluate potential impacts to environmental quality and to demonstrate compliance with DOE requirements and applicable federal, state and local laws, regulations and permits. Groundwater monitoring is a requirement of the RCRA Part B permit issued for WMF operations. The WMF is located adjacent to BNL Potable Supply Wells 11 and 12, which are located south of East Fifth Avenue and just north of the WMF site (**Figure 4-18**). Because of the close proximity of the WMF to Potable Wells 11 and 12, it is imperative that the engineered and institutional controls discussed above are effective in ensuring that waste handling operations at the WMF do not degrade the quality of the soils and groundwater in this area. 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 WMF.

4.11.1 Groundwater Monitoring

Well Network: Eight wells are used to monitor for potential contaminant releases from the three main waste handling and storage buildings (**Figure 4-18**). Four wells are used to assess background water quality, whereas four are positioned downgradient of the three waste handling and storage buildings.

Sampling Frequency and Analysis: During 2002, the WMF wells were monitored quarterly, and the samples were analyzed for VOCs, metals, anions, tritium, gamma spectroscopy, gross alpha, and gross beta (**Table 1-7**).

4.11.2 Monitoring Well Results

Radiological Analyses: Radioactivity levels in samples collected from the WMF wells were consistent with ambient (background) levels. No Laboratory related radionuclides were detected in the WMF wells during 2002.

Non-radiological Analyses: All water quality and most metals concentrations were below the applicable NYS AWQS. As in past years, sodium was detected at a concentration above the NYS AWQS of 20 mg/L in upgradient well 055-03, with a concentration of 29.5 mg/L. Compared to previous years when low levels of VOCs (1,1,1-trichloroethane and chloroform) were periodically detected in several of the upgradient wells, no VOCs were detected during 2002. Furthermore, the gasoline additive MTBE, which was detected in the February 2001 sample from well 056-22, was not detected in any of the WMF wells during 2002.

4.11.3 Groundwater Monitoring Program Evaluation

Groundwater monitoring results for 2002 are consistent with previous monitoring, and continue to show that WMF operations are not impacting groundwater quality. Groundwater analyses indicate that metals, anions and radionuclides are at concentrations that are consistent with established background levels.

In 2003, BNL will petition the NYSDEC to modify the RCRA Part B Permit groundwater monitoring requirements. With NYSDEC concurrence, BNL will reduce monitoring frequency to semiannual, and analyze samples for gross alpha, gross beta, gamma, and VOCs. Monitoring requirements for metals and anions will be reduced to annual analyses.

4.12 Biology Department Greenhouse Area

The Biology Department facility (Building 463) includes 11 greenhouses where various types of plants are grown for biological research. Eight of the greenhouses have dirt floors and three have concrete floors. Pesticides and fertilizers have been routinely used in the greenhouses. Records also indicate that copper sulfate was applied to the dirt floors on an annual basis until the mid-1980's. During the 1997 Facility Review Project, the pesticide Endosulphan II was detected in soil samples collected from a dry well located within Greenhouse 10. In accordance with DOE Order 5400.1, BNL established a groundwater monitoring program at the greenhouse area to evaluate potential impacts to environmental quality.

4.12.1 Groundwater Monitoring

Well Network: Two downgradient wells are used to monitor groundwater quality in the greenhouse area (**Figure 4-19**).

Sampling Frequency and Analysis: During 2002, the two greenhouse area wells were monitored one time, and samples analyzed for pesticides, metals and anions (**Table 1-7**).

4.12.2 Monitoring Well Results

The greenhouse area wells were sampled in September 2002, and tested for pesticides, metals, and anions. As in past years, groundwater monitoring results indicate that greenhouse operations are not impacting groundwater quality. Pesticides were not detected, and all water quality and most metals concentrations were below the applicable NYS AWQS. Sodium was detected at a concentration of 26.8 mg/L, slightly above the NYS AWQS of 20 mg/L in well 084-36. The detection of low levels of sodium is not uncommon in wells located within the developed area of the site, and could be related to road salting operations.

4.12.3 Groundwater Monitoring Program Evaluation

Analysis of groundwater samples collected since 2000 indicates that greenhouse operations have not impacted groundwater quality. No pesticides have been detected, and metals and nitrate levels are at concentrations that are consistent with established background levels. Starting in 2003, routine groundwater surveillance program for the greenhouse area will be suspended. The wells will be maintained for the collection of routine water level measurements, which are used to assess site-wide groundwater flow patterns, and for potential future water quality sampling.

4.13 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 cesium-137, strontium-90 and tritium at levels that exceeded drinking water standards. It is believed that the floodwater became contaminated when it came into contact with the basement floor, which contains significant residual contamination from historical spills. When the floodwater was pumped from the basement on March 8, 2002, approximately 4,950 gallons of contaminated water was removed. Taking into account possible losses due to evaporation, it was estimated that between 1,350 and 2,750 gallons of contaminated floodwater might have escaped into the soils below Building 801. To evaluate the potential impact that this release may have on groundwater quality, BNL initiated monthly monitoring of three existing downgradient monitoring wells, and installed a new water table well closer to the building.

4.13.1 Groundwater Monitoring

<u>Well Network</u>: From May through October 2002, three existing downgradient wells were sampled. Well 065-169 is located approximately 10 feet south of Building 801, whereas wells 065-37 and 065-170 are located approximately 80 feet downgradient of the building (**Figure 4-20**). 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 well 065-169 and 065-170 are screened approximately 10 feet below the water table. Because well 065-169 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.

<u>Sampling Frequency and Analysis</u>: BNL conducted monthly sampling of three existing shallow Upper Glacial aquifer wells starting in May 2002, and the new well starting in October 2002. The samples were analyzed for gross alpha, gross beta, strontium-90, cesium-137 and tritium.

4.13.2 Monitoring Well Results

During May through October 2002, the three monitoring wells located directly downgradient of the release area (western half) of Building 801 were monitored monthly for strontium-90, gamma spectroscopy, tritium, gross alpha and gross beta. Cesium-137 was not detected in any of the groundwater samples. Strontium-90 was consistently detected in all three wells. Strontium-90 levels in the two wells screened approximately 10 feet below the water table (065-169 and 065-170) were generally less than 2.5 pCi/L. Higher levels of strontium-90 (and associated gross beta levels) were detected in well 065-37, which is screened closer to the water table. Strontium-90 concentrations in all samples from well 065-37 exceeded the 8 pCi/L drinking water standard, with a maximum concentration of 18.2 pCi/L observed in July 2002 (**Figure 4-21**). Strontium-90 has been routinely detected in well 065-37 since 1999. Tritium was not detected in shallow well 065-37. Low levels (<10 pCi/L) of sodium-

22 were detected in deeper wells 065-169 and 065-170, and a trace level of tritium (389 pCi/L; with an analysis detection limit of 386 pCi/L) was detected in well 065-170 in July 2002.

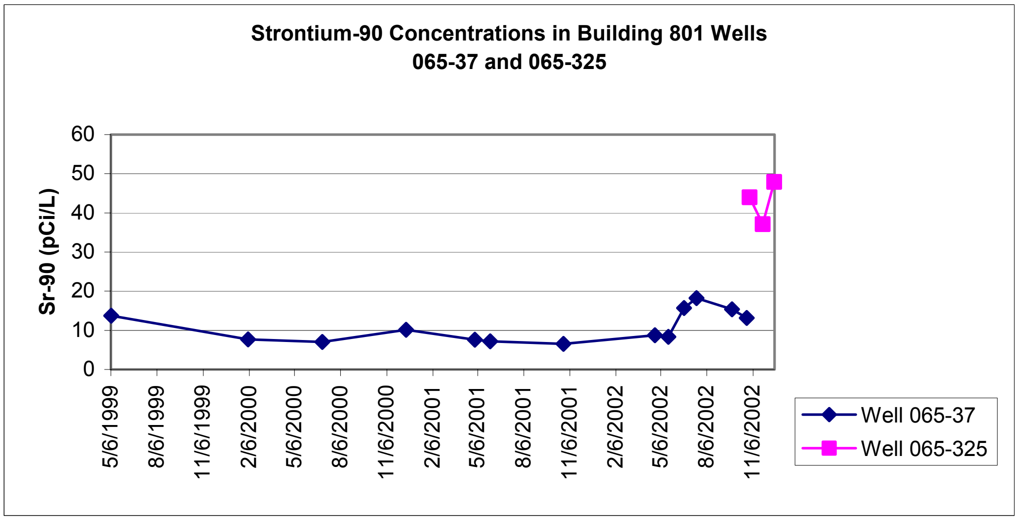


Figure 4-21. Strontium-90 concentrations detected in Building 801 monitoring well 065-37.

In early October 2002, BNL installed well 065-325 approximately 10 feet south of Building 801. The well was screened within the upper 10 feet of the aquifer to provide improved surveillance of potential releases from the Building 801 basement. The October, November and December samples from this well had strontium-90 concentrations of 44 pCi/L, 37 pCi/L, and 47.9 pCi/L, respectively. No cesium-137 or tritium was detected in any of the samples from well 065-325.

4.13.3 Groundwater Monitoring Program Evaluation

Strontium-90 concentrations in samples collected during 2002 from shallow groundwater wells located downgradient of Building 801 are consistent with pre-December 2001 values. Additionally, cesium-137 has not been detected in any of the groundwater samples. It is estimated that it could take approximately 3 to 8 years for strontium-90, and approximately 100 years for cesium-137 from the recent 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.

Because of the slow migration rates for strontium-90 and cesium-137 the monitoring frequency for well 065-325 be reduced from monthly to semiannually for calendar year 2003, and the monitoring will coincide with planned semiannual sampling of wells 065-37, 065-169 and 065-170 by the EM Sitewide Groundwater Monitoring Program. EM is planning additional groundwater characterization efforts in an effort to define the extent of legacy strontium-90 contamination in the BGRR/Building 801/PFS area in the fall of 2003.

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5.0 SUMMARY OF RECOMMENDATIONS

The following section is a summary of all of the recommendations from sections 3 and 4 is provided for a quick reference. The recommendations are sequenced as they appear in Sections 3 and 4.

5.1 Current Landfill

The following recommendations were presented in the *2002 BNL Environmental Monitoring Report, Current and Former Landfill Areas* (BNL, 2003a) and have been implemented:

- Reduce the frequency of sampling in the mid to deep Upper Glacial wells 087-24, 088-22, and 088-23 for VOCs from semi-annually to annually. Reduce the frequency of sampling these wells for metals and water chemistry from quarterly to semi-annually. Lowering the sampling and analysis frequencies for these wells is based on the absence of any detection above groundwater standards since 1998, and the consistently low concentrations where detections were recorded. These wells are screened significantly below the depth of the contaminants' migration from the landfill, and serve as perimeter data-points for the vertical extent of contamination. Changes in the vertical migration pathway for contaminants from the Current Landfill are not anticipated.

- Reduce the frequency of sampling for radionuclides from quarterly to annually. Tritium and Sr-90 were detected in several wells over the past several years at concentrations slightly above background. However, based on the low and consistent findings for radionuclides, together with the historical baseline that was established for radionuclides at the Current Landfill, a reduction in the frequency of sampling is recommended.

5.2 Former Landfill

The following recommendation was presented in the *2002 BNL Environmental Monitoring Report, Current and Former Landfill Areas* (BNL, 2002a) and has since been implemented:

- Due to the low concentrations detected, the substantial historical databases, and the stability of the water-chemistry parameters, reduce the frequency of analysis for these parameters from quarterly to semi-annually.

5.3 OU I South Boundary Pump and Treat System

The following are recommendations related to the OU I South Boundary groundwater remediation system and groundwater monitoring programs:

1. A baseline of over five years of groundwater data has been obtained from many of the OU I South Boundary Program wells, and it has been demonstrated that the system is functioning as planned. A routine operation and maintenance monitoring frequency will be implemented in the August of 2003. Plume core and perimeter wells will be monitored on a semi-annual frequency. Sentinel, and bypass wells will continue to be sampled at a quarterly frequency. This reduction in sampling frequency for plume core and perimeter wells was already implemented for many of the OU I South Boundary Program wells in 2001. Maintain current monitoring for tritium and strontium-90. Extraction wells EW-1

and EW-2 will be sampled quarterly instead of every two months beginning in August 2003.

2. Commission an engineering study in FY 04 to evaluate the life-cycle economics of the following options:
   i. Continue to operate the existing system for as long as 2027,
   ii. Install a third groundwater extraction well in BNL Grid 98 to directly pump the persistent hot spot in the vicinity of monitoring well 98-59. This would result in completing active operation by 2007.
   iii. Operate the existing system until 2007 and then rely on monitored natural attenuation until 2027.

   Since the performance of each option is essentially equal, the decision on which option to pursue would be based primarily on life-cycle economics. This is an adaptive approach to groundwater remediation and is consistent with CERCLA guidance and the OU III ROD.

3. Coordinate the groundwater remediation system with findings from the former HWMF characterization.

5.4 Carbon Tetrachloride Pump and Treat System

The following are recommendations for the OU III Carbon Tetrachloride groundwater remediation system and monitoring program:

1) Continue the operation of EW-15. Periodically pulse pump EW-13 and EW-14 due to rebounding of carbon tetrachloride in nearby monitoring wells.

2) The monitoring well network is adequate and no modifications are necessary at this time.

3) Place the groundwater monitoring program into a shutdown demonstration phase (quarterly monitoring of all wells) in August 2003 to develop a data set in anticipation of a shutdown petition in spring 2004.

5.5 OU III Building 96 Air-Stripping System

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

1) Beginning in May 2003, the Building 96 system has been operating in a “pulse” mode in order to determine if significant TVOC concentrations rebound in the re-circulation and/or monitoring wells once the local hydraulics have stabilized. In this case the term “pulsed” operation, refers to discontinuous operation of the system consisting of; activation for two weeks, then deactivation for 6 weeks, followed by operation for two weeks, and so on. Therefore, the system was deactivated in May 2003, for a period of approximately 6 weeks at the end of which the monitoring wells will be sampled. The system will then be reactivated and influent system samples will immediately be collected to determine if significant TVOC concentrations rebound in the subsurface. The system will remain operational for a two-week period with samples being collected at the end of each week. After the two weeks, the system will again be de-activated for approximately 6 weeks. If significant TVOC

concentrations return in the monitoring wells and system influent after system deactivation, the system will be "pulsed" through October 2003. During each subsequent "pulsed" operation of the system, system samples will be collected at start-up and shutdown. The monitoring wells will continue to be sampled quarterly.

2) Four additional monitoring wells will also be installed upgradient and west of the existing system to monitor the TVOC concentrations present in those areas.

3) Monitoring wells will continue to be monitored at a quarterly frequency over the next year as the system nears shutdown.

An engineering study on the source term and alternative technologies will be performed. Direct in situ treatment technologies (e.g. in situ chemical oxidation, alcohol or cosolvent flushing, surfactant injection, steam injection, molasses) should be screened for applicability. The study will also consider the risk to obtaining the OU III cleanup goals if this source area is treated no further. An evaluation will be performed to determine whether there is need for continued operation of the system. The results of this evaluation, as well as any further considerations for future system operation, will be provided under a separate cover.

5.6 OU III Middle Road Pump and Treat System

The following are recommendations for the OU III Middle Road groundwater remediation system and monitoring program:

- Place wells RW-4 and RW-5 in stand-by mode beginning in October 2003 due to the low concentrations being detected in these wells. Quarterly sampling of these wells will continue and if significant rebound is observed in either the extraction or in adjacent monitoring wells (TVOC greater than 50 ug/L) an evaluation will be conducted on whether pumping should be resumed.

- Eliminate monitoring of wells 106-53, 106-54, and 106-59, as the screen intervals of these wells are redundant with others nearby.

- A baseline of over five years of groundwater data has been obtained from many of the OU III Middle Road Program wells. A routine operation and maintenance monitoring frequency will be implemented in the August 2003. Plume core and perimeter wells will be monitored on a semi-annual frequency (**Figure 3.2.3-2**). Bypass wells will continue to be sampled at a quarterly frequency.

- BNL was granted approval by NYSDEC to change influent/effluent sampling from twice a month to monthly. This modification was implemented in the Spring of 2003.

5.7 OU III South Boundary Pump and Treat System

- A baseline of over five years of groundwater data has been obtained from many of the OU III South Boundary Program wells. A routine operations and maintenance monitoring frequency will be implemented in the fourth quarter of 2003. Plume core and perimeter wells will be monitored on a semi-annual frequency. Bypass wells will continue to be sampled at a quarterly frequency. This reduction in sampling frequency for plume core and perimeter wells was already implemented for many of the OU III South Boundary Program wells in 2001. In some cases shallow wells have been reduced to an annual sampling frequency. This frequency will be maintained during the O&M phase.

- Extraction well EW-12, which was installed in 1999 to address a slug of contamination that was to the east of the original capture zone of the South Boundary system, has now achieved VOC concentrations below NYS AWQS. This well will be placed in standby mode beginning October 2003. The well will be restarted should monitoring well data indicate that VOC concentrations are showing significant rebound.

5.8 OU III Western South Boundary Pump and Treat System

- Groundwater monitoring will continue in start-up phase mode (quarterly sampling) until May 2004.
- Complete the connection of wireless alarm communications to central on-site location.

5.9 OU III Industrial Park In-Well Air Stripping System

The following change is recommended:

A baseline of over four years of groundwater data has been obtained from many of the OU IIII Industrial Park Program wells. A routine operations and maintenance monitoring frequency will be implemented in August of 2003. Plume core and perimeter wells will be monitored on a semi-annual frequency. Bypass wells will continue to be sampled at a quarterly frequency. This reduction in sampling frequency for plume core and perimeter wells was already implemented for some of the shallow OU IIII Industrial Park Program wells in 2001.

5.10 Off-Site Monitoring Program

The plume core and perimeter wells will be monitored semi-annually and sentinel wells annually for VOCs beginning in the fourth quarter of 2003. A sufficient data baseline has been developed for these wells and the reduction of sampling to semi-annually in core and perimeter wells will not compromise BNL's ability to monitor off-site VOCs. As wells are incorporated into both the LIPA and Airport Remediation System programs the sampling frequency will be elevated in all wells to quarterly for a two-year system start-up duration.

5.11 North Street Groundwater Monitoring Program

The monitoring well network will be enhanced during 2003 by establishing monitoring wells associated with both the North Street and Airport Remediation Systems. There are no recommendations for the monitoring well network other than those currently planned as part of these efforts. The current sampling frequency and analytes will be maintained in 2004.

5.12 OU III Central Monitoring Program

Due to the recent VOC detections in well 109-03, the quarterly sampling frequency will be maintained for these SCWA well field sentinel wells.

5.13 Magothy Monitoring Program

Monitoring of the 13 new wells will begin in 2003 and the data presented in the 2003 BNL Groundwater Status Report. Sampling will initially be conducted quarterly under a start-up phase.

5.14 OU III HFBR Tritium Monitoring Program

The following are recommendations for the HFBR groundwater monitoring program.

1) Several temporary wells will be installed in 2003 to track the high concentration portion of the plume as per the HFBR Tritium Low Flow Pumping Evaluation Report (BNL 2001b).

2) Three temporary wells will be installed in 2003 to characterize the deeper tritium detected in 2002. One will be installed on Bell Avenue at the location of geoprobes 85-236. Two temporary wells will be installed immediately east of well 95-276 to assess the location of the 20,000 pCi/L plume leading edge in the vicinity of the Chilled Water Road/Weaver Drive. (Note: these were installed in early 2003).

3) The data will be evaluated to determine if additional wells are necessary in the Chilled Water Road and Weaver Drive areas. Based on the high concentration segment of the tritium plume having migrated south of Brookhaven Avenue, the frequency of monitoring for wells located to the north of this area should be reduced from monthly to quarterly beginning in August 2003. This includes monitoring wells 75-43, 75-224, 75-225, 75-230, 75-231, 75-236, 75-237, 75-242, 75-244, 75-296, 75-297, 75-298, 75-299, 75-414, 75-415, 75-416, 75-417, 75-418, 75-419, 75-285, 75-286, 75-287, 75-288, 75-289, 75-558, 85-286, 85-287, 85-288, and 85-289.

4) Based on the relative stability of groundwater flow directions in the tritium plume path the sampling frequency for western perimeter wells 75-47, 75-48, 75-75-87, 75-210, 75-211, 75-208, 75-209, 75-292, 85-39, 85-40, 85-41, 85-65, 85-66, 85-73, 85-74, 85-75, 85-87, and 85-78 will be reduced from quarterly to semi-annually (second and fourth quarters) beginning in August 2003.

- Up to five monitoring wells will be installed in 2003 along in the vicinity of Bell Avenue to enhance the monitoring network near the leading edge of the higher tritium concentrations.

5.15 OU III BGRR/WCF Strontium-90 Monitoring Program

The following are recommendations for the BGRR groundwater monitoring program:

- The BGRR/WCF/PFS and HFBR stack areas will be characterized in 2003 to determine the areas of highest strontium-90 contamination (hot spots) and to identify potential extraction well locations for the design of the Strontium-90 treatment system.

- Maintain the southerly groundwater flow direction by managing the pumping of BNL supply wells 10, 11, and 12.

Submit a Groundwater Characterization Report for the Building 701 below ground structures, building 702 pile, and remaining soils.

5.16 Chemical/Animal Holes Strontium-90 Pilot Test Monitoring

The following are recommendations for the OU III Chemical/Animal Holes groundwater monitoring program:

1) All 24 wells in the groundwater monitoring program will be sampled on a semi-annual basis and analyzed for strontium-90 in 2003. Specific wells will be sampled on a more frequent basis as part of the Strontium-90 Pilot Study.

- The installation of an additional sentinel monitoring well is recommended to monitor the leading edge of the strontium-90 plume downgradient of the Former Landfill area. This well would be located along Middle Path to the west of existing well 106-62.

5.17 South Boundary Radionuclide Monitoring Program

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

5.18 Air Sparge/Soil Vapor Extraction (AS/SVE) Remediation System

The following are recommendations for the OU IV AOC 5 groundwater monitoring program.

- Conduct quarterly monitoring of wells 76-06, 76-19, and 76-23 for VOCs, beginning in August of 2003 for an additional period of one year. Monitoring of these wells will continue at a semi-annual frequency for up to 5 years beginning in 2004. Well abandonment will be initiated following approval for closure.

- Terminate monitoring for all OU IV AOC 5 wells that are below NYS AWQS including 76-02, 76-04, 76-05, 76-08, 76-178, 76-179, 76-180, 76-185, 76-186, 76-18, 76-21, 76-380, 76-07, 76-09, 76-181, 76-182, 76-183, 76-184, and 76-24.

- Monitoring wells containing VOCs from source(s) in the Central Steam Facility area (76-18, 76-19, and 76-380) will continue to be monitored under the BNL Facility Monitoring Program.

5.19 OU IV Building 650 (Sump Outfall) Strontium-90 Monitoring Program

The following are recommendations for the OU IV AOC 6 Strontium-90 monitoring program:

1) Continue to monitor well 76-28 to determine if remediation of the Building 650 decon pad has removed the source of this contamination.

Following the soil excavation work in the area of the Building 650 sump outfall a low spot has created a situation where precipitation runoff is collecting in the low lying area. The standing water will be pumped from this area and well 76-18 abandoned to prevent any migration of standing water into the monitoring well.

5.20 OU V Sewage Treatment Plant Monitoring Program

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

- Although there are presently sentinel wells south of the leading edge of the VOC plume, additional wells are recommended because the plume is narrow and there is potential for it to bypass the existing wells. A hydrogeologic evaluation, including some updated modeling, is recommended to re-evaluate the monitoring network with respect to the signed ROD requirements. This will determine whether any modifications to the monitoring well network are warranted.

  - The contaminants of concern for the OU V STP are VOCs and tritium. Six years of semi-annual monitoring have resulted in only minor detections of radionuclides (other than tritium), pesticides, and metals. Therefore, it is recommended that these parameters be dropped from the sampling program beginning in August 2003. VOCs and tritium will continue to be monitored at a semi-annual frequency.

5.21 OU VI EDB Groundwater Monitoring Program

- The EDB Monitoring Program will be enhanced with additional wells in 2003 to more precisely monitor the high concentration area of the EDB plume and sentinel wells downgradient of the plume edge. No additional modifications to the monitoring program are warranted at this time.

- Eliminate annual sampling for gross alpha/beta. The only detections over the past several years have been barely above background levels and well below NYS AWQS.

5.22 Site Background Monitoring Program

No modifications are recommended to this monitoring program.

5.23 Alternating Gradient Synchrotron Facility

The following actions are either in progress or need to be completed:

- Finalize an Engineering Evaluation/Cost Analysis for the g-2 tritium plume and submit it to the regulatory agencies by November 1, 2003. The Action Memorandum will be submitted by June 1, 2004.
- Continue quarterly monitoring of wells used to track the g-2 tritium plume.
- Continue semiannual monitoring of wells used to monitor the former E-20 Catcher, former U-line Target and Stop areas, Building 912, J-10 Stop, the 914 Transfer area, and the Booster Stop.

5.24 Relativistic Heavy Ion Collider Facility

No changes to the groundwater monitoring program are recommended. Continue to sample groundwater monitoring wells semiannually, and analyze samples for tritium only. If tritium is detected in any of the samples, resume gamma analyses for sodium-22.

5.25 Brookhaven Linac Isotope Producer Facility

Groundwater samples should continue to be collected quarterly during 2003. Samples should be analyzed primarily for tritium. Particular wells immediately downgradient of the BLIP should be periodically tested for sodium-22. If tritium concentrations are continually less than the 20,000 pCi/L drinking water standard by the end of 2003, consideration should be given to reducing the sampling frequency to semiannually, starting in 2004.

5.26 Brookhaven Medical Research Reactor Facility

No changes to the BMRR groundwater monitoring program are recommended. Continue to sample the monitoring wells on a semiannual basis, and analyze samples for tritium.

5.27 Waste Management Facility

Petition NYSDEC to modify the RCRA Part B Permit groundwater monitoring requirements. With NYSDEC concurrence (anticipated by August 2003), reduce monitoring frequency to semiannual, and analyze samples for gross alpha, gross beta, gamma, and VOCs. Analyze samples annually for metals and anions.

5.28 Major Petroleum Facility

The following actions are recommended for CY 2003:

- Maintain the groundwater monitoring program on its current semiannual schedule in accordance with NYSDEC requirements.
- Install four Geoprobe wells downgradient of suspected VOC source areas near the Central Steam Facility.

5.29 Sewage Treatment Plant

No changes to the Sewage Treatment Plant groundwater monitoring program are recommended. Maintain the monitoring program on its current semiannual schedule.

5.30 Motor Pool

The following actions are recommended for CY 2003:

- Maintain the groundwater monitoring program for the gasoline UST area on its current semiannual schedule, and test for floating product and VOCs.
- Maintain the groundwater monitoring program for the Bldg. 423/326 area on its current annual schedule, and test for VOCs.
- Because SVOCs (semivolatile organic compounds) have not been detected in groundwater samples collected to date, reduce the sampling frequency for SVOCs to once every two years for the UST area wells.

5.31 Service Station

The following actions are recommended for the CY 2003 monitoring period:

- The Environmental Restoration Program will sample four of the five service station wells quarterly for VOCs, as part of the carbon tetrachloride plume monitoring project. The Environmental Surveillance Program will sample one well (085-235) semiannually for VOCs, and all five wells semiannually for floating product.
- Because monitoring continues to indicate nondetectable levels of SVOCs, sampling frequency for SVOCs will be reduced to once every two years.

5.32 Biology Department Greenhouse Area

None of the contaminants of concern have been detected since monitoring began in 2000. Assuming that the current controls on chemical use at the greenhouse area are maintained, it is recommended that the routine groundwater surveillance program for the greenhouse area be suspended. The wells will be maintained for the collection of routine water level measurements used to assess site wide groundwater flow patterns, and for potential future water quality sampling.

5.33 Shotgun Range

Lead has not been detected in groundwater since monitoring began in 2000. It is recommended that the routine groundwater surveillance program for the range be suspended. The wells will be maintained for the collection of routine water level measurements, which are used to assess site wide groundwater flow patterns, and for potential future water quality sampling.

5.34 Live-Fire Range

Lead has not been detected in groundwater since monitoring began in 2000. It is recommended that the routine groundwater surveillance program for the range be suspended. The wells will be maintained for the collection of routine water level measurements, which are used to assess site wide groundwater flow patterns, and for potential future water quality sampling.

5.35 Building 801

Because of the slow migration rates for strontium-90 and cesium-137 the monitoring frequency for well 065-325 be reduced from monthly to semiannually for calendar year 2003, and the monitoring will coincide with planned semiannual sampling of wells 065-37, 065-169 and 065-170 by the EM Sitewide Groundwater Monitoring Program. EM is planning additional groundwater characterization efforts in an effort to define the extent of legacy strontium-90 contamination in the BGRR/Building 801/PFS area in the fall of 2003.

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