BROOKHAVEN NATIONAL LABORATORY

2011

Site Environmental Report

GROUNDWATER STATUS REPORT

VOLUME II

2011
SITE ENVIRONMENTAL REPORT
VOLUME II
GROUNDWATER STATUS REPORT

September 7, 2012

Environmental Protection Division
Groundwater Protection Group

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

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From the initial collection of samples to the final reproduction, the *2011 BNL Groundwater Status Report* required the expertise and cooperation of many people and organizations to complete. The contributions of the following individuals are gratefully acknowledged:

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Acronyms and Abbreviations

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

AGS	Alternating Gradient Synchrotron
AOC	Area of Concern
AS/SVE	Air Sparge/Soil Vapor Extraction
AWQS (NYS)	Ambient Water Quality Standards
BGD	Below Ground Ducts
BGRR	Brookhaven Graphite Research Reactor
BLIP	Brookhaven Linac Isotope Producer
bls	below land surface
BMRR	Brookhaven Medical Research Reactor
BNL	Brookhaven National Laboratory
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
cfm	cubic feet per minute
CFR	Code of Federal Regulations
COC	Chain of Custody
Cr	chromium
Cr(VI)	hexavalent chromium
CRDL	Contract Required Detection Limit
CSF	Central Steam Facility
CY	calendar year
DCA	1,1-dichloroethane
DCE	1,1-dichloroethylene
DCG	Derived Concentration Guide
DNAPL	dense non-aqueous-phase liquid
DOE	United States Department of Energy
DQO	Data Quality Objective
DTW	Depth to Water
DWS	Drinking Water Standards
EDB	ethylene dibromide
EDD	Electronic Data Deliverable
EE/CA	Engineering Evaluation/Cost Analysis
EIMS	Environmental Information Management System
EM	Environmental Management
EMS	Environmental Management System
EPA	United States Environmental Protection Agency
EPD	Environmental Protection Division
ER	Emissions Rate
ERP	Emissions Rate Potential
ES	Environmental Surveillance
ESD	Explanation of Significant Differences
EW	extraction well
FFA	Federal Facility Agreement
ft	feet
ft msl	feet relative to mean sea level
GAC	granular activated carbon
gal/hr	gallons per hour
gpm	gallons per minute
HFBR	High Flux Beam Reactor
HWMF	Hazardous Waste Management Facility
IAG	Inter Agency Agreement
ID	identification
lb/gal	pounds per gallon
lb/hr	pounds per hour
lbs	pounds
LIE	Long Island Expressway
Linac	Linear Accelerator
LIPA	Long Island Power Authority
LTRA	Long Term Response Actions
mCi	milliCuries
MCL	Maximum Contaminant Level
MDA	Minimum Detectable Activity
MDL	Minimum Detection Limit
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MGD	millions of gallons per day
MNA	Monitored Natural Attenuation
MPF	Major Petroleum Facility
mrem/yr	millirems per year
MS/MSD	Matrix Spike/Matrix Spike Duplicate
msl	mean sea level
MTBE	methyl tertiary-butyl ether
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
NSE	North Street East
NSLS-II	National Synchrotron Light Source II
NSRL	NASA Space Radiation Laboratory
NYCRR	New York Code of Rules and Regulations
NYS	New York State
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health

O&M	Operation and Maintenance
OU	Operable Unit
PCBs	polychlorinated biphenyls
PCE	tetrachloroethylene
pCi/L	picoCuries per liter
PFS	Pile Fan sump
PLC	programmable logic controller
QA/QC	Quality Assurance and Quality Control
RA V	Removal Action V
RCRA	Resource Conservation and Recovery Act
RHIC	Relativistic Heavy Ion Collider
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RPD	Relative Percent Difference
RTW	Recirculating Treatment Well
RW	remediation well
SBMS	Standards Based Management System
SCDHS	Suffolk County Department of Health Services
SCWA	Suffolk County Water Authority
SDG	Sample Delivery Group
SDWA	Safe Drinking Water Act
SOP	Standard Operating Procedure
SPCC	Spill Prevention Control and Countermeasures
SPDES	State Pollutant Discharge Elimination System
Sr-90	strontium-90
STP	Sewage Treatment Plant
SU	standard unit
SVOC	semivolatile organic compound
TCA	1,1,1-trichloroethane
TCE	trichloroethylene
TVOC	total volatile organic compound
USGS	United States Geological Survey
UST	underground storage tank
VOC	volatile organic compound
µg/L	micrograms per liter
WCF	Waste Concentration Facility
WLA	Waste Loading Area
WMF	Waste Management Facility

2011 BROOKHAVEN NATIONAL LABORATORY

GROUNDWATER STATUS REPORT

Executive Summary

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

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

The *2011 BNL Groundwater Status Report* is a comprehensive summary of data collected during the calendar year, and an evaluation of Groundwater Protection Program performance. This is the sixteenth annual groundwater status report issued by BNL. This document examines the performance of the program on a project-by-project basis.

How to Use This Document: This detailed technical document includes summaries of laboratory data, as well as data interpretations. Area summary level review of this information is presented as Chapter 7 of Volume I of the *Site Environmental Report*. Groundwater restoration is performed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) by the Groundwater Protection Group, and includes measuring and monitoring of groundwater remediation performance, and efforts in achieving cleanup goals. Facility Monitoring refers to the monitoring of groundwater quality at active research and support facilities, primarily in response to New York State operating permits, Department of Energy (DOE) Order 458.1, Radiation Protection of the Public and Environment and DOE Order 436.1, Departmental Sustainability. Data are presented in five key areas:

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

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

Section 1 summarizes the regulatory requirements of the data collection work in 2011, 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 2011. **Section 3**

summarizes the groundwater cleanup data, progress towards achieving the site's cleanup goals, and recommended modifications to the remediation systems or monitoring programs.

Section 4 summarizes the facility monitoring data used to verify that operational and engineering controls are preventing further contamination from the site's active experimental and support facilities. The recommended changes to the Groundwater Protection Program are summarized in **Section 5**.

HYDROGEOLOGIC DATA

The following were important hydrogeologic findings in 2011:

- The desired flow conditions continued to be maintained in the central portion of the site during 2011, with 95 percent of the supply well water pumpage being derived from the western supply-well field. Minimal shifting of contaminant plumes was observed on site in 2011.
- Total annual precipitation in 2011 was 51.2 inches, which is slightly above the yearly average of 48.9 inches. Twelve of the past 16 years have featured above-normal average precipitation at BNL.

GROUNDWATER RESTORATION (CERCLA)

Table E-1 summarizes the status and progress of groundwater cleanup at BNL under the provisions of CERCLA. During 2011, 10 volatile organic compound (VOC) groundwater remediation systems were in operation, along with two strontium-90 (Sr-90) treatment systems, and a tritium pump and recharge system. In 2011, 156 pounds of VOCs were removed from the aquifers by the treatment systems. To date, 6,709 pounds of VOCs have been removed from the aquifer. The Operable Unit (OU) III Chemical/Animal Holes Sr-90 System removed 0.33 milliCuries (mCi) of Sr-90 from the Upper Glacial aquifer in 2011, for a total of 4.43 mCi since operations began in 2003. The OU III Brookhaven Graphite Research Reactor (BGRR) Sr-90 System removed 2.6 mCi of Sr-90 during the year, for a total of 21.2 mCi since operations began in 2005.

While groundwater remediation is expected to be a long-term process, there are noticeable improvements in groundwater quality for most of the plumes. The OU IV Air Sparging/Soil Vapor Extraction (AS/SVE) system was decommissioned in 2003, and the OU III Carbon Tetrachloride System was decommissioned during 2010. The Industrial Park East System was placed in shutdown mode in 2009. A number of individual extraction wells have been placed on standby in several systems because of remediation progress. The OU V/STP VOC plume has attenuated to below Drinking Water Standards (DWS) except for only one detection of trichloroethene slightly above the DWS in 2011. A petition to discontinue the OU V groundwater monitoring program was submitted to the regulators in March 2012. Groundwater remediation activities for the remaining plumes are expected to continue until the cleanup objectives for the plumes have been met. The specific goals are as follows:

- Achieve maximum contaminant levels (MCLs) for VOCs in the Upper Glacial aquifer by 2030
- Achieve MCLs for VOCs in the Magothy aquifer by 2065
- Achieve the MCL of 8 pico Curies per liter (pCi/L) for Sr-90 at the BGRR in the Upper Glacial aquifer by 2070
- Achieve the MCL of 8 pCi/L for Sr-90 at the Chemical/Animal Holes in the Upper Glacial aquifer by 2040

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

Table E-1.
BNL Groundwater Remediation System Treatment Summary for 1997 – 2011.

	1997 – 2010		2011	
VOCs Remediation (start date)	Water Treated (gallons)	VOCs Removed (pounds)(c)	Water Treated (gallons)	VOCs Removed (pounds)(c)
OU III South Boundary (June 1997)	3,690,854,850	2,786	192,928,000	48
OU III Industrial Park (Sept. 1999)	1,740,962,330	1,052	87,825,000	5
OU III W. South Boundary (Sept. 2002)	911,116,000	80	116,423,000	12
OU III Carbon Tetrachloride (Oct. 1999) (e)	153,538,075	349	0	0
OU I South Boundary (Dec. 1996)	3,853,732,000	359	172,540,000	3.5
OU III HFBR Tritium Plume (May 1997) (a)	537,129,000	180	87,855,000	0
OU IV AS/SVE (Nov. 1997) (b)	0	35	0	0
OU III Building 96 (Feb. 2001)	248,822,416	99	46,488,000	9
OU III Middle Road (Oct. 2001)	1,859,388,550	920	220,584,000	51
OU III Industrial Park East (May 2004)	357,192,000	38	0	0
OU III North Street (June 2004)	1,179,193,000	313	139,983,000	8
OU III North Street East (June 2004)	683,772,000	36	68,123,000	2
OU III LIPA/Airport (June 2004)	1,621,542,000	306	173,651,000	17
OU VI EDB (August 2004)	960,709,000	NA(d)	163,822,000	NA (d)
Totals	17,797,951,221	6,553	1,470,222,000	155.5

	2003 – 2010		2011	
Sr-90 Remediation (start date)	Water Treated (gallons)	Sr-90 Removed (mCi)	Water Treated (gallons)	Sr-90 Removed (mCi)
OU III Chemical Holes (Feb 2003)	31,242,826	4.1	6,920,000	0.33
OU III BGRR (June 2005)	47,939,000	18.6	3,624,000	2.6
Totals	79,181,826	22.7	10,544,000	2.93

Notes:

(a) System was placed in standby mode on Sept. 29, 2000, but restarted November 2007.
(b) Air Sparging/Soil Vapor Extraction (AS/SVE) system performance measured by pounds of volatile organic compounds (VOCs) removed. System was dismantled in December 2003.
(c) Values rounded to the nearest whole number.
(d) Ethylene dibromide (EDB) has been detected in the system influent since 2009 at levels slightly above the standard . Therefore, no removal of VOCs is reported.
(e) System was dismantled in 2010.

NA – Not applicable
mCi – milliCuries

The locations and extent of the primary VOC and radionuclide plumes at BNL, as of December 2011, are summarized on **Figures E-1** and **E-2**, respectively. Significant items of interest during 2011 were the following:

- A total of 662 monitoring wells were sampled as part of the CERCLA Groundwater Monitoring

Program, comprising a total of 1,470 groundwater samples. In 2011, 28 temporary wells were also installed under the CERCLA program. BNL continued to make significant progress in characterizing and restoring groundwater quality at the site.

- 1.5 billion gallons of groundwater were treated, and 156 pounds of VOCs and 2.93 mCi of Sr-90 were removed from the aquifer (**Table E-1**).
- Sr-90 concentrations in groundwater immediately down-gradient of the BGRR have not decreased as expected over the past six years. Because installation of the engineered cap has just recently been completed, BNL will continue to monitor the trends. If warranted, the feasibility of using remediation techniques (such as the applicability of additional source area stabilization/control techniques) will be assessed.
- Groundwater characterization of the deep Upper Glacial aquifer at the OU III South Boundary near EW-4, in conjunction with increased VOC concentrations in an off-site plume bypass well over the past several years, has resulted in the identification of an area of deep VOC contamination migrating off-site beneath this extraction well. An additional extraction well screened at the base of the Upper Glacial aquifer will be installed in 2012 to remediate this contamination.
- The High Flux Beam Reactor (HFBR) Tritium Pump and Recharge system was operational during 2011. Monitoring data for 2010 and 2011 indicate that the tritium concentrations have dropped below the 20,000 pCi/L DWS in the downgradient segment of the plume. A petition for shutdown of the pump and recharge system will be prepared during 2012. Although tritium concentrations in groundwater monitoring wells immediately downgradient of the HFBR were below the DWS throughout all of 2009 and early 2010, tritium concentrations increased to 50,800 pCi/L during the fourth quarter of 2010, and increased further to 142,000 pCi/L in 2011. This increase is associated with the historically high water table levels observed at the site in early 2010, which flushed residual tritium from the deep vadose zone beneath the HFBR. The overall reduction in tritium concentrations over the past few years indicates that the inventory of tritium remaining in the deep vadose zone is diminishing.
- During 2011, high levels of PCE were detected in groundwater monitoring wells located within and immediately downgradient of the Building 96 PCE contaminated soils area that was excavated in 2010. Although PCE was detected at concentrations up of 3,000 μg/L during the first quarter 2011, PCE levels decreased to less than 625 μg/L by the end of the year. The Building 96 Groundwater Treatment System will continue to operate to ensure that the cleanup goal is achieved.
- Although all VOC concentrations in the OU V monitoring wells were below the DWS from 2008 through 2010, during 2011, TCE was detected at slightly above the standard in a single off-site monitoring well. A petition to conclude the OU V monitoring program was submitted to the regulatory agencies in March 2012. As a result of regulatory review, the monitoring will conclude in 2012. However, monitoring of one well will continue for a minimum of two more years, to ensure there is a declining trend less than the DWS.

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

INSTITUTIONAL CONTROLS

Institutional controls are in place at BNL to ensure effectiveness of all groundwater remedies. During 2011, the institutional controls continued to be effective in protecting human health and the environment. In accordance with the *BNL Land Use Controls Management Plan* (2009), the following institutional controls continued to be implemented for the groundwater remediation program.

- Groundwater monitoring, including BNL potable supply systems and Suffolk County Department of Health Services (SCDHS) monitoring of Suffolk County Water Authority (SCWA) well fields closest to BNL
- Implement controls on the installation of new supply wells and recharge basins on BNL property
- Continue to offer private well testing (via SCDHS) for those homes in the previously defined hook-up area not connected to public water.
- Suffolk County Sanitary Code Article 4 placement of prohibitions on the installation of new potable water-supply wells where public water service exists.
- Maintain property access agreements for treatment systems off the BNL property

FACILITY MONITORING

BNL's Facility Monitoring program includes groundwater monitoring at 12 active research facilities (e.g., accelerator beam stops and target areas) and support facilities (e.g., fuel storage and waste management facilities). During 2011, groundwater samples were collected from 134 wells during 230 individual sampling events. During the year, nine temporary wells were installed to monitor the g-2 Tritium Plume and 41 temporary wells were used to characterize the newly discovered Building 452 Freon-11 plume. Approximately 400 groundwater samples were collected using these temporary wells.

Highlights of the Facility Monitoring surveillance program are as follows:

- Tritium continues to be detected in the g-2 source area monitoring wells, at concentrations above the 20,000 pCi/L, Federal DWS with a maximum concentration of 119,000 pCi/L during 2011. Although the engineered stormwater controls are effectively protecting the activated soil shielding at the source area, monitoring data indicate that the continued release of tritium appears to be related to the flushing of residual tritium from the deep vadose zone following significant natural periodic fluctuations in the local water table.

- Natural radioactive decay and dispersion has significantly reduced the size of the downgradient portion of the g-2 tritium plume, which is now located south of the NSLS facility. During the December 2011 characterization of this plume segment, tritium was detected above the 20,000 pCi/L ROD trigger level in several temporary wells installed south of Brookhaven Avenue, with a maximum concentration of 58,600 pCi/L. In response to exceeding the ROD trigger, BNL informed the regulatory agencies about the monitoring results and recommended that temporary wells be re-installed south of Brookhaven Avenue in June 2012 to re-characterize this plume segment. BNL will then evaluate whether additional actions are required. The tritium detected in this plume segment is expected to naturally attenuate to less than the 20,000 pCi/L DWS within several years.

- Since April 2006, all tritium concentrations in the Brookhaven Linear Isotope Producer (BLIP) facility surveillance wells have been less than the 20,000 pCi/L DWS. The maximum tritium concentration during 2011 was 2,000 pCi/L. These results indicate that the engineered stormwater controls are effectively protecting the activated soil shielding, and that the amount of residual tritium in the deep vadose zone is diminishing.

- At the Upton Service Station, VOCs associated with petroleum products and the solvent PCE continue to be detected in the groundwater directly downgradient of the facility. Total VOC concentrations in one well reached a maximum of 1,229 µg/L; with the contamination consisting mostly of xylenes, ethyl benzene, and trimethylbenzenes. Groundwater monitoring results indicate that the petroleum-related compounds break down within a short distance from the facility. It is believed that the contaminants detected in groundwater originated from historical vehicle maintenance activities and are not related to current operations.

- During 2011, a plume of trichlorofluoromethane (also known by the trade name Freon-11) was discovered in the area of site maintenance facility Building 452. The full extent of the plume was characterized using 41 temporary wells. The plume was found to extend from Building 452 to approximately 600 feet downgradient. The maximum Freon-11 concentration was 38,000 µg/L. Based upon the high levels of Freon-11 in the groundwater, BNL began to install a new treatment system in late 2011 to remediate the plume. The treatment system began operation in April 2012.

PROPOSED CHANGES TO THE GROUNDWATER PROTECTION PROGRAM

The data summarized in this report are the basis for several significant proposed operational and groundwater monitoring changes to the groundwater protection program. A summary of these significant changes follows (specific details of which are provided in **Section 5**).

- **OU I South Boundary System** – Submit a petition to shut down the system to the regulators during the fourth quarter of 2012 provided core well concentrations remain below the capture goal.
- **Building 96 System –**
    - Place treatment well RTW-4 in standby mode.
    - Reduce the frequency of monitoring for total chromium and hexavalent chromium in the monitoring wells from quarterly to annually.
- **Middle Road System** – Evaluate the monitoring data and perform additional groundwater modeling to determine if an additional extraction well to the west of extraction well RW-1 is needed.
- **OU III South Boundary System –**
    - Complete installation and begin operation of an additional extraction well near EW-4 to address the deeper VOC contamination.
    - Perform additional groundwater characterization in the industrial park south of well 121-43 to evaluate the extent of downgradient migration of the VOC plume under well EW-4.
- **OU III Western South Boundary System** – Install a monitoring well at the Middle Road in June 2012 to monitor the downgradient extent of the Freon-12 observed in well 103-15.
- **Industrial Park System –** Evaluate additional data collected from the temporary well between UVB-5 and UVB-6 and the new monitoring well to determine whether the criteria for system shutdown has been met. A petition to shut down this system will be submitted to the regulators if these criteria are met.

- **Industrial Park East System** – Since no rebound in VOC concentrations in core monitoring wells have been observed since system shutdown in December 2009, and since they remain below MCLs, a Petition for Closure of this system will be submitted to the regulators.
- **North Street System –** Since TVOC concentrations in all plume core monitoring and extraction wells have been below the capture goal of 50 μg/L for four consecutive sampling rounds in 2011, a Petition for Shutdown of the treatment system be submitted to the regulators for review and approval.
- **North Street East System –**
  - Install an additional temporary well upgradient of NSE-VP-02-2010 in June 2012.
  - Also in June 2012, install a new core monitoring well at the location of NSE-VP-02-2010. The new monitoring well at this location will be used to help evaluate when the treatment system can be shut down.
- **LIPA/Airport System –** Install a new monitoring well adjacent to well 800-59 that is screened about 40 feet deeper than this well. This will monitor higher concentrations of VOCs identified in upgradient well 800-92.
- **BGRR/WCF Sr-90 System –**
  - If warranted, evaluate the applicability of additional source area stabilization/control techniques.
  - Install a new monitoring well immediately south and east of the Center for Functional Nanomaterials (Building 735) to monitor for the leading edge of the BGRR Sr-90 plume.
  - Install a temporary well along Brookhaven Avenue south of the main entrance to the BNL Light Source (Building 725) to characterize the downgradient extent of Sr-90 in this area.
  - Install up to eight temporary wells to characterize Sr-90 concentrations upgradient and to the east of WCF plume extraction wells SR-6, SR-7, SR-8, and SR-9.
- **Chemical/Animal Holes Sr-90 System –**
  - To determine if there is a continuing source of Sr-90 contamination upgradient of EW-1, characterization of the groundwater and soil in the area of the 2008 temporary wells will be performed in the summer of 2012. Following review of the data, if warranted, the feasibility of using remediation techniques (such as in-situ stabilization or source removal) will be assessed.
  - Based on the 2010 temporary well data, install a new perimeter monitoring well in the summer of 2012 upgradient and to the west of well 106-48.
- **HFBR Tritium System –**
  - Submit a petition to the regulatory agencies to shut down EW-11 and EW-16 since tritium concentrations have been less than DWS in monitoring wells at Weaver Drive and extraction wells.
  - Following the shutdown of EW-11 and EW-16, confirm the reduction of tritium concentrations in the area from Weaver Drive to Princeton Avenue using a limited number of temporary and permanent monitoring wells during 2013 and 2014.

- **Operable Unit V** –
    - Well 000-122 will be monitored annually for VOCs for an additional two years. If the concentrations of VOCs decrease to below MCLs during that time, BNL will recommend that monitoring for well 000-122 be discontinued.
    - Monitoring of the remaining wells will be discontinued.
    - Five monitoring wells will be abandoned, and the remaining will continue to be used for water level measurements.
- **Operable Unit VI EDB System –** Install an additional perimeter monitoring well to the east of well EDB-MW-01-2011. The specific location will be dependent upon available property access.
- **g-2 Tritium Plume** – In June 2012, install additional temporary wells south of Brookhaven Avenue to verify expected attenuation of the plume to below DWS as required by the ROD.
- **Building 432 Freon-11** –
    - For 2012, the Building 452 monitoring wells will be monitored quarterly.
    - The Freon-11 treatment system will be monitored in accordance with the SPDES equivalency permit.
    - During 2012, soil samples will be collected near the Building 452 source area to evaluate residual Freon-11 concentrations in the vadose soils.

Table E-2.
Groundwater Restoration Progress.

Project	Target	Mode	Treatment Type	Expected System Shutdown	Highlights
OU I					
OU I South Boundary (RA V)	VOCs	Operational	P&T with AS	2013	All core wells below capture goal, except 107-40. This well is showing a declining trend. Submit Petition for Shutdown.
Current Landfill	VOCs tritium	Long Term Monitoring & Maintenance	Landfill capping	NA	Groundwater continues slow improvement. VOCs and tritium stable or slightly decreasing.
Former Landfill	VOCs Sr-90 tritium	Long Term Monitoring & Maintenance	Landfill capping	NA	No longer a continuing source of contaminants to groundwater.
Former HWMF	Sr-90	Long Term Monitoring & Maintenance	Monitoring	NA	Plume attenuating as expected.
OU III					
Chemical/Animal Holes	Sr-90	Operational (EW-1 and EW-3 pulse pumping)	P&T with ion exchange (IE)	2014	Monitoring well 106-16 continues to have elevated Sr-90. Characterize for potential continuing source in 2012.
Carbon Tetrachloride source control	VOCs (carbon tetra-chloride)	Decommis-sioned	P&T with carbon	2009 (Complete)	Treatment system was decommissioned in 2010.
Building 96 source control	VOCs	Operational	Recirculation wells with AS for 3 of 4 wells. RTW-1 is P&T with AS.	2016	PCE in source area monitoring well declining in 2011. RTW-1 also serves to help remediate Bldg. 452 Freon-11 plume.
Building 452	VOCs	Startup April 2012	P&T with AS	2017	Freon-11 remediation per OU III ESD. System constructed in 2011, startup in 4/12 (new AOC 32).
South Boundary	VOCs	Operational (EW-6, EW-7, EW-8 and EW-12 on standby)	P&T with AS	2017	Additional extraction well being installed near EW-4 to prevent further off-site migration of deep VOCs. Monitoring wells are also being installed.
Middle Road	VOCs	Operational (RW-4, RW-5, and RW-6 on standby)	P&T with AS	2025	Identified VOCs to the west of the system that may require an additional extraction well. Perform groundwater modeling to help evaluate.

continued

Project	Target	Mode	Treatment Type	Expected System Shutdown	Highlights
OU III (cont.)					
Western South Boundary	VOCs	Operational (Pulse WSB-2)	P&T with AS	2019	Characterize extent of Freon-12 near Middle Road.
Industrial Park	VOCs	Operational (UVB-1, UVB-2, and UVB-7 on standby)	In-well stripping	2012	VOC concentrations continued to decline. Evaluate data in 2012 to determine whether system can be shut down.
Industrial Park East	VOCs	Standby	P&T with carbon	2009 (Complete)	No rebound observed in either extraction or monitoring wells. Prepare Petition for Closure in 2012.
North Street	VOCs	Operational (Pulse NS-1)	P&T with carbon	2012	VOCs below capture goal in extraction and monitoring wells. Prepare Petition for Shutdown in 2102.
North Street East	VOCs	Operational (Standby NSE-2)	P&T with carbon	2013	Characterize remaining persistent area of elevated VOCs and determine if system can be shut down.
Long Island Power Authority (LIPA) Right of Way/ Airport	VOCs	Operational (Standby: EW-1L, EW-2L, EW-3L, Pulse: RTW-2A, RTW-3A, RTW-5A)	P&T and recirculation wells with carbon	2014 (LIPA) 2019 (Airport)	System operating as planned.
HFBR Tritium	Tritium	Operational (Standby EW-9 and EW-10)	Pump and recharge	2012	Extraction and monitoring wells near Weaver Drive less than DWS in 2010 and 2011. Submit petition in 2012 to shut down remaining extraction wells EW-11 and EW-16.
BGRR/WCF	Sr-90	Operational	P&T with IE	2026	Continued Sr-90 spikes in SR-3 in 2011 downgradient of BGRR. Enhance monitoring well network in downgradient and side gradient portion of plumes.
OU IV					
OU IV AS/SVE system	VOCs	Decommis-sioned	Air sparging/ soil vapor extraction	2003 (Complete)	System decommissioned in 2003.
Building 650 sump outfall	Sr-90	Long Term Monitoring	Monitored Natural Attenuation (MNA)	NA	Continue to monitor plume attenuation.
OU V					
STP	VOCs, tritium	Long Term Monitoring	MNA	NA	VOC plume has attenuated to below DWS. Continue to monitor well 000-122 through 2013 to ensure decreasing trend. Petition to discontinue monitoring submitted to the regulators in March 2012.

continued

Project	Target	Mode	Treatment Type	Expected System Shutdown	Highlights
OU VI					
Ethylene Dibromide (EDB)	EDB	Operational	P&T with carbon	2015	The EDB plume continues to attenuate as expected. The extraction wells are capturing the plume. Further characterize the eastern edge of the plume.
g-2 and BLIP					
g-2 Tritium Plume	Tritium	Long Term Monitoring & Maintenance	MNA	NA	Tritium concentrations exceeded the contingency level of 20,000 pCi/L at Brookhaven Avenue during December.
BLIP Tritium Plume	Tritium	Long Term Monitoring & Maintenance	MNA	NA	Plume is attenuating as expected. Tritium concentrations less than DWS.

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1.0 INTRODUCTION AND OBJECTIVES

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

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

The *BNL 2011 Groundwater Status Report* is a comprehensive summary of groundwater data collected in calendar year 2011 that provides an interpretation of information on the performance of the Groundwater Protection Program. This is the 16th annual groundwater status report issued by BNL. This document examines performance of the program on a project-by-project (facility-by-facility) basis, as well as comprehensively.

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 Protection Group. This document can also be obtained through BNL's website. Data are presented in four key subject areas:

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

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

Section 1 discusses the regulatory requirements of the data collection work in 2011, the site's groundwater classification, and the objectives of groundwater monitoring. **Section 2** discusses the hydrogeologic environment at BNL and its surrounding area. It also summarizes the dynamics of the groundwater flow system in 2011. In **Section 3**, the groundwater cleanup data and progress towards achieving the site's cleanup goals are described. **Section 4** outlines the groundwater surveillance data used to verify that operational and engineered controls are preventing further contamination from BNL's active experimental and support facilities. **Section 5** is a summary of the proposed recommendations to the Groundwater Protection Program identified in **Sections 3 and 4**.

Appendices A and **B** include hydrogeologic data that support the discussions in **Section 2**. **Appendix C** contains the analytical results for each sample obtained under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) program. **Appendix D** contains analytical results for each sample obtained under the Facility Monitoring program. Due to the volume of these data, all of the report appendices are included on a CD-ROM, which significantly reduces the size of this report in printed format. The CD-ROM has a contents table with active links; by selecting the specific project and analytical suite, the user will be directed to the associated table of results. The groundwater results are arranged by specific monitoring project and analytical group: volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), metals, general chemistry, pesticides/polychlorinated biphenyls (PCBs), and radionuclides. The data are organized further by well identification (ID) and the date of sample collection. Chemical/radionuclide concentrations, detection limits, and uncertainties are reported, along with a data verification, validation, and/or usability qualifier (if assigned), and/or a laboratory data qualifier. If a data verification/validation qualifier was not assigned, the laboratory data qualifier is shown. Results exceeding the corresponding groundwater standard or guidance criteria (**Section 1.1.2**) are identified by bold text. Including the complete results enables the reader to analyze the data in detail. **Appendix E** contains information on sample collection, analysis, and Quality Assurance/Quality Control (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

1.1.1 Regulatory Requirements

Activities at BNL are driven by federal and state regulations as well as Department of Energy (DOE) Orders.

Comprehensive Environmental Response, Compensation and Liability Act

On December 21, 1989, BNL was included as a Superfund Site on the National Priorities List (NPL) of contaminated sites identified for priority cleanup. DOE, the United States Environmental Protection Agency (EPA), and the New York State Department of Environmental Conservation (NYSDEC) created a comprehensive Federal Facility Agreement (FFA) that integrated DOE's response obligations under CERCLA, the Resource Conservation and Recovery Act (RCRA), and New York State hazardous waste regulations. The FFA, also known as the Interagency Agreement (IAG), was finalized and signed by these parties in May 1992, and includes a requirement for groundwater monitoring (USEPA 1992).

New York State Regulations, Permits, and Licenses

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

BNL's Major Petroleum Facility (MPF) is operated under NYSDEC Bulk Petroleum Storage License No. 01-1700. This license requires BNL to routinely monitor the groundwater. Together with approved engineering controls, the groundwater monitoring program verifies that storage operations for bulk fuel have not degraded the quality of the groundwater. The engineered controls and monitoring program for the MPF are described in the *BNL Spill Prevention, Control and Countermeasures Plan* (BNL 2011a).

BNL's Waste Management Facility (WMF) is a hazardous waste storage facility operated under NYSDEC RCRA Part B Permit No. 1-4722-00032/00102-0. The permit requires groundwater monitoring as a secondary means of verifying the effectiveness of the facility's administrative and engineered controls.

DOE Orders

BNL conducts groundwater monitoring at active research and support facilities in accordance with the environmental surveillance requirements defined in DOE Order 458.1, *Radiation Protection of the Public and the Environment* and DOE Order 436.1, *Departmental Sustainability*. Groundwater monitoring is conducted to: characterize pre-operational conditions; to detect, characterize, and respond to contaminant releases from site operations and activities; evaluate dispersal and attenuation patterns; and to characterize the potential pathways of exposure to members of the public.

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

For drinking water supplies, the applicable federal maximum contaminant levels (MCLs) are set forth in 40 CFR (Code of Federal Regulations) 141 (for primary MCLs) and 40 CFR 143 (for secondary MCLs). In New York State, the SDWA requirements relating to the distribution and monitoring of public water supplies are promulgated under the NYS Sanitary Code (10 NYCRR Part 5), enforced by the Suffolk County Department of Health Services (SCDHS) as an agent for the New York State Department of Health (NYSDOH). These regulations apply to any water supply that has at least five service connections or that regularly serves at least 25 individuals. BNL supplies water to approximately 3,500 employees and visitors, and therefore must comply with these regulations. In addition, DOE Derived Concentration Guides (DCGs) are used for radionuclides not covered by existing federal or state regulations (DOE 2011).

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

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

1.1.3 Monitoring Objectives

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

Groundwater Resource Management

- To support initiatives in protecting, managing, and remediating groundwater by refining the conceptual hydrogeologic model of the site and maintaining a current assessment of the dynamic patterns of groundwater flow and water-table fluctuations.
- To determine the natural background concentrations for comparative purposes. The site's background wells provide information on the chemical composition of groundwater that has not been affected by BNL's activities. These data are a valuable reference for comparison with the groundwater quality data from affected areas. The network of wells also can warn of any contaminants originating from potential sources that may be located upgradient of the BNL site.
- To ensure that potable water supplies meet all regulatory requirements.

Groundwater Facility Monitoring

- Determine pre-operational/baseline groundwater quality at new facilities.
- To verify that administrative and engineered controls effectively prevent groundwater contamination.

- To demonstrate compliance with applicable DOE and regulatory requirements for protecting groundwater resources.

Groundwater -CERCLA Monitoring

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

The details of the monitoring are described in the *BNL 2011 Environmental Monitoring Plan* (BNL 2011b). This plan includes a description of the source area, description of groundwater quality, criteria for selecting locations for groundwater monitoring, and the frequency of sampling and analysis. **Figure 1-1** highlights BNL's operable unit (OU) locations designated as part of the CERCLA program, and key site features. Details on the sampling parameters, frequency, and analysis by well are listed in **Tables 1-5** and **1-6**. Screen zone, total depth, and ground surface elevations have been summarized in **Table 1-7**. **Figure 1-2** shows the locations of wells monitored as part of the Laboratory's groundwater protection program. Detailed groundwater monitoring rationale can be found in the *BNL 2011 Environmental Monitoring Plan*. BNL's CERCLA groundwater monitoring has been streamlined into five general phases **(Table 1-8)**:

<u>Start-up Monitoring</u>

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

<u>Operations and Maintenance (O&M) Monitoring</u>

This is a period of reduced monitoring during the time when the system is in a routine operational state. The timeframe for each system varies. This phase is also utilized for several plume monitoring programs not requiring active remediation.

<u>Shutdown Monitoring</u>

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

<u>Standby Monitoring</u>

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

<u>Post Closure Monitoring</u>

This is a monitoring period of varying length for approximately 20 percent of the key wells in a given project following system closure. Monitoring continues until the Record of Decision (ROD) goal of meeting MCLs for VOCs in the Upper Glacial aquifer is reached. This is expected to occur by 2030. This phase is considerably longer for the Magothy and Sr-90 cleanups due to greater length of the time to reach MCLs required for those projects.

Since 2001, BNL uses a structured Data Quality Objective (DQO) process to continually review and refine the groundwater monitoring and remediation projects. The results of the DQO reviews are documented annually in updates to the *BNL 2011 Environmental Monitoring Plan (BNL 2011b).*

Table 1-8. CERCLA Groundwater Monitoring Program – Well Sampling Frequency.

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

Notes:
*- Varies by project, see Table 1-5.
** - Magothy: 2065, BGRR Sr-90: 2070, South Boundary Rad: 2038, Chem Holes Sr-90: 2045
*** - Verification monitoring for achieving MCLs.
****- Sr-90 monitoring projects use approximately half the defined sampling frequency.

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

- Background –water quality results will be used to determine upgradient water quality
- Plume Core – utilized to monitor the high concentration or core area of the plume
- Perimeter – used to define the outer edge of the plume both horizontally and vertically
- Bypass – used to determine whether plume capture performance is being met
- Sentinel – An early warning well to detect the leading edge of a plume.

1.2 Private Well Sampling

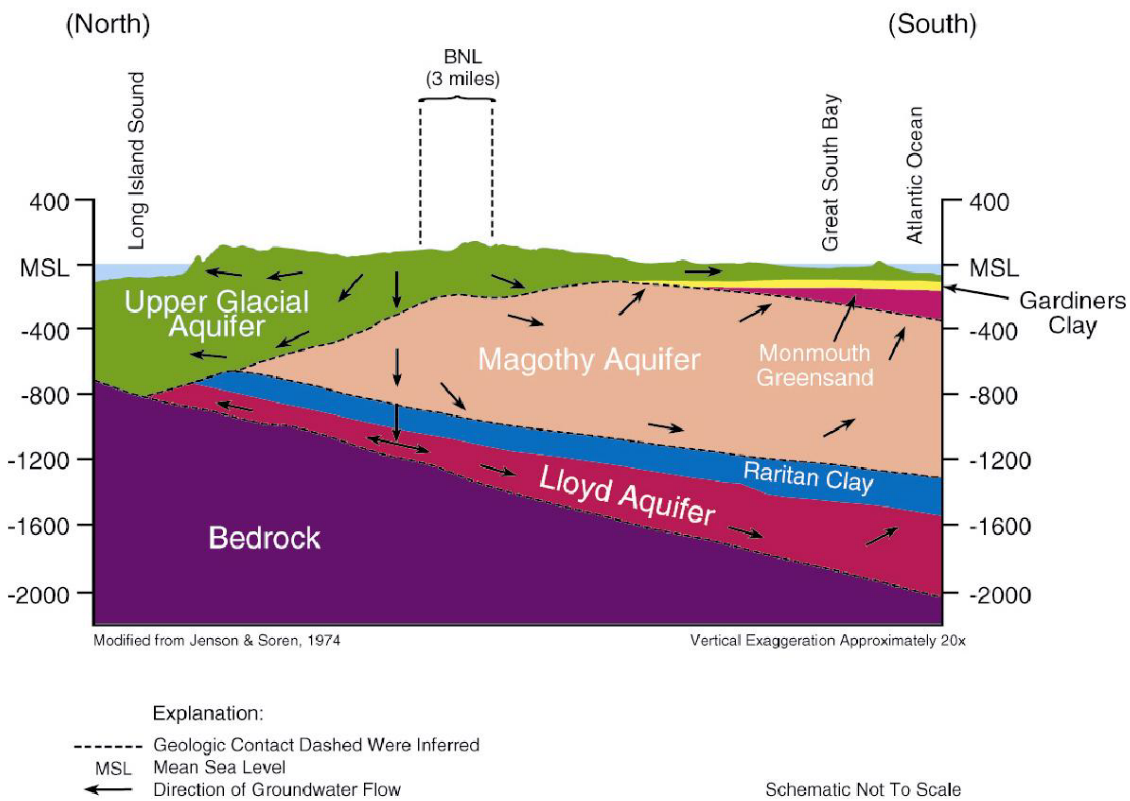
During 2011, there were eight known homeowners in the residential area overlying the plumes who continue to use their private wells for drinking water purposes. In accordance with the OU III and OU VI RODs, DOE formally offers these homeowners free testing of their private drinking water wells on an annual basis. SCDHS coordinates and performs the sampling and analysis. During 2011, four of the homeowners who were offered the free testing accepted this service. During 2011, except for naturally occurring iron, only one home had a positive result above DWS. Chlorodifluoromethane (Freon 22) was detected at one home at a maximum concentration of 91 μg/L which is above the DWS of 5 μg/L. Based on the location of this private well and it's shallow depth, this contamination did not originate from BNL. The property owner subsequently hooked up to public water in August 2011.

2.0 HYDROGEOLOGY

This section briefly describes the hydrogeologic environment at BNL and the surrounding area. It also summarizes the dynamics of the groundwater flow system in 2011, along with on-site pumping rates and rainfall recharge.

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

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



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

Where it exists, the Gardiners Clay acts as a confining or semi-confining unit that impedes the vertical flow and migration of groundwater between the Upper Glacial aquifer and the underlying Magothy aquifer.

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

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

2.1 Hydrogeologic Data

Various hydrogeologic data collection and summary activities were undertaken as part of the 2011 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 from a network of on-site and off-site wells screened at various depths within the Upper Glacial aquifer and upper portions of the Magothy aquifer. These data are used to characterize the groundwater flow-field (direction and rate) and to evaluate seasonal and artificial variations in its flow patterns. Additional water-level data from off-site wells are obtained from the USGS.

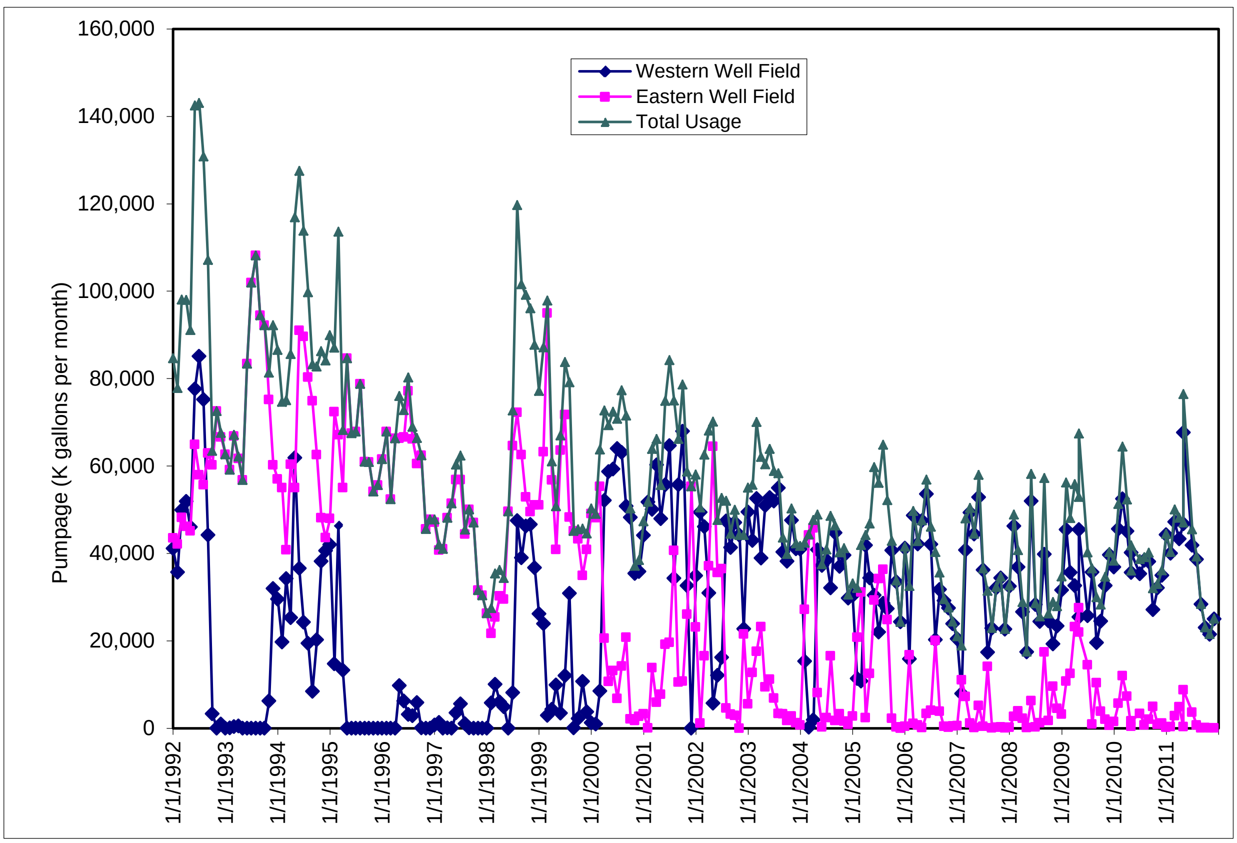
The synoptic water-level measurement events comprising the complete network of on-site and off-site wells were conducted in November 2011 with data collected from approximately 775 wells. Smaller scale synoptic measurement using wells located only in the central part of the BNL site were conducted in March, June and August 2011, with data collected from approximately 100 shallow Upper Glacial aquifer wells. Water levels were measured with electronic water-level indicators following the BNL *Environmental Monitoring Standard Operating Procedure* EM-SOP-300. **Appendix A** provides the depth-to-water measurements and the calculated groundwater elevations for these measurements. Monitoring results for long-term and short-term hydrographs for select wells are discussed in **Section 2.2**.

2.1.2 Pumpage of On-Site Water Supply and Remediation Wells

BNL operates six water supply wells to provide potable and process cooling water, and 62 treatment wells used for the remediation of contaminated groundwater. All six water supply wells are screened entirely within the Upper Glacial aquifer. During 2011, 18 of the 62 treatment wells were in standby mode. **Figures 2-2** and **2-3** show the locations of the water supply and remediation wells. The effects the groundwater withdrawals have on the aquifer system are discussed in **Section 2.2**.

Table 2-1 provides the monthly and total water usage for 2011 for the six on-site potable supply wells (4, 6, 7, 10, 11, and 12). It includes information on each well's screened interval and pumping capacity. These wells primarily withdraw groundwater from the middle to deep sections of the Upper Glacial aquifer. The variation in monthly pumpage reflects changes in water demand, and maintenance schedules for the water supply system. The western potable well field includes wells 4, 6, and 7; the eastern field contains wells 10, 11, and 12. Supply well 12 has been out of service since October 2008, when a propane gas explosion destroyed the pump house and associated pump controls. The water supply operating protocols, which have been established by the BNL Water and Sanitary Planning Committee, currently require that the western well field be used as the primary source of water, with a goal of obtaining 75 percent or more of the site-wide water supply from that well field. Using the western well field minimizes the groundwater flow direction effects of supply well pumping on several segments of the groundwater contaminant plumes located in the center of the BNL site. **Figure 2-4** below summarizes monthly pumpage for the eastern and western well fields.

Figure 2-4.
Summary of BNL Supply Well Pumpage 1992 through 2011.



Since 1999, the implementation of effective water conservation measures has resulted in a significant reduction in the amount of water pumped from the aquifer. During 2011, a total of 467 million gallons of water were withdrawn from the aquifer, and BNL met its goal of obtaining more than 75 percent of its total water supply from the western well field. The western well field provided approximately 95 percent of the water supply, with most of the pumpage obtained from wells 4 and 7. Supply well 10 has been maintained in standby mode since 2000 due to the impacts it might have on contaminant plume flow directions in the central portion of the site (specifically on the g-2 tritium plume and the Waste Concentration Facility Sr-90 plume). However, with the loss of well 12 in October 2008, in early 2009 BNL started to use well 10 for short periods of time. **Table 2-2** summarizes the 2011 monthly water pumpage for the groundwater remediation systems. Additional details on groundwater remediation system pumping are provided in **Section 3** of this report.

2.1.3 Off-Site Water Supply Wells

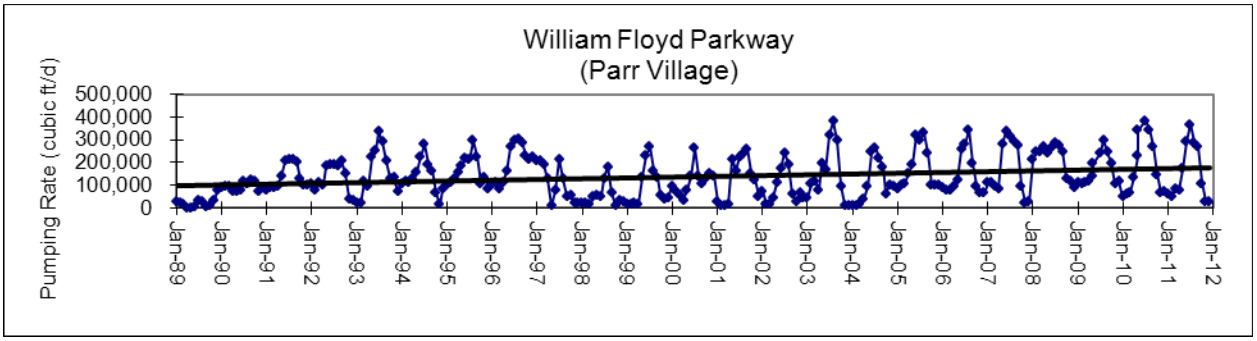
Several Suffolk County Water Authority (SCWA) well fields are located near BNL. The William Floyd Parkway Well Field is west/southwest of BNL (**Figures 2-2 and 2-3**), and consists of three water supply wells that withdraw groundwater from the mid Upper Glacial aquifer and the upper portion of the Magothy aquifer. The Country Club Drive Well Field is south/southeast of BNL, and consists of three water supply wells that withdraw groundwater from the mid section of the Upper Glacial aquifer. Pumpage information for 1989 through 2011 is provided as **Figure 2-5.** In 2011, the William Floyd Parkway (Parr Village) and Country Club Drive Well Fields produced 417 and 371 million gallons for the year, respectively. The Lambert Avenue Well Field, located south of BNL, produced 431 million gallons for the year.

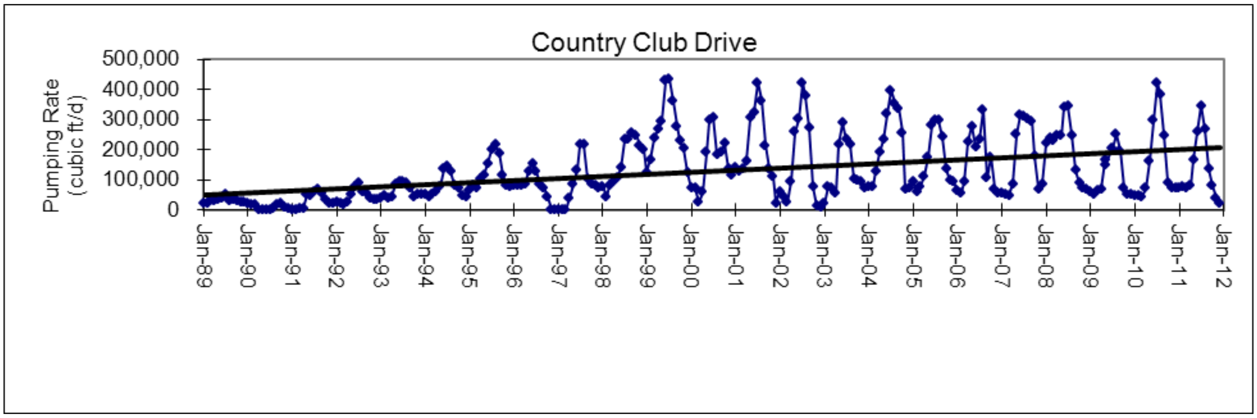
2.1.4 Summary of On-Site Recharge and Precipitation Data

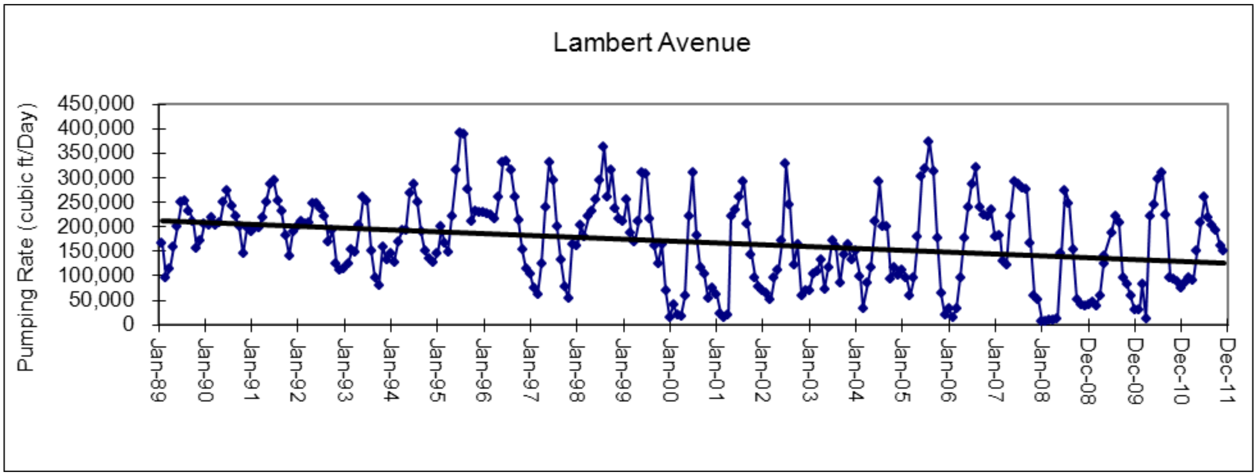
This section summarizes artificial (i.e., on-site recharge basins) and natural recharge from precipitation. **Table 2-3** summarizes the monthly and total flow of water through 10 on-site recharge basins during 2011. Their locations are shown on **Figures 2-2 and 2-3**. **Section 2.2** (Groundwater Flow) provides a discussion on the effects associated with recharge. Seven of the basins (HN, HO, HS, HT-W, HT-E, HX, and HZ) receive stormwater runoff and cooling water discharges. Flow into these basins is monitored monthly per NYSDEC State Pollutant Discharge Elimination System (SPDES) permit requirements. Generally, the amount of water recharging through the groundwater system to these basins reflects supply well pumpage. Annual water supply flow diagrams show the general relationships between recharge basins and the supply wells, and are published in Volume I of the annual *Site Environmental Report (Chapter 5, Water Quality)*.

The remaining three basins (Removal Action V [RA V], OU III, and Western South Boundary) were constructed to recharge water processed through several of the groundwater remediation systems. Until September 2001, treated groundwater from the OU III South Boundary Pump and Treat System was discharged solely to the OU III basin, adjacent to former recharge basin HP along Princeton Avenue. After September 2001, groundwater from that system and the OU III Middle Road system was discharged equally to the OU III and RA V basins. Treated groundwater from the OU I South Boundary and the High Flux Beam Reactor (HFBR) system is discharged to the RA V basin. **Table 2-3** gives estimates of flow to these basins. The discharge to these basins during 2011 (21 and 35 million gallons per month, average, for the OU III and RA V basins, respectively) is significantly greater than that from other individual on-site basins. Pulse pumping and the placement of several groundwater remediation extraction wells on standby resulted in an overall decrease of discharge totals. Other important sources of artificial recharge, not included on **Table 2-3**, include a stormwater retention basin referred to as HW (on Weaver Drive), and the sand filter beds at the STP. The sand filter beds causes localized mounding of the water table. Of the approximately 300,000 gallons of wastewater treated at the STP each day, about 20 percent of the treated effluent seeps directly to the underlying water table beneath the filter beds tile-drain collection system, and the remaining treated effluent is discharged to the Peconic River. Most of the water released to the Peconic River recharges to the aquifer before it reaches the BNL site boundary, except during times of seasonally high water levels.

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







Precipitation provides the primary recharge of water to the aquifer system at BNL. In an average year, approximately 24 inches of precipitation recharges the Upper Glacial aquifer. Under long-term conditions in undeveloped areas of Long Island, about 50 percent of precipitation is lost through evapotranspiration and direct runoff to streams; the other 50 percent infiltrates the soil and recharges the groundwater system (Aronson and Seaburn 1974; Franke and McClymonds 1972). For 2011, it is estimated that the recharge at BNL was approximately 25 inches. **Table 2-4** summarizes monthly and annual precipitation results from 1949 to 2011 collected on site by BNL Meteorology Services. Variations in the water table generally can be correlated with seasonal precipitation patterns. As depicted on **Table 2-4**, total annual precipitation in 2011 was 51.2 inches, which was slightly above the long-term yearly average of 48.9 inches. Twelve of the past 16 years have featured above-normal annual average precipitation at BNL.

2.2 Groundwater Flow

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

2.2.1 Water-Table Contour Map

Figure 2-2 is a groundwater elevation contour map representing the configuration of the water table for November 7-10, 2011. The contours were generated from the water-level data from shallow Upper Glacial aquifer wells, assisted by a contouring package (Quick SURF). Localized hydrogeologic influences on groundwater flow were considered, including on-site and off-site pumping wells, and on-site recharge basins (summarized in **Section 2.1**).

Groundwater flow in the Upper Glacial aquifer is generally characterized by a southeasterly component of flow in the northern portion of the site, with a gradual transition to a more southerly direction at the southern boundary and beyond. Flow directions in the eastern portion of BNL are predominately to the east and southeast (**Figure 2-2**). The general groundwater flow pattern for 2011 was consistent with historical flow patterns. As described in **Section 2.1.2**, the water supply operating protocols established by BNL in 2005 require that the western well field be used as the primary source of water, with a goal of obtaining 75 percent or more of the site's water supply from these wells. This protocol has resulted in a more stable south-southeast groundwater flow direction in the central portion of the site.

Localized man-made disturbances to groundwater flow patterns are evident on the groundwater contour maps. They result primarily from active on-site and off-site well pumpage and the discharge of water to on-site recharge basins. Influences from the pumping wells can be seen as cones of depressions, most notably near potable supply wells 4 and 7, and near the groundwater treatment wells along the southern boundary (**Figure 2-2**).

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

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

2.2.2 Deep Glacial Contour Map

Figure 2-3 shows the potentiometric surface contour map of the deep zone of the Upper Glacial aquifer for November 7-10, 2011. 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 sections of the Upper Glacial aquifer.

The 2011 patterns for groundwater flow in the deep Upper Glacial are similar to those in the shallow (or water-table) zone. They are characterized by a southeasterly component in the northern portion of the site, with a gradual transition to a more southerly flow at the southern site boundary and beyond. In areas south/southwest of BNL, the deep glacial contour map also indicates flow toward the Carmans River. The localized influences of pumping on the potentiometric surface configurations are evident as cones of depression. As with the water-table configurations, variations in these localized hydrogeologic effects are attributed to the monthly variations in pumpage.

Although the localized influences of recharging on the potentiometric surface configurations are evident for the deep Upper Glacial aquifer, they are not as pronounced as those observed at the water table. Such hydrogeologic effects generally decrease with depth in the aquifer. Furthermore, mounding is not present beneath the STP sand filter beds because mounding is controlled by shallow, near-surface clay layers. Finally, the surface water/groundwater interactions that take place along the Peconic River in the vicinity of BNL do not influence the deep glacial zone.

2.2.3 Well Hydrographs

Groundwater hydrographs are useful in estimating recharge rates and the location of the water table relative to contaminant sources. Long-term (typically 1950–2010) and short-term (1997–2010) well hydrographs were constructed from water-level data that were obtained for select USGS and BNL wells, respectively. These hydrographs track fluctuations in water level over time. Precipitation data also were compared to natural fluctuations in water levels. **Appendix B** contains the well hydrographs, together with a map depicting the locations of these wells.

A long-term hydrograph was constructed from historical water-level data from BNL well 065-14 (NYSDEC # S-5517.1; USGS Site Number 405149072532201). This well was installed by the USGS for the DOE in the late 1940s. The well is located near the BNL Brookhaven Center building, and is screened in the Upper Glacial aquifer close to the water table. The USGS has collected monthly water-level information from this well from 1953 through 2005. In 2006, the USGS installed a real time continuous water-level recorder in the well. Data from this monitoring station can be accessed on the World Wide Web at: http://groundwaterwatch.usgs.gov/AWLSites.asp?S=405149072532201&ncd=rtn.

The long-term hydrographs indicate that typical seasonal water-table elevation fluctuations are on the order of 4 to 5 feet. Some of the water-table elevation changes have occurred during prolonged periods of low precipitation, where a maximum fluctuation of nearly 14 feet was observed during the regional drought of the early 1960s.

Short-term hydrographs from three well clusters (well cluster 075-39/075-40/075-41, 105-05/105-07/105-24, and 122-01/122-04/122-05) are used to evaluate water-table fluctuations and fluctuations in vertical gradients from 1999 through 2011. Generally, the highest groundwater elevations can be observed during the March-May time period in response to snow melt and spring rains. Normally, the position of the water table drops through the summer and into the fall.

2.2.4 Groundwater Gradients and Flow Rates

Evaluation of the horizontal hydraulic gradients provides information on the driving force behind groundwater flow. These gradients can be used with estimates of aquifer parameters such as hydraulic conductivity (175 feet per day [ft/day]) and effective porosity (0.24) to assess the velocities of groundwater flow. The horizontal hydraulic gradient at the BNL site is typically 0.001 feet per foot (ft/ft), but in recharge and pumping areas it can steepen to 0.0024 ft/ft or greater. The natural groundwater flow velocity in most parts of the site is estimated to be approximately 0.75 ft/day, but flow velocities in recharge areas can be as high as 1.45 ft/day, and those in areas near BNL supply wells can be as high as 28 ft/day (Scorca et al. 1999).

2.3 New Geologic Data

Although a number of new wells were drilled at the BNL site during 2011, the geologic information obtained during their installation was consistent with previous investigations.

2.4 Monitoring Well Maintenance Program

BNL has a program to maintain its groundwater monitoring wells which includes maintaining the protective casings, concrete pads and sample pumps. During 2011, BNL repaired nine monitoring wells and replaced one monitoring well that was beyond repair. These well were damaged during activities associated with the decommissioning of the BGRR.

3.0 CERCLA GROUNDWATER MONITORING AND REMEDIATION

Chapter 3 gives an overview of groundwater monitoring and remediation efforts at BNL during 2011. The chapter is organized first by Operable Unit, and then by the specific groundwater remediation system and/or monitoring program. **Figure 1-2** shows the locations of monitoring wells throughout the site by project. Monitoring well location maps specific to particular monitoring programs are included throughout **Section 3**.

Report and Data on CD

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

About the Plume Maps

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

The extent of plumes containing VOC contamination was contoured to represent concentrations that were greater than the typical NYS AWQS of 5 micrograms per liter (µg/L) for most compounds. Radionuclide plumes were contoured to their appropriate drinking water standard (DWS). **Figure 3.0-1** shows the VOC and radionuclide plumes as well as the locations and groundwater capture zones for each of the treatment systems.

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

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

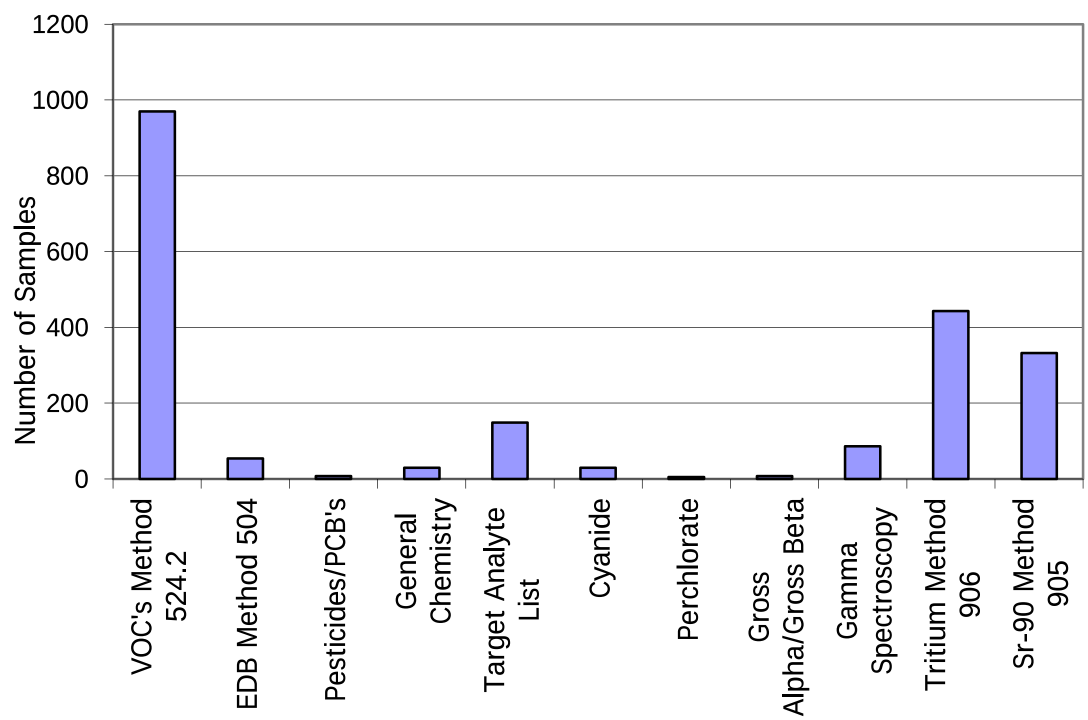
Additionally, BNL's ability to accurately depict these plumes has been enhanced over the years by the:

- installation of additional permanent monitoring wells to the existing well networks
- installation of temporary wells that helped to fill in data gaps

During 2011, the contaminant plumes were tracked by collecting 1,470 groundwater samples obtained from 662 on-site and off-site monitoring wells. **Figure 3.0-2** below provides a summary of the number of analyses performed, arranged by analytical method. Unless otherwise noted, the extent of contamination for a given plume is depicted by primarily using 2011 data from permanent monitoring wells. In several cases, data from temporary and permanent wells installed during the first three months of 2012 were utilized. Contaminant plumes associated with OU I South Boundary, Western South Boundary, Middle Road, OU III South Boundary, HFBR Tritium, Brookhaven Graphite Research Reactor/Waste Concentration Facility (BGRR/WCF) Sr-90, Building 96, Freon-11 and g-2 Tritium Plume projects were further defined in 2011 or the first three months of 2012 using temporary wells (i.e., direct push Geoprobes® or vertical profiles).

A single representative round of monitoring data was usually chosen for each plume, typically from the last quarter of the year because it includes the most comprehensive sampling round for the year. This report also serves as the fourth quarter operations report for the remediation systems. Contaminant concentration trend plots for key monitoring wells in each plume are provided to identify significant changes. Data from monitoring wells sampled under BNL's Facility Monitoring Program are evaluated in **Section 4.0**.

Figure 3.0-2.
Summary of Laboratory Analyses Performed for the CERCLA Monitoring Well Program in 2011.



History and Status of Groundwater Remediation at BNL

Groundwater remediation systems have operated at BNL since 1997 beginning with the OU I South Boundary Pump and Treat System. The goal of groundwater remediation, as defined by the OU III Record of Decision, is to prevent or minimize plume growth and not to exceed MCLs in the Upper Glacial aquifer within 30 years or less (by 2030). Based on additional information obtained during the Strontium-90 Pilot Study, the *OU III Explanation of Significant Differences* (BNL 2005a) identified changes to the cleanup goal timeframes for the Sr-90 plumes. For the BGRR/WCF and Chemical Holes Sr-90 plumes, MCLs must be reached by 2070 and by 2040, respectively. In addition, cleanup of the Magothy aquifer VOC contamination must meet MCLs by 2065.

There are currently 13 groundwater remediation systems in operation. Two systems have met their cleanup goals and have been decommissioned: the OU IV, Area of Concern (AOC) 5, Air Sparge/Soil Vapor Extraction System (OU IV AS/SVE) and the Carbon Tetrachloride Pump and Treat System. **Figure 3.0-1** shows the locations and groundwater capture zones for each of the treatment systems. In addition to the groundwater treatment systems, two landfill areas (Current and Former) were capped, which minimizes the potential for groundwater contamination.

BNL's Facilities and Operations personnel perform routine maintenance checks on the treatment systems in addition to their routine and non-routine maintenance. BNL's Environmental Protection Division (EPD) collects the treatment system performance samples. In 2011, 1,007 treatment system samples were obtained from 97 sampling points. The data from the treatment system sampling is available in **Appendix F** tables. Full details of the maintenance checks are recorded in the system's operation and maintenance daily inspection logs. The daily logs are available at the treatment facility, or in the project files.

In general, BNL uses two types of groundwater remediation systems to treat VOC contamination: pump and treat with air stripping or carbon treatment, or recirculation wells with air stripping or carbon treatment. Pump and treat remediation consists of pumping groundwater from the plume up to the surface and piping it to a treatment system, where the contaminants are removed by either air stripping or granular activated carbon. Treated water is then introduced back into the aquifer via recharge basins, injection wells, or dry wells. BNL utilizes pump and treat using ion-exchange treatment for remediating Sr-90. Pump and recharge (without treatment) is utilized to hydraulically contain the HFBR tritium plume. Starting in 2008, BNL also used ion-exchange treatment for localized hexavalent chromium groundwater contamination at Building 96.

Table 3.0-1 summarizes the operating remediation systems. Groundwater remediation at BNL is proceeding as projected. As discussed in the following sections, groundwater modeling is also used as a tool to help determine if remediation of the plumes is proceeding as planned to meet the overall groundwater cleanup goals. When modifications to the remediation systems are necessary, the groundwater model is also used as a tool to aid in the design.

Table 3.0-1. 2011 Summary of Groundwater Remediation Systems at BNL.

Operable Unit System	Type	Target Contaminant	No. of Wells	Years in Operation	Recharge Method	Pounds VOCs Removed in 2011/Cumulative
Operable Unit I						
South Boundary	P&T, AS	VOC	2	14	Basin	3.5/363.5
Operable Unit III						
South Boundary	P&T, (AS)	VOC	7	14	Basin	48/2,834
HFBR Pump and Recharge	Pump and Recirculate	Tritium	4	Operate: 7.0 Standby: 7.5	Basin	0/180
Industrial Park	Recirculation/ In-Well (AS/Carbon)	VOC	7	12	Recirculation Well	5/1,057
*Carbon Tet	P&T (Carbon)	VOC	3	Operate: 5 Standby: 5	Basin	NA/349
****Building 96	Recirculation Well (AS/Carbon)	VOC	4	Operate: 8 Standby: 3	Recirculation Well	9/108
Middle Road	P&T (AS)	VOC	6	10	Basin	51/971
Western South Boundary	P&T (AS)	VOC	2	9	Basin	12/93
Chemical Holes	P&T (IE)	Sr-90	3	9	Dry Well	0.33**/4.4
North Street	P&T (Carbon)	VOC	2	7	Wells	8/322
North Street East	P&T (Carbon)	VOC	2	7	Wells	2/38
LIPA/Airport	P&T and Recirc. Wells (Carbon)	VOC	10	7	Wells and Recirculation Well	17/323
Industrial Park East	P&T (Carbon)	VOC	2	7	Wells	0/37
BGRR/WCF	P&T (IE)	Sr-90	9	6	Dry Wells	2.6**/21.2
Operable Unit VI						
EDB	P&T (Carbon)	EDB	2	7	Wells	NA***

Notes:
AS = Air Stripping
AS/SVE = Air Sparging/Soil Vapor Extraction
EDB = ethylene dibromide
IE = Ion Exchange
LIPA = Long Island Power Authority
NA = Not Applicable
* This system was decommissioned in May 2010.
P&T = Pump and Treat
Recirculation = Double screened well with discharge of treated water back to the same well in a shallow recharge screen
In-Well = The air stripper in these wells is located in the well vault.

** Sr-90 removal is expressed in mCi.
*** No cumulative EDB calculations are performed based on the low concentrations detected.

**** Well RTW-1 was modified from a recirculation well to surface discharge in May 2008. At the same time, hexavalent chromium treatment via ion-exchange resin was also added to RTW-1.

3.1 OPERABLE UNIT I

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

The plumes from the Current Landfill and former HWMF became commingled south of the former HWMF. The commingling was partially caused by the pumping and recharging effects of a spray aeration system, which operated from 1985 to 1990. This system was designed to treat VOC-contaminated groundwater originating from these areas. The VOC plume is depicted on **Figure 3.1-1**.

The on-site segment of the Current Landfill/former HWMF plume is being remediated by a groundwater pump and treat system consisting of two wells screened in the deep portion of the Upper Glacial aquifer at the site property boundary (OU I South Boundary Treatment System). The extracted groundwater is treated for VOCs by air stripping, and is recharged to the ground at the RA V basin, located northwest of the Current Landfill. A second system (North Street East System) was built to treat the off-site portion of the plume. The off-site groundwater remediation system began operations in June 2004 and was included under the Operable Unit III Record of Decision (**Section 3.2.9**).

3.1.1 OU I South Boundary Pump and Treat System

This section summarizes the operational and monitoring well data for 2011 from the OU I South Boundary Groundwater Pump and Treat System. This system began operating in December 1996.

Discharge Monitoring Reports for treated effluent water from the air-stripping tower were submitted to EPA and NYSDEC each month.

3.1.2 System Description

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

3.1.3 Groundwater Monitoring

Well Network

The OU I South Boundary monitoring program uses a network of 49 monitoring wells (**Figure 1-2).** A discussion of monitoring well data specific to the Current Landfill source area is provided in BNL *2011 Environmental Monitoring Report, Current and Former Landfill Areas* (BNL, 2012a).

Sampling Frequency and Analysis

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

3.1.4 Monitoring Well VOC Results

Figure 3.1-1 shows the areal extent of VOC contamination from the Current Landfill/former HWMF area based on the samples collected in the third and fourth quarters of 2011. The primary VOCs detected in the on-site segment of this plume include chloroethane and 1,1-dichloroethane (DCA), which originated from the Current Landfill. The VOCs prevalent in the off-site segment of the plume (North Street East) are 1,1,1-trichloroethane (TCA), 1,1-dichloroethylene (DCE), trichloroethylene (TCE), and chloroethane.

TVOC concentrations less than 25 µg/L are currently detected in monitoring wells immediately downgradient of the Current Landfill. The landfill was capped in November 1995 and the leading edge of the VOC plume appears to be attenuating to levels below 5 µg/L several hundred feet southeast of the landfill footprint. A detailed discussion of the landfill monitoring well data is provided in the *2011 Environmental Monitoring Report, Current and Former Landfill Areas (BNL 2012a).* The OU I South Boundary plume (defined by TVOC concentrations greater than 5 µg/L) has attenuated into two discrete segments. The first is associated with the Current Landfill as discussed above. The other segment extends approximately 1,000 feet north of extraction wells EW-1 and EW-2 (which are located at the site boundary). The area of the plume displaying the highest TVOC concentrations (greater than 50 µg/L) is located in the immediate vicinity of well 107-40. The off-site portion of the plume is discussed in **Section 3.2.9,** the North Street East Pump and Treat System.

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

The plume remains bounded by the current network of wells. **Figure 3.1-3** gives the historical trends in VOC concentrations for key plume core and bypass wells. **Appendix C** has a complete set of 2011 analytical results. Significant findings for 2011 include:

- The highest remaining VOC concentrations are currently located in the immediate vicinity of well 107-40. The plume in this area is migrating through the Upton Unit and Gardiners Clay. The lower hydraulic conductivity of these materials in comparison to the Upper Glacial aquifer sands tends to reduce the plume migration rate.
- A new monitoring well (OU I-MW01-2010) was installed approximately 100 feet north of EW-2 in early 2011 as per a recommendation in the *2009 Groundwater Status Report*. The purpose of this well is to monitor the higher concentration area of VOCs approaching the extraction wells. TVOC concentrations in this well declined from 43 µg/L to 11 µg/L in May 2012. It appears that the highest remaining VOCs are attenuating in the Upton Unit and Gardiners Clay in the vicinity of well 107-40.
- There were no detections of VOCs above AWQS in perimeter wells.
- Individual VOC concentrations in bypass wells 115-42 and 000-138 remained at levels below AWQS in 2011. VOCs greater than AWQS continue to be hydraulically contained at the site boundary.

3.1.5 Radionuclide Monitoring Results

A subset of the OU I Monitoring Program wells is analyzed for tritium and Sr-90 semiannually, and gamma spectroscopy annually. The complete results for these wells are provided in **Appendix C**.

The tritium concentration in the sampled wells continues to be significantly below the 20,000 pCi/L DWS. The highest tritium concentration during 2011 was in Current Landfill monitoring well 087-27 at 1,560 pCi/L. A plot of historical tritium results for select OU I South Boundary program wells is shown on **Figure 3.1-4**.

There are 40 wells used to monitor Sr-90 contamination from the former HWMF **(Table 1-5)**. Two new monitoring wells (OUI-MW01-2011, and OU I-MW02-2011) were installed in 2011 at locations where the highest Sr-90 concentrations were observed during the 2009 characterization. The highest Sr-90 detected in 2011 was 17 pCi/L in well 107-35. A detection of Sr-90 at 1 pCi/L in sentinel well OUI-MW03-2010 is indicative of the leading edge of the plume. The location of monitoring wells and the extent of Sr-90 concentrations is shown on **Figure 3.1-5**. Sr-90 concentration trends for key monitoring wells are provided on **Figure 3.1-6**.

3.1.6 System Operations

The extraction wells are currently sampled quarterly. The influent and effluent of the air-stripper tower are sampled monthly for VOCs and weekly for pH. **Table 3.1-1** provides the effluent limitations for meeting the requirements of the SPDES equivalency permit. The system was in full-time operation until July 2011 when it was changed to a pulse pumping mode.

The following is a summary of the OU I operations for 2011:

January–September 2011
The system operated normally during the first and second quarters with only minor down time. During the second quarter the system was down for several days for blower maintenance, and flow meter repair. The system was down in May for a few days to repair a power supply cable. During the month of June only one extraction well was operational while the other flow meter was being repaired. The system was placed in a pulse pumping mode in July (one month on and one month off) with both extraction wells off for the month.

October–December 2011
The system operated normally during the last quarter of 2011.

3.1.7 System Operational Data

Extraction Wells

During 2011, 173 million gallons of groundwater were treated by the OU I system, with an average flow rate of 327 gallons per minute (gpm) for the year. **Table 2-2** contains the monthly pumping data for the two extraction wells. **Table 3.1-2** contains the monthly extraction well pumping rates. VOC and tritium concentrations in samples from EW-1 and EW-2 are provided on **Table F-1**. VOC levels in both wells continued to show a slight decreasing trend with time (**Figure 3.1-7**). Year-end tritium levels were below detection limits in both wells.

System Influent and Effluent

VOC concentrations in 2011 for the air-stripper influent and effluent are summarized on **Tables F-2** and **F-3**. The influent concentrations of TCA and DCA generally have displayed an overall decrease over the 14 years of OU I South Boundary System operation.

The air-stripper system effectively removed all contaminants from the influent groundwater. All 2011 effluent data for this system were below the analytical method detection limit and below the regulatory limit specified in the equivalency permit conditions.

Table 3.1-1.
OU I South Boundary Pump and Treat System
2011 SPDES Equivalency Permit Levels

Parameters	Permit Level	Max. Measured Value
pH	6.0 – 9.0 SU	6.0– 8.2 SU
Benzene	0.8 µg/L	<0.50 µg/L
Chloroform	7.0 µg/L	<0.50 µg/L
Chloroethane	5.0 µg/L	<0.50 µg/L
1,2-Dichloroethane	5.0 µg/L	<0.50 µg/L
1,1-Dichloroethene	5.0 µg/L	<0.60 µg/L
1,1,1-Trichloroethane	5.0 µg/L	<0.50 µg/L
Carbon tetrachloride	5.0 µg/L	<0.50 µg/L
1,2-Dichloropropane	5.0 µg/L	<0.50 µg/L
Methylene chloride	5.0 µg/L	<0.50 µg/L
Trichloroethylene	5.0 µg/L	<0.50 µg/L
Vinyl chloride	2.0 µg/L	<0.50 µg/L
1,2-Xylene	5.0 µg/L	<0.50 µg/L
Sum of 1,3- & 1,4-Xylene	10.0 µg/L	<0.50 µg/L

Notes:
SU = Standard Units
Required sampling frequency is monthly for VOCs and weekly for pH.

Cumulative Mass Removal

Average flow rates for each monthly monitoring period were used, in combination with the TVOC concentration in the air-stripper's influent, to calculate the rate of contaminants removed. The cumulative mass of VOCs removed by the treatment system vs. time was then plotted (**Figure 3.1-8**). During 2011, 3.5 pounds of VOCs were removed. Cumulatively, 363 pounds have been removed since 1997. Cumulative mass removal data for this system are summarized on **Table F-4**.

Air Discharge

Table 3.1-3 presents the VOC air emissions data for the year 2011 and compares the values to levels stipulated in NYSDEC Air Guide 1 regulations. Emission rates are calculated through mass balance for water treated during operations. The concentration of each constituent of the air-stripper's influent was averaged for the year. That value was converted from µg/L to pounds per gallon (lb/gal), which was multiplied by the average pumping rate (gal/hr) to compare with the regulatory value. The VOC air emissions were well below allowable levels.

Recharge Basin

There are seven sentinel monitoring wells in the immediate area surrounding the RA V recharge basin (**Figure 1-2**). This basin receives discharge water from the OU I South Boundary, OU III Middle Road and HFBR Pump and Recharge Systems. These wells are used to monitor water quality and water levels to assess the impact of the recharge basin on the aquifer. **Appendix C** contains the data for these monitoring wells. A discussion of tritium results from these wells is included in **Section 3.2.17.3**.

3.1.8 System Evaluation

The pump and treat system continued to maintain hydraulic control of contaminants originating from the Current Landfill and former HWMF, and to prevent further contaminant migration across the site's southern boundary. No SPDES or air equivalency permit limits have been exceeded, and no operating difficulties were experienced beyond normal maintenance. The OU I South Boundary Pump and Treat system performance can be evaluated based on the major decisions identified by applying the Data Quality Objectives (DQO) process.

<u>*1. Is there a continuing source of contamination? If present, has the source area been remediated or controlled?*</u>

No, there are no continuing significant sources of contamination presently observed in at the FHWMF. VOCs leaching out from the Current Landfill are attenuating to levels below AWQS several hundred feet south of the landfill.

<u>*2. Were unexpected levels or types of contamination detected?*</u>

No, there were no unexpected detections of contaminants in 2011. An analysis of the plume perimeter and bypass wells reveals no significant increases in VOC concentrations in perimeter and bypass monitoring wells; thus, the VOC plume has not grown and continues to be controlled.

Table 3.1-3
OU I South Boundary
2011 Air Stripper VOC Emissions Data

Parameter	Allowable ERP* (lb/hr)	Actual** ERP* (lb/hr)
Carbon tetrachloride	0.016	0.0000
Chloroform	0.0086	0.00015
1,1-Dichloroethane	10**	0.00021
1,2-Dichloroethane	0.011	0.0000
1,1-Dichloroethylene	0.194	0.00023
Chloroethane	10**	0.00017
1,1,1-Trichloroethane	10**	0.00001
Trichloroethylene	0.119	0.0000

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

3. Has the downgradient migration of the plume been controlled?
Figure 3.1-1 illustrates that the VOC plume has been effectively cut off at the south boundary and there is significant separation with the off-site segment of the plume. The groundwater contour maps are used to evaluate the capture zones of the OU I South Boundary Pump and Treat System (**Figures 2-2** and **2-3**). The capture zone for the OU I South Boundary Pump and Treat System is indicated on **Figure 3.0-1**. The capture zone depicted includes the 50 µg/L TVOC isocontour that is the capture goal of this system.

The leading edge of an area of elevated Sr-90 contamination has migrated to the vicinity of the new sentinel wells (OU I-MW02-2010 and OU I-MW-03-2010) which are approximately 800 feet north of the site boundary.

4. Can individual extraction wells or the entire treatment system be shut down or placed in pulse pumping operation?
Yes. Based on plume core well data the only area of TVOC concentrations greater than the system capture goal of 50 µg/L is in the immediate vicinity of well 107-40. This well ranged from 88µg/L to 56 µg/L during the four 2011 sampling rounds and in May 2012 decreased to 48 µg/L. Well OUI-MW01-2010 was installed approximately 450 feet downgradient of this area in 2010 (immediately north of EW-2) and TVOC concentrations to date have decreased from 43 µg/L in March 2011 to 11 µg/L in May 2012. TVOC concentrations in EW-1 and EW-2 were below 5 µg/L in 2011 and have largely remained below 5 µg/L since 2005.

4a. Are TVOC/Sr-90 concentrations in plume core wells above or below 50 µg/L or 8 pCi/L?
Aquifer cleanup continues to be demonstrated based on the continued decreasing slope to the trend of average TVOC concentrations, as shown on **Figure 3.1.9**. TVOC concentrations in plume core well 107-40 have been at or near 50 µg/L as discussed above. TVOC concentrations in the remainder of the plume core wells were below 50 µg/L during 2011. There are presently two monitoring wells with Sr-90 concentrations above the 8 pCi/L DWS.

4b. Is there a significant concentration rebound in core wells and/or extraction wells following shutdown?
The system is still operating so this cannot be evaluated at this time. System pulse pumping was initiated in July 2011 and there has been no observed effect on VOC concentrations.

5. Has the groundwater cleanup goal of meeting MCLs by 2030 been achieved?
No. MCLs have not been achieved for individual VOCs in plume core wells. Updated groundwater modeling predicts that MCLs will be achieved by2030. Changes in the distribution of the plume are shown on **Figure 3.1-10**, which compares the VOC plume from 1997 to 2011.

3.1.9 Recommendations

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

- A petition to shut down the system will be submitted to the regulators during the fourth quarter of 2012 provided core well concentrations remain below the capture goal.
- Continue pulse pumping of the extraction wells (one month on and one month off).

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3.2 OPERABLE UNIT III

There were several VOC, Sr-90, and tritium plumes addressed under the OU III Remedial Investigation/Feasibility Study (RI/FS). The VOC plumes originated from a variety of sources, including Building 96, various small sources in the north-central developed portion of the site, the Former Landfill, OU IV, and the former carbon tetrachloride underground storage tank (UST). **Figure 3.2-1** is a representation of the plumes using TVOC concentrations. The eastern portion of **Figure 3.2-1** also includes the OU IV plume and the North Street (OU I/IV) plumes. **Figure 3.2-2** is cross-section B–B′, which is drawn through the north–south center-line of the primary OU III VOC plumes, as shown in **Figure 3.2-1**.

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

Figure 3.2-3 presents a comparison of the OU III plumes between 1997 and 2011. Several changes in the plumes can be observed in this comparison:

- The extent of the higher concentration segments of the plumes both on and off-site has decreased over the 13-year period. This is due primarily to the groundwater remediation that has been implemented, along with the affects of natural attenuation.
- Hydraulic control of the plumes by the OU III South Boundary Treatment System at the site boundary and the LIPA system is evidenced by the break in the plumes in these areas.
- Concentrations have been significantly reduced in the vicinity of the Industrial Park East System.
- The attenuation of the on-site portion of the North Street VOC plume.

Three radiological plumes were addressed under Operable Unit III. The HFBR tritium has travelled several thousand feet south from the HFBR spent fuel pool. The downgradient, higher concentration slug is presently being captured by EW-16. Sr-90 plumes are present downgradient of the former WCF and several sources related to the BGRR. A Sr-90 plume is also present downgradient of the Chemical/Glass Holes and Animal Pits area.

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

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3.2.1 Former Carbon Tetrachloride Pump and Treat System

This section summarizes the data from the former OU III Carbon Tetrachloride Pump and Treat System and offers conclusions and recommendations for monitoring. This plume originated from a former 1000-gallon UST that had been used to store carbon tetrachloride. The tank was removed in 1998 and several gallons of carbon tetrachloride were released to the groundwater during this removal. This system began operating in October 1999, and was formally shut down and placed in standby mode in August 2004. Groundwater monitoring has continued and a Petition for Closure of the system was submitted to the regulators in August 2009. Final regulatory approval for decommissioning was received in October 2009. Decommissioning and Demolition (D&D) work commenced in May of 2010 and was completed in August 2010. The scope of work included well abandonment of specific monitoring wells and all three extraction wells. All of the equipment in building TR 829 was removed.

3.2.1.1 Groundwater Monitoring

Well Network

A network of 18 wells was designed to monitor the extent of the plume (**Figure 1-2**). Monitoring will continue until MCLs are achieved for a minimum of four consecutive sampling events in each monitoring well.

Sampling Frequency and Analysis

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

3.2.1.2 Monitoring Well Results

Eighteen monitoring wells have been maintained for post closure monitoring. Wells 085-17 and 105-23 were the only monitoring wells to have concentrations of carbon tetrachloride above MCL of 5 μg/L. The concentrations of carbon tetrachloride in wells 085-17 and 105-23were 19 μg/L and 13 μg/L, respectively. The carbon tetrachloride in well 085-17 appears to be from the gas station as other compounds are present in this well and the upgradient monitoring wells in the source area have been below MCLs for several years. Well 105-23 (**Figure 3.2-1**) is about halfway between the Former Carbon Tetrachloride system and the Middle Road system. Wells 085-17, 085-236 and 085-237 did have other VOCs above MCLs related to the historical operations at the gas station. This is discussed further in **Section 4.8 On-Site Service Station**. In addition, well 104-11 had a detection of 1,1-dichloroethene of 6.8 μg/L which is above the MCLs of 5 μg/L. This result is not related to the carbon tetrachloride release. All other monitoring wells have had VOC concentrations below the MCLs for all compounds for at least four sampling rounds. **Figure 3.2.1-1** shows that there is no longer a groundwater plume associated with this project.

3.2.1.3 System Evaluation

The monitoring program for the former Carbon Tetrachloride Pump and Treat System performance can be evaluated based on the decision rules identified by applying the DQO process.

1. Is there a continuing source of contamination? If present, has the source area been remediated or controlled?

No there is not a continuing source of contamination. The source area has been remediated.

2. Were unexpected levels or types of contamination detected?

No unexpected contamination was observed in 2011.

3 Is the plume naturally attenuating as expected?

Yes, there is no longer a carbon tetrachloride plume associated with this project above MCLs.

4. Have the groundwater cleanup goal of meeting MCLs been achieved?
Yes, although two wells, 085-17 and 105-23, had carbon tetrachloride concentrations above the MCL of 5 μg/L, well 105-23 is over 2000 feet downgradient of the source area and the carbon tetrachloride in well 085-17 is believed to be related to historical releases from the service station. This well is currently monitored under the facility monitoring program for the on-site service station.

3.2.1.4 Recommendations

The following is the recommendation for the monitoring program for the former OU III Carbon Tetrachloride Groundwater Remediation System and monitoring program:

- The following well abandonment and reassignment to other programs will end the carbon tetrachloride groundwater monitoring program.
  - Since the VOC concentrations have been below the MCLs for four or more sampling events, it is recommended that the following wells be dropped from the monitoring program and abandoned: 085-162, 085-163, 085-98, 095-279, 095-280, 095-300, 095-42, 095-53, 095-90, and 095-277.
  - Since VOC concentrations have been below MCLs for four or more sampling events, it is recommended that the following wells be dropped from the Carbon Tetrachloride monitoring program and continue to be monitored by the On-Site Service Station monitoring program: 085-236 and 085-237, 085-17 (**Section 4.8**).
  - Since the carbon tetrachloride concentrations have been below the MCLs for four or more sampling events, it is recommended that the following wells be dropped from the Carbon Tetrachloride monitoring program and added to the Middle Road monitoring program since the constituents of concern detected in these wells affects the long term operation of that treatment system: 104-11, 104-36, 105-23, 105-42 (**Section 3.2.3**).
  - Well 085-13 will be maintained as a water level well for the Magothy aquifer and no longer sampled for VOCs.

3.2.2 Building 96 Air Stripping System

This section summarizes the 2011 operational data from the OU III Building 96 Treatment System, which consists of three recirculation wells and one pumping well with air stripping and vapor-phase carbon treatment. It also presents conclusions and recommendations for future operation of the system. The system began operation in February 2001. All treatment wells, RTW-1 through RTW-4 operated during 2011. For a history of the operation of these wells over the last ten years, refer to previous Groundwater Status Reports. Starting in early 2012, treatment well RTW-1 is also being used to treat the low level downgradient portion of the Building 452 Freon-11 plume (**Section 4.13** for further discussion of the Freon-11 plume**).**

3.2.2.1 System Description

For the recirculation wells, contaminated groundwater is drawn from the aquifer via a submersible well pump in a lower well screen, 48 to 58 feet bls, near the base of the contaminant plume. The groundwater then is pumped into a stripping tray adjacent to each of the four wells. After treatment, the clean water is recharged in wells RTW-2 through RTW-4 back to the shallow portion of the plume through the upper screen, 25 to 35 feet bls. In May 2008, well RTW-1 was modified from a recirculation well to a pumping well with hexavalent chromium ion exchange treatment, and discharge to the nearby surface drainage culvert. The contaminated air stream from the air stripper from the four treatment wells is routed to a treatment and control building, where it is passed through two vapor-phase granular activated carbon (GAC) units in series to remove the VOCs. Treated air is then discharged to the atmosphere. A complete description of the system is included in the *Operations and Maintenance Manual Building 96 Groundwater Treatment System* (BNL 2009a).

3.2.2.2 Source Area Remediation

A summary of the VOC source area soil excavation and disposal activities performed between August and November 2010 is documented in the Building 96 Soil Excavation and Disposal Closure Report (BNL 2011). This work was performed in accordance with the *Final Operable Unit III Explanation of Significant Differences for Building 96 Remediation* (BNL 2009b). This closure report was submitted to the regulators in January 2011, and EPA found it acceptable. Responses to NYSDEC comments received in March 2011 were approved, and the January 2011 Report did not require modification and was considered final.

In addition to the excavation of contaminated soils, operation of the RTW-1 groundwater treatment system will continue until the capture goal is attained, which is expected within three to six years of the soil excavation (by 2016). Excavation of the soil is expected to reduce the number of years of treatment to allow the cleanup goal of the ROD for this groundwater plume (i.e., meeting drinking water standards by 2030) to be met.

Figure 3.2.2-1 shows the location of the excavated soil contamination area in relation to the 2011 VOC groundwater plume. Figure 3.2.2-3 shows a cross section of the area.

3.2.2.3 Groundwater Monitoring

A network of 35 wells is used to monitor the VOC plume and the effectiveness of the Building 96 groundwater remediation system (**Figure 1-2**). The majority of the wells are sampled quarterly and analyzed for VOCs in accordance with **Table 1-5**. In addition, since 2008, all wells are sampled quarterly for total chromium (Cr) and hexavalent chromium (Cr [VI]).

3.2.2.4 Monitoring Well Results

Complete VOC results are provided in **Appendix C**. The fourth quarter 2011 plume is shown on **Figure 3.2.2-1**. A summary of key monitoring well data for 2011 follows:

Former Source Area to RTW-1:

- The highest TVOC concentration seen in 2011 was 3,013 µg/L in groundwater from core well 095-305 during the first quarter sampling round. The primary contaminant is PCE, with a value of 3,000 µg/L. This well is located about 70 feet downgradient of the former soil excavation area. The previous TVOC historical high value in this well was 644 µg/L in 2007. As noted on trend **Figure 3.2.2-2**, VOCs in this well began increasing following the excavation of the soil in October 2010. The TVOC values then dropped to less than 30 µg/L by the end of 2011. VOC concentrations in core well 095-306, located adjacent to well 095-305, but deeper, began increasing in 2008 and has since remained high with TVOC values ranging between 1,200 µg/L and 2,500 µg/L. Concentrations in this well are expected to start dropping off since the contaminated soil was removed.
- Monitoring well 085-379 which was installed in November 2010, detected TVOC concentrations as high as 2,435 µg/L in the second quarter 2011, but dropped to 620 µg/L in the fourth quarter and 477 µg/L in January 2012. This well replaced well 085-353 (which was removed in 2010), and is located within the downgradient portion of the former excavation area. This well straddles the water table with a 20 foot screen in order to ensure that ensure that any residual groundwater contamination from the former source area is identified during fluctuations in the water table.

RTW-1 to Downgradient Recirculation Wells RTW-2 through RTW-4:

- VOC concentrations in plume core well 095-159 (located between treatment well RTW-1 and downgradient recirculation wells RTW-2) began increasing since 2007 to 652 µg/L TVOC in October 2010, its highest level since 2001. TVOC concentrations remained elevated for this well in 2011 with concentrations ranging from 322 µg/L to 541 µg/L. In January 2012, TVOC concentrations dropped to 146 µg/L. This contamination will be captured by RTW-2.
- TVOC concentrations in core well 095-312, located approximately 100 feet upgradient of recirculation wells RTW-2, RTW-3, and RTW-4 began increasing since it was installed in 2009. Concentrations ranged from 13µg/L to 123 µg/L in 2011.

Bypass Wells Downgradient of RTW-2 through RTW-4:

- The bypass monitoring wells immediately downgradient of extraction wells RTW-2, RTW-3, and RTW-4 generally showed reduced TVOC concentrations since 2007. The reduced concentrations are consistent with the downgradient extraction wells being placed back in service in late 2007 and early 2008. Core monitoring well B96-MW01-2010, located along Weaver Drive detected TVOC concentrations of 80 µg/L in January 2011, with concentrations dropping off to 5 µg/L in January 2012. The maximum hexavalent chromium detected in this well was 8 µg/L in April 2011.

Hexavalent Chromium Monitoring:

- None of the 35 monitoring wells detected hexavalent chromium above the SPDES discharge limit of 100 µg/L in 2010 or 2011. The well with the highest hexavalent chromium value in 2011 was 085-352 with a value of 42 µg/L in April 2011. In 2008 there were seven monitoring wells and in 2009 there was one well that exceeded 100 µg/L of hexavalent chromium, respectively. The drop in concentrations over the last three years is an indication that the hexavalent chromium is converting back to the trivalent form, which is less toxic. The hexavalent chromium monitoring well data for 2011 is posted on **Figure 3.2.2-4.**

Trichlorofluoromethane (Freon-11):

- Upgradient monitoring well 085-378 (installed in November 2010) detected low levels of TVOCs in 2011 except for an elevated value of 47 µg/L in the first quarter. Trichlorofluoromethane (Freon-11) was the primary VOC in this well at 46 µg/L. Freon-11 concentrations in the remaining three quarters from this well were less than 11 µg/L. From April through August 2011, a temporary well investigation was conducted as part of the BNL Facility Monitoring Program to determine the extent and source of the Freon-11 contamination. The source of the high concentrations of Freon-11 (up to 36,000 µg/L) was determined to be releases/spills from the area around the Bldg. 452 Site Maintenance Facility. As further described in **Section 4.13**, remediation of this plume is being performed under the authority of an Explanation of Significant Differences to the OU III ROD. In addition to the installation of a new extraction well to remediate the majority of the Freon-11 plume, Building 96 extraction well RTW-1 will also be used to address the low level downgradient portion of the plume.

  Historical detections of Freon-11 in the Building 96 plume were limited to extraction well RTW-1 influent with a maximum concentration of 0.6 µg/L in 2010. The maximum Freon-11 concentration in RTW-1 in 2011 was 8.1 µg/L in June. During 2011, additional detections of Freon-11 were identified in several of the Building 96 monitoring wells. The maximum detection was 16 µg/L in well 095-162 in the fourth quarter. This well is located downgradient of RTW-1. The most downgradient detection of Freon-11 in 2011 was in extraction well RTW-2 at 0.75 µg/L.

Additional Characterization:

- As per the recommendation in the 2010 Groundwater Status Report, in January 2012 three temporary wells were installed approximately 50 feet upgradient of recirculation wells RTW-2, RTW-3, and RTW-4 to help determine if these wells could be placed in standby mode (**Figure 3.2.2-1**). The maximum TVOC concentrations detected were 271 µg/L in B96-TW01-2012 at 66 feet bls. The primary VOC was Freon-11 at 270 µg/L. This temporary well is upgradient of RTW-2 but the Freon-11 contamination is approximately 10 feet deeper than the extraction well influent screen. There were no other VOCs identified in this well above standards. Temporary well B96-TW02-2012, located upgradient of RTW-3 detected a maximum of 60 µg/L TVOCs, with PCE at 56 µg/L. This contamination was approximately 54 to 58 feet bls and would be captured by RTW-3. There was no Freon-11 detected above standards in temporary well B96-TW02-2012. Temporary well B96-TW03-2012 had no detections of VOCs exceeding the 5µg/L standard.
- As part of the remediation system monitoring program for the Freon-11 plume, monitoring well 095-313 was installed in September 2011 to the northwest of RTW-1 to monitor the low concentration segment of the Freon-11 plume. Freon-11 was not detected in 2011; however, PCE was in November, at 32 µg/L. This well is screened slightly deeper than the adjacent Building 96 monitoring wells with the screen interval at 45 to 60 feet bls. The February 2012 sample detected 114 ug/L of PCE. The July 2011 temporary well installed as part of the Freon-11 plume characterization at this location detected PCE up to 360 µg/L at 32 feet bls, but only 6 µg/L at 48 feet bls.

3.2.2.5 System Operations

Operating Parameters

All treatment wells, RTW-1 through RTW-4 were intended to operate full time during 2011.

January – September 2011

During this period the system operated the majority of the time. In January the system was off for part of the month due to weather related issues. In April and May the system was down for a couple of days due to problems with a control module. In July the system was down again for two weeks waiting for a part to repair the control module. During this period the system pumped a total of approximately 33 million gallons.

October – December 2011

The system operated normally for this period. During 2011, the groundwater treatment system pumped and treated a total of approximately 46 million gallons of water (Table F-8).

Table 3.2.2-1
OU III Building 96 RTW-1 Pump & Treat Well
2011 SPDES Equivalency Permit Levels

Parameter	Permit Level (µg/L)	Max. Measured Value (µg/L)
pH range	5.0–8.5 SU	5.9–7.5 SU
chromium (hexavalent)	100	13
tetrachloroethylene	5.0	<0.5
1,1,1-trichloroethane	5.0	<0.5
Thallium	Monitor	1.8

Note: Required effluent sampling frequency is monthly following a period of 24 consecutive weekly with no exceedances. *Weekly* for pH.

3.2.2.6 System Operational Data

Recirculation/Treatment Well Influent and Effluent

Table F-6 lists the monthly influent and effluent TVOC concentrations for the three recirculation wells, and treatment well RTW-1. The highest TVOC concentration from the influent of these wells was 145 µg/L in RTW-1 in the fourth quarter. The maximum TVOC in the influent of the downgradient wells was 4 µg/L in RTW-2 in October 2011. **Figure 3.2.2-5** shows the TVOC concentrations in the treatment wells over time. **Table 3.2.2-1** shows the maximum measured effluent contaminant concentrations compared to the SPDES equivalency permit for well RTW-1. The system met all equivalency parameters for operation in 2011. The maximum hexavalent chromium discharge level detected in the effluent in RTW-1 for the year 2011 was 13 µg/L in January. In January 2010, the resin treatment was bypassed and remained in standby mode for the entire year as well as in 2011.

In January 2012, DOE submitted a modification request to NYSDEC to include trichlorofluoromethane (Freon-11) as a discharge parameter to the SPDES equivalency permit, as well as a renewal request to extend system operations an additional five years. The State approved the request in March 2012, as well as adding additional parameters to the permit equivalency.

Air Treatment System

In 2011, quarterly air sampling was performed from the GAC vessels before treatment (influent), between the two vessels (midpoint), and after the second vessel (effluent). The analytical data are available on **Table F-7**, and the VOC emission rates are summarized on **Table 3.2.2-2.** The findings are utilized to monitor the efficiency of the GAC units and to determine when a carbon change-out is required. Airflow rates, measured for each air-stripping unit inside the treatment building, show that they typically range between 250 and 450 cubic feet per minute (cfm) for each of the four wells. Assuming a total airflow rate of 1,200 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.

Cumulative Mass Removal

Table 3.2.2-3 shows the monthly extraction well pumping rates. The annual average pumping rate for all four wells was 92 gpm. The pumping and mass removal data are summarized on **Table F-8**. In 2011, approximately 9 pounds of VOCs were removed. Since February 2001, the system has removed approximately 108 pounds of VOCs.

3.2.2.7 System Evaluation

The OU III Building 96 Treatment System performance can be evaluated based on the major decisions identified by applying the DQO process.

1. Is there a continuing source of contamination? If present, has the source area been remediated or controlled?

As noted in **Section 3.2.2.2** above, the previously identified high PCE concentrations in soil were excavated in the summer of 2010. Confirmatory soil samples indicate the concentrations were well below the soil cleanup objective for PCE of 1,400 µg/kg. Over the last year, TVOC concentrations in well 085-379 (located in the former source area) have been declining from 2,435 µg/L in the second quarter 2011 to 477 µg/L in January 2012. The selected remedy for the PCE soil source area also included continued groundwater treatment. Well 085-379 and other source area monitoring wells will continue to be sampled to evaluate the effectiveness of the source area soil remediation.

2. Were unexpected levels or types of contamination detected?

Yes. As noted in the 2010 Groundwater Status Report and in Section 3.2.2.4 above, new upgradient monitoring well 085-378 detected up to 46 µg/L of Freon-11 in January 2011. An investigation to define the extent of the Freon-11 was performed from April through August 2011, and the source was determined to be releases/spills from around the Bldg. 452 Site Maintenance Facility. This detection was classified as a BNL Groundwater Contingency Plan Action Level 3 event. See **Section 4.13** for additional discussion on the Freon-11 contamination.

Table 3.2.2-2
OU III Building 96 Area
2011 Average VOC Emission Rates

Parameter	Allowable ERP* (lb/hr)	Actual** ER (lb/hr)
dichlorodifluoromethane	0.0000187	0.00000286
acetone	0.000674	ND
methylene chloride	0.000749	0.0000741
2-butanone	0.000187	ND
benzene	0.000112	0.0000183
tetrachloroethylene	0.000165	ND
m,p-xylene	0.0000116	ND
isopropylbenzene	0.000243	ND
n-propylbenzene	0.0000599	ND
1,3,5-trimethylbenzene	0.000375	0.00000177
1,2,4-trimethylbenzene	0.000225	0.0000314
4-isopropyltoluene	0.00000749	ND
naphthalene	0.0000225	ND
carbon disulfide	0.0000487	ND
styrene	0.00000637	ND
trans-1,3-dichloropropane	0.0000157	ND

Notes:

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

As noted in Section 3.2.2.4 above, the PCE concentrations detected in Freon-11 monitoring well 095-313 were not expected at this depth. Monitoring will continue.

3. Has the downgradient migration of the plume been controlled?

Yes, the downgradient portion of the PCE plume has been controlled. Following the modification of extraction well RTW-1 as a pumping well, it has demonstrated effective capture of the plume source area (**Figure 3.2.2-6**). Based on the low concentrations of VOCs in recirculation wells RTW-2, RTW-3, and RTW-4 and the nearby monitoring wells it appears that RTW-1 is effectively capturing the VOCs migrating from the source area. A small area of VOCs located near well 095-159 will be captured by downgradient extraction well RTW-2. As noted in **Section 3.2.2.4** above, the PCE detected in temporary well B96-TW02-2012 should be captured by RTW-3.

A discussion of the impacts and follow-up actions planned for the Freon-11 detected in downgradient temporary well B96-TW02-2012 is discussed in **Section 4.13** of this Report.

4. Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?

The system has not met all shutdown requirements. Groundwater modeling also determined that following some "tailing" effect from the vadose zone source area after it is excavated, well RTW-1 will need to operate for another three to six years (by 2016). Influent TVOC concentrations in downgradient recirculation wells RTW-2 through RTW-4 have been below 50 µg/L since 2008. However, as described in **Section 3.2.2.4**, based on the data from the three temporary wells and monitoring wells, elevated TVOCs greater than 50 µg/L exist immediately upgradient of RTW-2 and RTW-3. Since TVOC concentrations in B96-TW03-2012 were below 5µg/L, downgradient recirculation well RTW-4 can be shut down and placed in standby mode.

4a. Are TVOC concentrations in plume core wells above or below 50 ug/L?

TVOC concentrations in 15 of 22 core wells were above 50 µg/L in 2011.

4b. Is there a significant concentration rebound in core wells and/or extraction wells following shutdown?

The system was not shut down in 2011.

5. Has the groundwater cleanup goal of meeting MCLs been achieved?

MCLs have not been achieved for individual VOCs in all plume core wells. However, following several more years of treatment system operation followed by monitored natural attenuation, MCLs are expected to be achieved by 2030.

3.2.2.8 Recommendations

The following are recommendations for the OU III Building 96 Groundwater Remediation System and monitoring program:

- Maintain full time operation of treatment well RTW-1, RTW-2, and RTW-3. Maintain a monthly sampling frequency of the influent and effluent for each well.
- Since TVOC concentrations are below 50 µg/L in temporary well B96-TW03-2012 and the extraction well, place RTW-4 in standby mode. Maintain a monthly sampling frequency of the influent and effluent associated with well RTW-4. Restart the well if extraction or monitoring well data indicate that TVOC concentrations exceed 50 µg/L.
- Continue to monitor the PCE concentrations in the Freon-11 monitoring well 095-313 quarterly, and include it in the Building 96 monitoring program. After review of the data in 2012, the need for further characterization will be evaluated.
- Since there have been no detections of hexavalent chromium above the SPDES discharge limit of 100 µg/L in 2010 and 2011, reduce the frequency of monitoring for total chromium and hexavalent chromium in the monitoring wells from quarterly to annually.
- Continue to analyze for total chromium and hexavalent chromium in the effluent associated with RTW-1 two times per month.
- Continue to maintain the RTW-1 resin treatment in standby mode, and if concentrations of hexavalent chromium in the influent increase to over 50 µg/L (an administrative limit established that is half of the SPDES limit of 100 µg/L), treatment would resume.

3.2.3 Middle Road Pump and Treat System

The Middle Road Groundwater Pump and Treat System began operating in October 2001. This section summarizes the operational data from the Middle Road system for 2011, and presents conclusions and recommendations for future operation. The analytical data from the monitoring wells are also evaluated in detail.

3.2.3.1 System Description

The Middle Road system was designed with six extraction wells and air-stripping technology to remove VOCs from the groundwater. In September 2003, extraction wells RW-4 and RW-5 were placed in standby mode due to low concentrations of VOCs. In September 2006, well RW-6 was also placed in standby mode due to low VOC concentrations. The system is currently operating utilizing wells RW-1, RW-2 and RW-3 at a total pumping rate of approximately 500 gpm. A complete description of the system is included in the *Operation and Maintenance Manual for the OU III Middle Road and South Boundary Groundwater Treatment Systems, Revision 1* (BNL 2003a).

3.2.3.2 Groundwater Monitoring

The Middle Road Monitoring Program consists of a network of 31 monitoring wells located between the Princeton Avenue firebreak road and the OU III South Boundary Pump and Treat System (**Figure 1-2**). Two new monitoring wells were added in 2010 one upgradient of well RW-1 (OU3-MR-MW02-2010), and one was added just west of RW-2 (OU3-MR-MW01-2010). The data and locations of these wells are shown on **Figure 3.2.3-1**. In addition two Vertical Profile wells were installed to evaluate VOC concentrations on the western edge of the plume; these were OU3-MRVP-01 and OU3-MRVP-02installed in January 2011. The locations are shown on **Figure 3.2.3-1**.

The 31 Middle Road wells are sampled and analyzed for VOCs. Nine of the wells are sampled quarterly, and the remainder are sampled semiannually (**Table 1-5**).

3.2.3.3 Monitoring Well Results

The complete VOC results are provided in **Appendix C**. The highest plume concentrations are found in the areas between extraction wells RW-1 and RW-3, based on influent data for these wells and monitoring well data (**Figure 3.2.3-1**) upgradient and downgradient of these wells. TVOC concentrations in monitoring wells east of RW-3 are well below 50 µg/L capture goal for this system. Results for key monitoring wells are as follows:

- Plume core well 105-23 is approximately 2,000 feet upgradient of RW-1, near Princeton Avenue. TVOC concentrations have decreased from 1,794 µg/L during 2001, to 30 µg/L in the fourth quarter of 2011 (**Figure 3.2.3-1)**.
- TVOC concentrations in plume core wells to the east of well 105-23, along Princeton Avenue, were below 100 µg/L in 2011.Well 104-37 to the west of this area however had concentrations ranging from 352 µg/L in April 2011 to 312 µg/L in November 2011. The primary contaminants observed in this well are carbon tetrachloride and PCE.
- Monitoring well 113-29, located west of RW-1, installed to monitor the western edge of the plume, showed a significant increase in concentrations, in 2010 to a high of 298 µg/L in May 2010. In 2011 concentrations ranged from 117 µg/L in April to 70 µg/L in November. This well is a perimeter monitoring well for the western edge of the Middle Road System. This is above the capture goal for the treatment system of 50 µg/L. A vertical profile well was installed to the west of this well (OU3-MRVP-02-2010) and showed concentrations all below MCLs. A permanent monitoring well is planned for installation in 2012 at the location of this VP to provide a western perimeter monitoring well.
- Monitoring well 105-66, installed upgradient of extraction wells RW-1 and RW-2, showed a TVOC concentration of 149 µg/L in November 2011. This is a core well installed in 2008 to

monitor levels of VOCs migrating to these extraction wells. This well is sampled on a quarterly basis.

- Bypass well 113-17 has shown a significant decrease in TVOC concentrations since 2005, with concentrations dropping from 1,347 µg/L to less than 61 µg/L in November 2011.
- Two new monitoring wells were installed in 2010, one upgradient of well RW-1 (OU3-MR-MW02-2010), and another just west of RW-2 (OU3-MR-MW01-2010). The data and locations of these wells are shown on **Figure 3.2.3-1.** Well OU3-MR-MW01-2010 was installed at the location of a prior vertical profile and showed concentrations of 14 µg/L TVOC concentrations in November 2011. The vertical profile had previously detected much higher concentrations. It is likely that this shows the positive impact of the increased pumping rate in well RW-2, due to the extraction well capturing these higher concentrations. Well OU3-MR-MW02-2010 located directly upgradient of this area had TVOC concentrations of 331 µg/L in November 2011.

Table 3.2.3-1.
OU III Middle Road Air Stripping Tower
2011 SPDES Equivalency Permit Levels

Parameters	Permit Limit	Max. Observed Value
pH range (SU)	6.5–8.5	6.9 – 7.6
carbon tetrachloride	5 µg/L	ND
chloroform	7 µg/L	ND
dichlorodifluoromethane	5 µg/L	ND
1,1-dichloroethane	5 µg/L	ND
1,1-dichloroethylene	5 µg/L	ND
methyl chloride	5 µg/L	ND
tetrachloroethylene	5 µg/L	ND
toluene	5 µg/L	ND
1,1,1-trichloroethane	5 µg/L	ND
1,1,2-trichloroethane	5 µg/L	ND
trichloroethylene	10 µg/L	ND

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

Figure 3.2.3-2 shows the vertical distribution of contamination running along an east–west line through the extraction wells; the location of this cross section (E–E') is given on **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. This figure shows that the area of TVOCs exceeding the capture goal of 50 µg/L is limited to the western portion of the treatment system in the vicinity of RW-1, RW-2 and RW-3. The data shows that the highest concentrations are in the vicinity of RW-1 but at the depth correlating with the screen interval of RW-2 located approximately 150 feet east of this area. The concentration observed in well 113-29 of 70 µg/L TVOC in November 2011 is just outside the estimated capture zone of the pumping wells.

3.2.3.4 System Operations

The effluent sampling parameters for pH and VOCs follow the requirements for monthly sampling, as per the SPDES equivalency permit (**Table 3.2.3-1**). The effluent concentrations from the treatment system during this period of operation were below equivalency permit levels.

Approximately 221 million gallons of water were pumped and treated in 2011 by the OU III Middle Road System. The following summarize the Middle Road System operations for 2011.

January – September 2011

The system was off for a few weeks in March due to maintenance and repair needed on the blower for the air stripper. In the months of August and September maintenance was performed and the the water was diverted into the OU III South Boundary air stripper tower. Approximately 165 million gallons of water were treated.

October – December 2011
The system operated normally in October, November and December, and pumped and treated approximately 56.5 million gallons of water during this quarter.

3.2.3.5 System Operational Data

System Influent and Effluent
Figure 3.2.3-5 plots the TVOC concentrations in the extraction wells versus time. Results of the extraction wells samples are found on **Table F-9.** The influent VOC concentrations remained constant over the reporting period. The average TVOC concentration in the influent during 2011 was 34 µg/L. The results of the influent and effluent sampling are summarized on **Tables F-10** and **F-11**, respectively.

Cumulative Mass Removal
Mass balance was calculated for the period of operation to determine the mass removed from the aquifer by the pumping wells. Average flow rates for each monthly monitoring period were used, in combination with the TVOC concentration in the air-stripper influent, to determine the pounds removed. Flow averaged 394 gpm during 2011 (**Table 2.2.3-3**, and **Table F-12)**, and approximately 51 pounds of VOCs were removed. Approximately 974 pounds of VOCs have been removed since the system began operations in October 2001. The cumulative total of VOCs removed vs. time is plotted on **Figure 3.2.3-4**.

Table 3.2.3-2.
OU III Middle Road Air Stripper
2011 Average VOC Emission Rates

Parameter	Allowable ERP* (lb/hr)	Actual** (lb/hr)
carbon tetrachloride	0.022	0.0018
chloroform	0.0031	0.00011
1,1-dichloroethane	10***	0.000033
1,2-dichloroethane	0.008	0
1,1-dichloroethylene	0.034	0.00006
cis-1,2-dichloroethylene	10***	0.00002
trans-1,2-dichloroethylene	10***	0
tetrachloroethylene	0.387	0.0021
1,1,1-trichloroethane	10***	0.0005
trichloroethylene	0.143	0.00010

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

Air Discharge
Table 3.2.3-2 shows the air emissions data from the system for the OU III Middle Road tower during 2011, and compares the values to levels stipulated in NYSDEC Air Guide 1 regulations. Emission rates are obtained through mass-balance calculations for the water treated during that time (**Table F-10**). The concentration of each constituent was averaged for 2011, and those values were used in determining the emissions rate. The air emissions for the Middle Road system were below permitted limits.

Extraction Wells
Extraction wells RW-4 and RW-5 were shut down in September 2003 and placed on standby due to low concentrations of VOCs. The extraction wells are sampled quarterly. RW-6 was shut down in September 2006 due to low VOC concentrations in this well. Quarterly sampling of the wells will continue. Well RW-2 had the highest concentration of all the extraction wells for the year with 64 µg/L in April 2011. **Table 3.2.3-3** shows the monthly extraction well pumping rates.

3.2.3.6 System Evaluation

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

1. Is there a continuing source of contamination? If present, has the source area been remediated or controlled?
No, there is no known continuing source of contamination. Upgradient contamination that is being observed is anticipated from other source areas (Building 96, Carbon tetrachloride and Freon)that have been remediated and or controlled.

2. Has the downgradient migration of the plume been controlled?
No, based upon concentrations observed on the western edge of this area some VOCs may be bypassing the extraction wells. Continued monitoring of this area including a new monitoring well to the west to bound the plume on the western edge. A modification to the existing system may be required.

3. Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?
Wells RW-1, RW-2 and RW-3 have continued operations. Wells RW-4, RW-5 and RW-6 have been shut down.

3a. Are TVOC concentrations in plume core wells above or below 50 ug/L?
Several of the core wells are still above the capture goal of 50 µg/L TVOC concentrations.

3b. Is there a significant concentration rebound in core wells and/or extraction wells following shutdown?
The system is still operating so this cannot be evaluated at this time.

4. Has the groundwater cleanup goal of meeting MCLs been achieved?
No, the cleanup goal has not been met at this time.

3.2.3.7 Recommendations

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

- Maintain the routine O&M monitoring frequency that is currently in effect.
- Maintain extraction wells RW-4, RW-5 and RW-6 in standby mode. Restart the wells if extraction or monitoring well data indicate that TVOC concentrations exceed the 50 µg/L capture goal. Maintain a minimum pumping rate of 250 gpm on well RW-2. The system's extraction wells will continue to be sampled on a quarterly basis.
- Evaluate the monitoring data and perform additional groundwater modeling to determine if an additional extraction well to the west of extraction well RW-1 is needed.

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 2011, and gives conclusions and recommendations for future operation. Also included within this section is an evaluation of the system and extraction well, monitoring and sampling data.

3.2.4.1 System Description

This system began operation in June 1997. It utilizes air-stripping technology for treatment of groundwater contaminated with chlorinated solvents. There are seven extraction wells. The system is currently operating at a pumping rate of approximately 350 gpm, utilizing three extraction wells. Extraction wells EW-12 and EW-8 were placed on standby in October 2003 and October 2006, respectively, due to low VOC concentrations. Wells EW-6 and EW-7 were placed in standby mode in November and December 2007, respectively. A complete description of the system is included in the *Operation and Maintenance Manual for the OU III Middle Road and South Boundary Groundwater Treatment Systems, Revision 1* (BNL 2003a).

3.2.4.2 Groundwater Monitoring

The monitoring well network consists of 44 wells and was designed to monitor the VOC plume(s) in this area of the southern site boundary, as well as the efficiency of the groundwater remediation system (**Figure 3.2.4-1**). The South Boundary wells are sampled and analyzed for VOCs at frequencies detailed on **Table 1-5**. A number of OU III South Boundary wells are also analyzed for radionuclides as detailed in **Section 3.2.14**.

3.2.4.3 Monitoring Well Results

The south boundary segment of the OU III VOC plume continued to be bounded by the existing monitoring well network. Western perimeter well 121-08 had a TVOC concentration of 9 μg/L in November and eastern perimeter well 114-07 had a concentration of 10 μg/L. Individual VOC concentrations in the remaining plume perimeter wells were less than 5 μg/L for VOCs in November 2011. This is well below the capture goal of the system of 50 μg/L for TVOC concentrations. VOCs were detected in the deep Upper Glacial aquifer in the vicinity of the site boundary, as depicted on **Figures 3.2-2, 3.2.4-1,** and **3.2.4-2. Appendix C** has the complete groundwater monitoring results for 2010.

The plume core wells continued to show the same trend of decreasing VOC concentrations that were observed following the start-up of the pump and treat system in 1997 except for several key wells located in the deep Upper Glacial; in the vicinity of well EW-4. The bulk of the VOC contamination in this area is currently located between EW-3 and EW-5, as can be seen on **Figure 3.2.4-2,** which is a cross section (F–F') drawn along the south boundary. The VOC concentration trends for specific key wells are shown on **Figure 3.2.3-3.** Results for key monitoring wells are as follow:

- Bypass detection well 121-43 located several hundred feet south of extraction well EW-4 has consistently shown elevated levels of VOCs. The TVOC concentration in this well was 160 μg/L in November 2009. In April 2011 levels were at 338μg/L, but dropped to 145 μg/L in November. A temporary well (MRVP-03-2010) was installed during 2010 in close proximity to well EW-4, and showed high VOC concentrations (maximum of 456 μg/L of TVOCs) at depths below the screened interval of well EW-4. As a follow up to this a permanent monitoring well SB-MW01-2011 was installed in 2011 and analytical results showed TVOC concentrations of 1256 μg/L. This indicates that the high concentrations in this area are migrating underneath the extraction well. A new deeper extraction well is being installed in this area in 2012. (**Figure 3.2-2**).
- Plume core well 114-07 is immediately upgradient of EW-12 and had a TVOC concentration of 10 μg/L in November 2011.

- Monitoring well 121-45 was installed in 2006 to monitor the higher VOC concentrations present at wells 113-17 and 113-11. This well is located between the Middle Road and South Boundary systems. In 2011 TVOC concentrations ranged from 170 µg/L in January to 138 µg/L in November **(Figure 3.2.4-1)**. This continues a downward trend in this monitoring well.
- Plume core well 121-11 is upgradient of EW-3. TVOC concentrations ranged from 29 µg/L in April 2011 to 24µg/L in November.
- Plume core well 122-05 is a Magothy monitoring well west of EW-8. TVOC concentrations have been showing a decreasing trend with concentrations at 12 µg/L in November 2011 **(Figure 3.2.4-1)**.

3.2.4.4 System Operations

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

System Operations

In 2011, approximately 192 million gallons of water were pumped and treated by the OU III South Boundary System. Well EW-8 was put in standby mode in October 2006, and EW-12 has remained in standby since 2003. Wells EW-6 and EW-7 were put on standby near the end of 2007.

January – September 2011

Approximately 143 million gallons of water were pumped and treated. There were repairs with the EW-3 flow meter, and maintenance on the blower during the second quarter. The system operated normally for the first and third quarter.

Table 3.2.4-1.
OU III South Boundary Air Stripping Tower
2011 SPDES Equivalency Permit Levels

Parameters	Permit Limit*	Max. Observed Value
pH range (SU)	6.5 – 8.5	5.8–7.8
carbon tetrachloride	5 µg/L	ND
chloroform	7 µg/L	ND
dichlorodifluoromethane	5 µg/L	ND
1,1-dichloroethane	5 µg/L	ND
1,1-dichloroethylene	5 µg/L	ND
methyl chloride	5 µg/L	ND
tetrachloroethylene	5 µg/L	ND
toluene	5 µg/L	ND
1,1,1-trichloroethane	5 µg/L	ND
1,1,2-trichloroethane	5 µg/L	ND
trichloroethylene	10 µg/L	ND

Notes:

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

October – December 2011

The OU III South Boundary System pumped and treated approximately 49 million gallons of water. The system was operating normally for the fourth quarter.

3.2.4.5 System Operational Data

System Influent and Effluent

Figure 3.2.4-3 plots the TVOC concentrations in the extraction wells versus time. The overall influent water quality and the individual extraction wells show a general declining trend in concentrations. System influent and effluent sampling results are summarized on **Tables F-14** and **F-15**, 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 (**Table F-16**). The cumulative total of VOCs removed by the treatment system versus time is plotted on **Figure 3.2.4-4**. The 2011 total was approximately 52 pounds. Cumulatively, the system has removed approximately 2,835 pounds since it was started in June 1997.

Air Discharge

Table 3.2.4-2 shows the air emissions data from the OU III South Boundary system for 2011, and compares the values to levels stipulated in NYSDEC Air Guide 1 regulations. Emission rates are obtained through mass-balance calculations for water treated during that time (**Table F-14**). The concentration of each constituent was averaged for the year, and that value was used in the calculation. System air emissions were below allowable levels.

Table 3.2.4-2.
OU III South Boundary Air Stripper
2011 Average VOC Emission Rates

Parameter	Allowable ERP*	Actual** ER
carbon tetrachloride	0.022	0.0005
chloroform	0.0031	0.00005
1,1-dichloroethane	10***	0.00003
1,2-dichloroethane	0.008	0
1,1-dichloroethylene	0.034	0.0001
cis-1,2-dichloroethylene	10***	0.0004
trans-1,2-dichloroethylene	10***	0
tetrachloroethylene	0.387	0.0051
1,1,1-trichloroethane	10***	0.0001
trichloroethylene	0.143	0.0001

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

Extraction Wells

Of the three extraction wells that are still operating well EW-4 continued to show slowly decreasing TVOC concentrations in 2011 (106 µg/L in January to 82 µg/L in October). Wells EW-3 and EW-5 had low VOC concentrations that are close to the drinking water standards in 2011. (**Figure 3.2.4-3**). **Table F-13** summarizes the data for the extraction wells. **Table 3.2.4-3** shows the monthly extraction well pumping rates.

3.2.4.6 System Evaluation

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

1. Were unexpected levels or types of contamination detected?

Yes, elevated levels of TVOCs detected in Monitoring well SB-MW01-2011 are below the capture zone of the existing extraction wells. This data correlates with the data in downgradient well 121-43. An additional extraction is being installed in 2012 to capture this contamination.

2. Has the downgradient migration of the plume been controlled?

No, although the system is capturing the majority of the plume VOCs are migrating beneath EW-4.

3. Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?

Yes, four of the seven extraction wells have been shut down as they have achieved the cleanup goals for this system. The other three wells need to continue to operate to capture higher levels of TVOCs in this area.

4. Are TVOC concentrations in plume core wells above or below 50 µg/L?

There are still several plume core wells above 50 µg/L in the vicinity of the western extraction wells.

5. Is there a significant concentration rebound in core wells and/or extraction wells following shutdown?

The wells that have been shut down on the eastern portion of this system have not shown a concentration rebound in the monitoring or extraction wells. The three western most wells are still operating.

6. Has the groundwater cleanup goal of meeting MCLs been achieved?

No, the system is still operating and MCL's have not been achieved.

3.2.4.7 Recommendations

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

- Based on the monitoring results from well SB-MW01-2011 and the results from monitoring well 121-43, an additional extraction well is being installed near EW-4 but at a greater depth.
- Maintain wells EW-6, EW-7, EW-8, and EW-12 in standby mode. The system's extraction wells will continue to be sampled on a quarterly basis. The wells will be restarted if extraction or monitoring well data indicate TVOC concentrations exceed the 50 μg/L capture goal.
- Maintain the routine O&M monitoring frequency implemented last year.
- Perform additional groundwater characterization in the Industrial Park south of well 121-43 to evaluate the extent of downgradient migration of the VOC plume beneath EW-4.

3.2.5 Western South Boundary Pump and Treat System

The Western South Boundary Pump and Treat System was designed to capture TVOC concentrations exceeding 20 µg/L in the Upper Glacial aquifer along the western portion of the BNL south boundary. The system reduces 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 and was changed to pulse pumping mode in late 2005, one month on and two months off. Based on increasing VOC concentrations in an upgradient monitoring well, extraction well WSB-1 was put back into full-time operation starting in November 2008, and has continued through 2011. Extraction well WSB-2 remains in a pulse-pumping mode.

3.2.5.1 System Description

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

3.2.5.2 Groundwater Monitoring

A network of 17 wells is used to monitor this plume. In accordance with the recommendation in the *2009 Groundwater Status Report*, an additional core monitoring well (WSB-MW-01-2010) was installed in February 2011 and is located approximately 700 feet north of WSB-1 to provide a data point between this extraction well and well 119-06. The well locations are shown on **Figure 3.2.5-1**. The wells are sampled at the O&M phase frequency (**Table 1-5** for details).

3.2.5.3 Monitoring Well Results

The primary VOCs associated with this plume are dichlorodifluoromethane (Freon-12), TCA, TCE, 1,1-DCE, and chloroform. VOC contamination is located in the mid to deep Upper Glacial aquifer. **Figure 3.2.5-1** presents fourth-quarter 2011 monitoring well concentrations. A summary of key monitoring well data for 2011 follows:

- Monitoring well 119-06 was installed in 2008 along Middle Road. This core well had TVOC concentrations up to 170 µg/L in December 2008, with TCA (100 µg/L) as the primary compound. Since then, this well showed a steady decrease in TVOC concentrations to less than 3 µg/L in 2011 (**Figure 3.2.5-2).** This drop off is indicative of the trailing edge of high concentrations passing through the vicinity of the Middle Road monitoring well.
- New core well WSB-MW-01-2010 detected TVOC concentrations up to 388 µg/L in the first sample in February 2011, and dropped slightly in the fourth quarter to 234 µg/L. This is the maximum TVOC value for the entire plume in 2011. The primary compounds detected in February were TCA and 1,1-DCE at 230 µg/L and 150 µg/L, respectively. As shown on **Figure 3.2.5-1**, the higher concentration VOCs are located between Middle Road and extraction well WSB-1.
- Core well 103-15, installed in 2009 between Middle Road and East Princeton Avenue detected TVOC concentrations up to 53 µg/L in the first quarter to 36 µg/L in the fourth quarter 2011. VOCs exceeding the 5 µg/L AWQS were Freon-12 and TCE, with maximum concentrations of 38 µg/L and 6 µg/L, respectively in February. The maximum TVOC value in 2009 was 69 µg/L. As recommended in the *2009 Groundwater Status Report*, two temporary wells (WSB-VP-01-2010 and WSB-VP-02-2010) were installed in February 2011 south of East Princeton Avenue to better define the extent of the Freon-12 contamination. The maximum TVOC value detected was 28 µg/L at 150 feet below grade in WSB-VP-01-2010 (**Figure 3.2.5-1**). The maximum VOC detected in this well was 1,1-DCE at 13 µg/L. The maximum value of Freon-12 detected was 2.1 µg/L. No Freon-12 was detected in WSB-VP-02-2010.

- TVOC concentrations in plume core wells 121-42, 127-04, and 127-06, located immediately upgradient of extraction well WSB-2, have remained less than 20 µg/L since 2005.

- TVOC concentrations in plume core wells 126-11 and 126-13, located immediately upgradient of extraction well WSB-1, began increasing in 2009 (see trends on **Figure 3.2.5-2)**. The maximum historical TVOC concentration in these wells was 79 µg/L and 130 µg/L, respectively, as observed in the April 2010 samples. This contamination was captured by extraction well WSB-1. TVOC concentrations in these core wells began decreasing in 2011 with a maximum value of 18 µg/L in well 126-13 in April.

- In bypass detection well 130-08, located south of extraction well WSB-1, the maximum TVOC concentration during 2011 was 29 µg/L in the first quarter. The highest individual VOC detected was TCA at 7 µg/L. TVOC values in this well have remained relatively steady since 2003.

- In bypass well 126-16, located south and between the two extraction wells, TVOC concentrations averaged approximately 20 µg/L in 2011, showing a slight decreasing trend over the last three years. Bypass well 127-07, located downgradient of WSB-2, has shown steadily declining VOCs since 2005. This is indicative of the operation of WSB-2. In 2011, TVOC concentrations were less than 11 µg/L in well 127-07, and no individual compound exceeded the AWQS.

- Well 130-03, located west of extraction well WSB-1, had a maximum TVOC concentration of 24 µg/L in April 2011. This well has shown a decreasing trend since the historical high TVOC concentration of 58 µg/L in December 2004, but remained fairly stable over the last three years. The capture zone of the Western South Boundary extraction well WSB-1 was not intended to include this area.

Table 3.2.5-1
OU III Western South Boundary Pump & Treat System
2011 SPDES Equivalency Permit Levels

Parameter	Permit Level (µg/L)	Max. Measured Value (µg/L)
pH range	6.5–8.5 SU	6.6–8.1 SU
carbon tetrachloride	5	<0.5
chloroform	7	<0.5
dichlorodifluoromethane	5	<0.5
1,1-dichloroethane	5	<0.5
1,1-dichloroethylene	5	<0.5
methyl chloride	5	<0.5
tetrachloroethylene	5	<0.8
toluene	5	<0.5
1,1,1-trichloroethane	5	<0.5
1,1,2-trichloroethane	5	<0.5
trichloroethylene	10	<0.5

Note:

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

3.2.5.4 System Operations

During 2011, the extraction wells were sampled quarterly and the influent and effluent of the air-stripper tower were sampled twice per month. Extraction well WSB-1 continued full-time operation through 2011 due to increasing TVOC concentrations greater than the capture goal of 20 µg/L in upgradient core wells. System samples were analyzed for VOCs. In addition, the effluent was analyzed for pH twice a month. **Table 3.2.5-1** provides the effluent limitations for meeting the requirements of the SPDES equivalency permit. The system's effluent discharges met the SPDES equivalency permit requirements during 2011. The system operations are summarized below.

January – September 2011

The treatment system operated normally from January to September. The WSB-1 extraction well operated for the entire year. The WSB-2 extraction well schedule was one month on and two months off. During this time, approximately 87 million gallons of groundwater were treated.

October – December 2011

The system operated normally except for being down a few days for maintenance. During this quarter, approximately 30 million gallons of groundwater were treated.

Table 3.2.5-3
OU III Western South Boundary
2011 Air Stripper VOC Emissions Data

Parameter	Allowable ERP* (lb/hr)	Actual ERP (lb/hr)
carbon tetrachloride	0.016	0.00005
chloroform	0.0086	<0.0001
1,1-dichloroethane	10**	<0.0003
1,2-dichloroethane	0.011	<0.0001
1,1-dichloroethene	0.194	0.0004
chloroethane	10**	0.00004
1,1,1-trichloroethane	10**	<0.0075
trichloroethylene	0.119	<0.0001

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

3.2.5.5 System Operational Data

Extraction Wells

During 2011, approximately 117 million gallons of groundwater were treated by the OU III Western South Boundary System, with an average flow rate of approximately 230 gpm. **Table 2-2** gives monthly pumping data for the two extraction wells. **Table 3.2.5-2** shows the monthly extraction well pumping rates. VOC and tritium concentrations for extraction wells WSB-1 and WSB-2 are provided on **Table F-17**. VOC levels in both wells had been showing a slight decreasing trend since system start-up in 2002, through 2005. In 2006 WSB-2 showed increasing TVOC concentrations, but began decreasing in 2007. Since 2008, TVOC levels remained fairly constant. WSB-1 TVOC levels began rising in 2006 and have remained steady over the last five years. The maximum TVOC value in 2011 was 19.5 μg/L in the first quarter in WSB-1. Extraction well TVOC values continue to remain less than the 20 μg/L capture goal. **Figure 3.2.5-3** provides a graph of extraction well trends over time. Most of the individual VOC compounds were either below or slightly above the AWQS.

System Influent and Effluent

Influent TVOC concentrations continued to remain slightly below 20 μg/L. Individual VOC concentrations slightly exceeded the AWQS during the year, with a maximum TCA value of 8.6 μg/L in March. These levels are consistent with the historical influent concentrations. The influent consists primarily of TCA, 1,1-DCE, Freon-12, TCE, and chloroform (**Table F-18**).

The air-stripper system effectively removed the contaminants from the influent groundwater. The system's effluent data were below the analytical method detection limit and below the regulatory limit specified in the equivalency permit conditions **(Table F-19)**.

Cumulative Mass Removal

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 of VOCs removed per month (**Table F-20**). The cumulative mass of VOCs removed by the treatment system is provided on **Figure 3.2.5-4**. During 2011, twelve pounds of VOCs were removed. A total of 93 pounds have been removed since the start-up of the system in 2002.

Air Discharge

Table 3.2.5-3 presents the VOC air emission data for 2011 and compares the values to levels stipulated in NYSDEC Air Guide 1 regulations. Emission rates are calculated through mass balance for water treated during operation. The VOC air emissions were well below allowable levels.

3.2.5.6 System Evaluation

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

1. Were unexpected levels or types of contamination detected?
No.

2. Has the downgradient migration of the plume been controlled?
Yes. VOC concentrations in the plume perimeter wells (except 130-03) remained below the AWQS during 2011, indicating that the plume is being controlled as shown on **Figure 3.2.5-1**. TVOC concentrations in well 130-03 had been slowly decreasing since late 2004 with a slight increase to 33 μg/L in November 2009 and April 2010. The capture zone of WSB-1 was not intended to include this area. As noted above, low VOC concentrations in the bypass wells were present before the system was operational and not within the capture zone of the extraction wells. The capture zone for the treatment system is depicted on **Figure 3.0-1**.

3. Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?
The system has not met all shutdown requirements. Pulse pumping continues for WSB-2.

3a. Are TVOC concentrations in plume core wells above or below 20 μg/L?
Three of the ten core wells exceed the 20 μg/L capture goal. **Figure 3.2.5-5** shows the average core monitoring well TVOC concentrations.

3b. Is there a significant concentration rebound in core wells and/or extraction wells following shutdown?
No significant rebound was observed due to pulse pumping of extraction well WSB-2.

4. Has the groundwater cleanup goal of meeting MCLs been achieved?
No. MCLs have not been achieved for individual VOCs in all plume core wells. However, MCLs are expected to be achieved by 2030.

3.2.5.7 Recommendations

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

- Continue full-time operation of extraction well WSB-1, and pulse pumping of WSB-2 at the schedule of one month on and two months off. This process will continue and any changes to the VOC concentrations in the influent and the monitoring wells will be evaluated.
- Install a monitoring well at the Middle Road in June 2012 to monitor the downgradient extent of the Freon-12 observed in well 103-15.
- Based on the data from the new monitoring well, determine the need to update the groundwater model to determine the migration and attenuation of the Freon-12 contamination.
- Maintain the routine O&M monitoring frequency.

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 2011 and presents conclusions and recommendations for its future operation. The system began operation in September 1999. The OU III Industrial Park system was designed to contain and remediate a portion of the OU III plume between BNL's southern boundary and the southern boundary of the Parr Industrial Park. **Figure 3.2.6-1** illustrates the extent of the OU III contaminant plume in the vicinity of the Industrial Park. The primary VOCs associated with this portion of the OU III plume are TCA, PCE, and carbon tetrachloride.

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) 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). Some of the treated groundwater that is recharged through the upper screen recirculates through the cell and is drawn back into the extraction screen for further treatment, while the balance flows in the direction of regional groundwater flow.

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

3.2.6.2 Groundwater Monitoring

Well Network

The monitoring well network consists of 43 wells and is designed to monitor the VOCs in the vicinity of the industrial park south of the site, and the effectiveness of the in-well air stripping groundwater treatment system on this part of the high-concentration OU III VOC plumes. The wells are located throughout the Industrial Park and on Carleton Drive, as shown on **Figure 3.2.6-1.** Screen depths are set to monitor water levels at multiple depths and to obtain water quality data as follows: 1) above the treatment well effluent depth, 2) at the effluent depth, and 3) at the treatment well influent depth.

Sampling Frequency and Analysis

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

3.2.6.3 Monitoring Well Results

The complete analytical results are included in **Appendix C**. VOC concentrations in the plume perimeter wells that monitor the width of the plume (000-245 and 000-272) remained below AWQS during 2011. Based on this data, the plume is effectively bounded by the current well network. **Figure 3.2.6-1** shows the plume distribution based on fourth-quarter 2011 data. The vertical extent of contamination is shown on **Figure 3.2.6-2**. The location of this cross section (G–G') is illustrated on **Figures 3.2-1 and 3.2.6-1**. The 2011 results for key monitoring wells are:

Plume Core Wells

- Wells 000-253 (just east of UVB-1) and 000-256 (between UVB-1 and UVB-2), which both contained TVOC concentrations over 1,000 µg/L in 2001, have continued to show concentrations below AWQS. In 2011 well 000-253 had a high TVOC concentration of 6 µg/L and well 000-256 had a high TVOC concentration of 2.7 µg/L. Wells UVB-1, UVB-2 are in standby due to low VOC concentrations..
- Well 000-259 is located between UVB-2 and UVB-3. In 2011 this well was sampled May and November, and had TVOC concentrations of 7.5 µg/L and 5.5 µg/L, respectively. This is consistent with data observed in extraction wells UVB-2 and UVB-3. Well UVB-2 was placed in standby mode in August 2010.
- A steady decline in TVOC concentrations was observed in well 000-112 (immediately upgradient of UVB-1 and UVB-2) since 1999, when concentrations were near 2,000 µg/L. TVOC concentrations were at 3.7 µg/L in November 2011 (**Figure 3.2.6-3**).
- Well 000-262 (between UVB-4 and UVB-5) began showing decreasing TVOC concentrations in 2002 (**Figure 3.2.6-3**). The TVOC concentration in this well had fluctuated for the past few years between 200 µg/L and 600 µg/L until 2010 when TVOC concentrations dropped from 244 µg/L in April to 6.4 µg/L in November. In 2011 this trend of low TVOC concentrations continued with a high TVOC concentration of 9 µg/L in November 2011.
- The TVOC concentration in well 000-268 (between UVB-6 and UVB-7) was 2.6 µg/L in April and 1.3 µg/L November 2011. (**Figure 3.2.6-3**). This is consistent with data observed in UVB wells UVB-6 and UVB-7.
- A vertical profile well was installed to evaluate concentrations of VOCs between wells UVB-3 and UVB-4 as per recommendations in the 2009 Annual Groundwater Status Report. This VP (IP-VP-01-2010) was installed to approximately 220 feet below grade. The results showed the highest concentration (111 µg/L TVOC) at about 210 feet below grade. A permanent monitoring well will be installed at this location in 2012.

Plume Bypass Wells

- TVOC concentrations in most of the wells located near Carleton Drive were stable or decreasing during 2011. Wells 000-431 and 000-432 serve as bypass monitoring points downgradient of UVB-2. TVOC concentrations in 000-431and 000-432 were below AWQS during 2011. The low VOC concentrations in these wells indicate that the system is effective in hydraulically controlling the plume.
- VOC concentrations in bypass wells 000-275, 000-276, and 000-277 were below AWQS during 2011, indicating that the system is effective in capturing the plume. The highest VOC concentration observed was 4 µg/L (February 2011) in well 000-276.
- Well 000-278 is directly downgradient of well UVB-4 and in November 2011 it had a TVOC concentration of 1.9 µg/L.TVOC concentrations in well 000-273 ranged from a low of 2.5 µg/L in February 2011 to 8.1 µg/L in November. Well 000-274 had TVOC concentrations ranging from10 µg/L in February to 5 µg/L in November 2011. These wells are located immediately downgradient of well UVB-1, which was shut down in October 2005. These concentrations are well below the capture goal of TVOC concentrations of 50 µg/L.

Perimeter Wells

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

3.2.6.4 System Operations

In 2011, approximately 88 million gallons of groundwater were pumped and treated by the Industrial Park In-Well Air Stripping System. Well UVB-1, UVB-2 and UVB-7 remained in standby mode throughout the year.

Operating Parameters

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

System Operations

System extraction well pumping rates are included on Table 3.2.6-1. The following summarizes the system operations for 2011.

January – September 2011

The system was down for about two weeks in January due to electrical problems. In May the system was off for the last part of the month to replace a belt on the blower and again in June for part of the month due to maintenance work. Individual wells were off for various periods due to repair or maintenance activities. The system pumped and treated a total of approximately 59 million gallons of water during this period.

October – December 2011

Well UVB-4 was off for the majority of October due to mechanical repairs. The system operated normally for the remainder of this period. Approximately 29 million gallons were treated during this period.

3.2.6.5 System Operational Data

Recirculation Well Influent and Effluent

During 2011, influent TVOC concentrations in the treatment system wells were all below the capture goal of 50 µg/L (Figure 3.2.6-4). The corresponding effluent well concentrations are shown on Figure 3.2.6-5. UVB-1, UVB-2 and UVB-7 remained in standby mode for 2011. There was varying downtime for individual wells in 2011 due to electrical problems, flow meter issues and routine maintenance and cleaning of the wells.

The removal efficiencies for the air strippers in the extraction wells for 2011 are shown in Table F-21.

Cumulative Mass Removal

Calculations were performed to determine the VOC mass removed from the aquifer by the remediation wells during the year. The average estimated flow rates for each monthly monitoring period were used, in combination with the influent and effluent TVOC concentrations. **Table F-22** summarizes these data. During 2011, flow averaged approximately 42 gpm per well for the four operating wells. **Figure 3.2.6-6** plots the total pounds of VOCs removed by the treatment system vs. time. During 2011, five pounds were removed from the aquifer, with a total of 1,057 pounds removed since 1999.

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 was needed. In addition, airflow rates were recorded to optimize the efficiency of individual recirculation wells.

Airflow rates are measured for each in-well air-stripping unit inside the treatment building. These rates averaged 611 cfm during 2011(**Table F-23**).

3.2.6.6 System Evaluation

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

1. Were unexpected levels or types of contamination detected?
No, There were no unusual or unexpected VOC concentrations observed in the monitoring wells or extraction wells associated with the OU III Industrial Park System during 2011.

2. Has the downgradient migration of the plume been controlled?
Yes, an analysis of the plume perimeter and bypass well data reveals that there are no TVOC concentrations above the capture goal of the system in 2011. The capture zone for the OU III Industrial Park System is depicted on **Figure 3.0-1**. The capture zone includes the TVOC 50 µg/L isocontour, which represents the capture goal of this system.

3. Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?
Wells UVB-1, UVB-2 and UVB-7 are already in standby. The treatment system is effectively removing contamination. The current estimate for treatment system operations is for the system to operate through 2012. However, the concentrations detected in the vertical profile well (IP-VP-01-2010) located between UVB-3 and UVB-4 are above the capture goal of the system at several deeper intervals. **Figure 3.2-3** compares the OU III plume from 1997 to 2011.

The overall trend in the mean TVOC concentrations in the core groundwater monitoring wells has been declining (**Figure 3.2.6-7**) with all monitoring wells now below the capture goal of the treatment system of 50 µg/L. Based upon the results of a permanent monitoring well being installed at the location of VP IP-VP-01-2010 and the results of an additional VP being installed between UVB-5 and UVB-6 a petition to shutdown the system will be made in 2012 or if concentrations in either of these wells exceed the capture goal of the system a recommendation to pulse pump several of these wells (UVB-3, UVB-4, UVB-5, UVB-6) for another year will be made.

4. Are TVOC concentrations in plume core wells above or below 50ug/L?
Plume core wells are currently below the 50 µg/L capture goal. However the concentration detected in IP-VP-01-2010 was above this concentration at 111 µg/L.

5. Is there a significant concentration rebound in core wells and/or extraction wells following shutdown?
There has not been a rebound in the vicinity of wells UVB-1, UVB-2 and UVB-7 which are in standby.

6. Has the groundwater cleanup goal of meeting MCLs been achieved?
No, they have not yet been achieved.

3.2.6.7 Recommendations

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

- Maintain the O&M monitoring frequency of quarterly (shutdown sampling frequency). Monthly recovery well sampling will continue, and if TVOC concentrations greater than 50 µg/L are observed, wells UVB-1, UVB-2 or UVB-7 will be restarted.
- The additional data collection from the temporary well between well UVB-5 and UVB-6 as well as the new monitoring well and quarterly well sampling will be used to evaluate whether the criteria for system shutdown of TVOC concentrations less than 50 µg/L in core monitoring wells and extraction wells has been met. A petition to shut down this system will be submitted to the Regulators if these criteria are met. If the new monitoring well has TVOC concentrations above the capture goal then wells UVB-3 and UVB-4 will be put on a monthly pulse pumping schedule of one month on and one month off and UVB-5 and UVB-6 will be shut down.
- If all TVOC concentrations are below 50 µg/L in the new monitoring well and the vertical well profile then a Petition for Shutdown will be submitted in the Fall of 2012.

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3.2.7 Industrial Park East Pump and Treat System

This section summarizes the 2011operational and monitoring well data for the OU III Industrial Park East (IPE) Groundwater Treatment System, and presents conclusions and recommendations for its future operation. The system began full operation in June 2004 to provide capture and control for a downgradient portion of the OU III VOC plume, which had migrated beyond the BNL site boundary. The Petition to Shutdown the OU III IPE Groundwater Treatment System was submitted to the regulators for review in early October 2009. In November 2009, the regulators concurred with the Petition. The system was placed in standby in December 2009 and has remained in standby through all of 2011.

3.2.7.1 System Description

The IPE treatment facility (Building OS-2) is located at the Industrial Park immediately east of Building OS-1, the Industrial Park Groundwater Treatment System. This system includes two extraction wells and two recharge wells. Extraction well EWI-1 is screened in the Upper Glacial Aquifer and EW I-2 is screened in the upper portion of the Magothy aquifer (**Figure 3.2.7-1** and **Figure 3.2.7-2**). Extraction well EWI-1 is designed to operate at a maximum rate of approximately 120 gpm; extraction well EWI-2 is designed for approximately 100 gpm.

The treated water is recharged to the Upper Glacial aquifer through two recharge wells located near the extraction wells, designated as DWI-1 and DWI-2. A complete description of the system is contained in the *Operations and Maintenance Manual for the Industrial Park East Offsite Groundwater Remediation System* (BNL 2004a).

3.2.7.2 Groundwater Monitoring

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

3.2.7.3 Monitoring Well Results

The primary VOCs associated with this portion of the OU III plume are TCA, trichloroethylene, and 1,1-dichloroethylene. Groundwater monitoring for this system was initiated in 2004; however, three of the wells have been monitoring the plume since 1999. Fourth-quarter well data are posted on **Figure 3.2.7.1**. The complete analytical results are in **Appendix C.** Results for key monitoring wells are as follow:

- The maximum TVOC concentration detected during 2011 was 48 μg/L in downgradient well 000-429 during May 2011, (**Figure 3.2.7-1**). This is a Magothy monitoring well located 400feet downgradient of the extraction wells. This contamination was likely downgradient of the extraction wells prior to their installation.
- In plume core well 000-514, approximately 100 feet west of the extraction wells, VOC concentrations were less than AWQS during 2011.
- VOCs in plume bypass well 000-493 have remained below the AWQS since it was installed in June 2004.
- Upgradient wells 122-24 and 122-25, which had shown TVOC concentrations as high as 570 μg/L in 2002, have been below AWQS since 2008.
- A new Magothy monitoring well (MW-MAG) was installed in September 2011 near well 000-107 (**Figures 3.2.7-1** and **3.2.7-2**) as per a recommendation in the 2010 Groundwater Status report. This well was installed to monitor downgradient contamination that has been observed in well 000-494. The initial sampling of this well in November 2011 showed VOC concentrations below detection limits.

3.2.7.4 System Operations

Operating Parameters

The system was in standby mode since December 2009. When operating the influent, midpoint, and effluent of the carbon vessels are sampled once a month and analyzed for pH and VOCs. Sampling for pH and VOCs adheres to the requirements of the SPDES equivalency permit. The system's effluent permit levels are shown in **Table 3.2.7-1.**

Table 3.2.7-1.
OU III Industrial Park East Pump & Treat System
2011 SPDES Equivalency Permit Levels

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

Note: N/A Not Applicable
Required sampling frequency is monthly for VOCs and pH.

System Operations

The following information summarizes the system operations for 2011.

The system was in standby mode for this entire period.

Extraction Wells Operational Data

During 2011, the extraction wells did not operate. However the wells were sampled quarterly. In 2011, TVOC concentrations in EWI-1 ranged from 1 to 3.8 µg/L and 1.3 to 3.3 µg/L in EWI-2. All individual VOC compounds were below AWQS in both extraction wells.

3.2.7.5 System Operational Data

System Influent and Effluent

There were no influent or effluent samples as the system was in standby for all of 2011.

Cumulative Mass Removal

The sytem did not operate in 2011. Approximately 37 pounds of VOCs were removed from the aquifer since system start-up in 2004.

3.2.7.6 System Evaluation

This system is designed to achieve the overall OU III ROD objectives of minimizing plume growth and meeting AWQS in the Upper Glacial aquifer by 2030. According to the *OU III Explanation of Significant Differences* (BNL 2005a), AWQS within the Magothy aquifer must be met by 2065. The system will address the highest VOC concentration portion of the plume (above 50 µg/L TVOC).

The Industrial Park East Treatment System performance during 2011 can be evaluated based on the major decisions identified for this system from the groundwater DQO process:

1. Were unexpected levels or types of contamination detected?

No. There were no unusual or unexpected VOC concentrations observed in the monitoring wells or extraction wells associated with the Industrial Park East Groundwater Treatment System during 2011.

2. Is the plume naturally attenuating as expected?.

Yes, there has been no increase in downgradient TVOC concentrations.

3. Has the downgradient migration of the plume been controlled?
Yes, the upgradient portion of this plume near the extraction wells is below AWQS.

4. Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?
The system is currently shutdown and has met the cleanup objectives for this project.

5. Are TVOC concentrations in plume core wells above or below 50ug L?
All core wells are below *50ug L* for the Upper Glacial aquifer. MCLs have been achieved for individual VOCs in all IPE plume core wells.

6. Is there a significant concentration rebound in core wells and/or extraction wells following shutdown? No, rebound has not been observed in any of the wells.

7. Has the groundwater cleanup goal of meeting MCLs been achieved?
All Upper Glacial and Magothy core wells are now below MCLs, however several downgradient Magothy wells are still above MCLs.

3.2.7.7 Recommendations

The following is recommended for the Industrial Park East Treatment System and groundwater monitoring program.

- Continue the current post shutdown groundwater monitoring schedule.
- Since no rebound in concentrations in core monitoring wells has been observed since system shutdown in December 2009 and because they remain below MCLs a Petition for Closure of this project will be submitted to the regulators in the Fall of 2012.

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3.2.8 North Street Pump and Treat System

The North Street Pump and Treat System addresses a VOC plume that originated at the Former Landfill/Chemical Holes area. The VOC plume is presently located south of the site boundary, with the leading edge extending south to the Brookhaven Airport (**Figure 3.2.8-1**). The groundwater pump and treat system began operating in May 2004.

Groundwater treatment consists of two extraction wells operating at a combined pumping rate of approximately 400 gpm. The system captures the higher concentration portion of the VOC plume (i.e., TVOC concentrations greater than 50 µg/L) in the Upper Glacial aquifer, and will minimize the potential for additional VOC migration into the Magothy aquifer.

The North Street plume has been divided into two segments for remediation purposes. The area to the north of extraction well NS-2 is being addressed by the North Street remediation system, whereas the Airport System handles the area to the south (**Figure 3.0-1**). The Airport System was constructed in part to address the leading edge of this plume (**Section 3.2.10**).

3.2.8.1 System Description

The North Street system consists of two extraction wells. Extracted groundwater is piped through two 20,000-pound GAC units located in Building OS-5 on a parcel of land owned by DOE, and discharged to four injection wells located downgradient along North Street. Both the North Street and North Street East systems share the four injection wells. Extraction wells NS-1 and NS-2 are planned to operate at a rate of approximately 200 gpm. A complete description of the system is contained in the *Operations and Maintenance Manual for the North Street/North Street East Offsite Groundwater Treatment Systems* (BNL 2004b).

3.2.8.2 Groundwater Monitoring

Well Network

A network of 20 wells monitors the North Street VOC plume (**Figure 1-2**). As recommended in the 2010 Groundwater Status Report, wells 086-43 and 800-115 were dropped from the North Street monitoring program. The monitoring program also addresses radiological contaminants that may have been introduced to groundwater in the OU IV portion of the site (particularly the Building 650 and 650 sump outfall areas), as well as the Former Landfill/Chemical Holes. Wells sampled under the Airport program are also utilized for tracking this plume.

Sampling Frequency and Analysis

Sampling of the 20 monitoring wells was increased in 2011 from the operations and maintenance frequency (semi-annual) to shutdown frequency (quarterly) and analyzed for VOCs according to the schedule on **Table 1-5**. All wells, except for 000-343, are also sampled and analyzed annually for tritium.

3.2.8.3 Monitoring Well Results

The primary VOCs associated with this plume are carbon tetrachloride, TCE, TCA, and chloroform. **Figure 3.2-1** and **Figure 3.2.8-1** depict the TVOC plume distribution and include data from the monitoring wells. The complete groundwater monitoring well data for 2011 are included in **Appendix C**. A north–south hydrogeologic cross section (H–H') of the plume is provided on **Figure 3.2.8-2.** The location for the cross section is shown on **Figure 3.2-1**. A summary of key monitoring well data for 2011 follows:

- In 2011 the highest TVOC concentration in the plume was 48 µg/L in well 800-63 during fourth quarter sampling. This bypass detection well is located on Vita Drive approximately 1,600 feet south of extraction well NS-1. The primary VOCs detected in this well in 2011 was TCE. As displayed on trend **Figure 3.2.8-3**, TVOCs in this well have slowly declined from a high in 2008 of 174 µg/L to its current levels.

- TVOC concentrations in plume core well 000-472 have been on a downward trend since the middle of 2007 reaching a low of 23 µg/L in the fourth quarter 2011. This well is located approximately 90 feet west of extraction well NS-2 and is within the capture zone. Contamination downgradient of extraction well NS-2 will be captured by the Airport System.

- TVOC concentrations in core well 000-474, located approximately 500 feet upgradient of extraction well NS-2 have also slowly declined from a high of 76 µg/L in 2004 to 23 µg/L in 2011.
- Plume core well 000-465 was installed 100 feet upgradient of extraction well NS-1 in 2004. This well had historically shown the highest VOC concentrations (primarily carbon tetrachloride) in the North Street area. TVOC concentrations were as high as 1,796 µg/L in 2004 and have since declined to 13 µg/L in November 2011. This correlates well with the low TVOC concentrations currently observed in NS-1 (< 10 µg/L). VOC concentrations in plume core well 000-463, located approximately 200 feet north of NS-1, have shown a steady decline since 2009 as shown on **Figure 3.2.8-3.**
- Plume core well 000-154 had historically shown high VOC concentrations (primarily carbon tetrachloride). TVOC concentrations of 1,000 µg/L were observed in this well in 1997 and 1998, but have steadily declined since then to less than 5 µg/L in 2011. The trailing edge of the higher concentration segment of this plume has migrated south of this location.
- As shown on trend **Figure 3.2.8-3**, Airport monitoring wells 800-92 and 800-101, located south of the North Street extraction wells have displayed increasing VOC concentrations over the past several years. Well 800-92 reached a historical maximum TVOC concentration of 239 µg/L in the first quarter 2011 and Magothy well 800-101 detected a maximum TVOC concentration of 21 µg/L in December 2011. The leading edge of the higher concentration segment, which had migrated beyond the North Street extraction well locations prior to that system start-up, has reached this location. This deeper contamination is being captured by the Airport System Magothy treatment well RTW-4A (**Figure 3.2.8-2**).
- Historically, tritium has been detected in localized off-site areas and within the vicinity of the North Street VOC plume. The maximum historical tritium concentration in the plume was 4,263 pCi/L in 1997 in well 000-108. Tritium concentrations have not exceeded 1,000 pCi/L in any of the North Street monitoring wells since 2006. Tritium concentrations continue to be well below the DWS of 20,000 pCi/L.
- The plume continues to be bounded as indicated on **Figure 3.2.8-1** by perimeter wells. One perimeter well, 000-475, located upgradient and to the east of NS-2, detected TVOC concentrations between 4 µg/L to 10 µg/L since 2007. However, individual VOCs continue to remain below drinking water standards.

3.2.8.4 System Operations

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

Table 3.2.8-1
OU III North Street
2011 SPDES Equivalency Permit Levels

Parameters	Permit Limit (µg/L)	Max. Observed Value (µg/L)
pH (range)	5.5 – 8.5 SU	5.7 – 6.8 SU
carbon tetrachloride	5	ND
chloroform	5	ND
1,1-dichloroethane	5	ND
1,2-dichloroethane	5	ND
1,1-dichloroethylene	5	ND
tetrachloroethylene	5	ND
toluene	5	ND
1,1,1-trichloroethane	5	ND
trichloroethylene	10	ND

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

January – September 2011

Approximately 101 million gallons of water were pumped and treated during the first three quarters. The system was off periodically to allow for scheduled carbon filter change-outs and for two weeks in March and April due to cleaning and maintenance on injection wells IW-1 and IW-2. The system was off periodically during May for maintenance. As recommended in the *2010 Groundwater Status Report*, pulse-pumping of extraction well NS-1, one month on and one month off, began in May 2011 (BNL 2011c).

October – December 2011

The system operated normally with no significant downtime. Approximately 38 million gallons were pumped and treated during this quarter.

3.2.8.5 System Operational Data

The system was operational from January to December 2011, with some minor shutdowns due to electrical issues, scheduled maintenance, and GAC change-outs.

Extraction Wells

Table F-28 contains the monthly pumping data and mass removal data for the system. **Table 3.2.8-2** shows the monthly extraction well pumping rates. The average pumping rates for NS-1 and NS-2 for the year were 105 gpm and 171 gpm, respectively. **Figure 3.2.8-4** shows the plot of the TVOC concentrations from the extraction wells over time. VOC concentrations for the extraction wells are provided on **Table F-29**. TVOC values in well NS-1 have steadily dropped over the last six years, from a high of 599 µg/L in 2004 to less than 7 µg/L in 2011. Well NS-2 has remained consistently low over the last six years from 34 µg/L in 2004 to less than 8 µg/L in 2011. The NS-1 TVOC concentrations correlate to the concentrations in monitoring wells 000-463, 000-464, and 000-465, located immediately upgradient of NS-1. There was no tritium detected in the extraction wells in 2011.

System Influent and Effluent

The 2011 VOC concentrations for the North Street carbon influent and effluent are summarized on **Tables F-30** and **F-31**. The combined influent TVOC concentration declined from 260 µg/L in 2004 to 5.2 µg/L in December 2011. There was one detection of tritium (**Table F-31**) in the effluent in 2011 at an estimated concentration of 150 pCi/L.

The carbon vessels for the system effectively removed the contaminants from the influent groundwater. All 2011 effluent data for this system were below the MDL.

Cumulative Mass Removal

The mass of VOCs removed from the aquifer by the OU III North Street Pump and Treat System was calculated using the average flow rates for each monthly monitoring period, in combination with the TVOC concentration in the carbon unit's influent, to calculate the pounds removed per month. The cumulative mass of VOCs removed by the treatment system vs. time is plotted on **Figure 3.2.8-5**. During 2011, approximately 139 million gallons of groundwater were pumped and treated by the North Street system, and approximately 8 pounds of VOCs were removed. Since May 2004, the system has removed 322 pounds of VOCs. The mass removal data are summarized on **Table F-28**.

3.2.8.6 System Evaluation

Figure 3.2.8-6 compares the TVOC plume from 1997 to 2011. The following changes were observed in the plume over this period:

- The extraction wells have captured all of the plume greater than the capture goal of 50 µg/L TVOCs. As of 2011, all monitoring wells upgradient of NS-1 and NS-2 are less than 50 µg/L TVOCs.
- The downgradient portion of the plume that was south of the North Street system prior to start-up is being captured by the Airport Treatment system eastern extraction wells. Further detail on the Airport system is provided in **Section 3.2.10**.

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

1. Were unexpected levels or types of contamination detected?

No. There were no unusual or unexpected concentrations of contaminants observed in monitoring wells associated with the North Street plume in 2011.

2. Has the downgradient migration of the plume been controlled?

Yes. The plume perimeter and bypass wells show that there have been no significant increases in VOC concentrations in 2011; therefore the plume continues to be controlled. A segment of the plume passing through the Vita Drive well was beyond the capture zone of the North Street extraction well NS-1 at the time of system start-up. As described in **Section 3.2.10**, this portion of the plume is being addressed by the Airport extraction wells directly downgradient.

The hydraulic capture performance of the system is operating as modeled in the system design, and the system has been removing VOCs from the deep Upper Glacial aquifer. After seven years of operation, the system influent VOC concentrations have steadily declined. TVOCs have been below 10 µg/L in both extraction wells through 2010 and 2011. The pre-design modeling predicted that the system will need to operate until 2012. Based on current data this prediction appears to remain valid.

3. Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?

Yes. TVOC concentrations in monitoring wells upgradient of extraction well NS-1 have been less than 50 µg/L during 2010 and 2011. In addition, TVOC concentrations in NS-1 have been below 25 µg/L since 2008.

TVOC concentrations in monitoring wells upgradient of extraction well NS-2 were less than 50 µg/L for all four sampling events in 2011. The most recent detection exceeding 50 µg/L TVOCs in these wells was in well 000-472 in November 2010 at 66 µg/L. In addition, TVOC concentrations in NS-2 have been below 20 µg/L since 2007. As noted above, both extraction wells have remained less than 10 µg/L TVOCs in 2010 and 2011.

3a. Are TVOC concentrations in plume core wells above or below 50 ug/L?
Currently none of the 11 plume core wells of the North Street system are showing concentrations greater than 50 µg/L TVOC. There are TVOC concentrations above 50 µg/L downgradient of the North Street system in Airport system monitoring wells just south of Moriches Middle Island Road. These higher concentrations are being captured by the Airport system extraction wells.

3b. Is there a significant concentration rebound in core wells and/or extraction wells following shutdown?
In 2011 there was no rebound in either the core wells or extraction wells from the pulse pumping of NS-1.

4. Has the groundwater cleanup goal of meeting MCLs been achieved?
MCLs have not been achieved for individual VOCs in all North Street plume core wells. During 2011 five of 11 core wells were less than MCLs. The maximum VOC detected in the remaining six plume core wells during 2011 was 17 µg/L of carbon tetrachloride in well 000-463. Based on the data, groundwater modeling, and current system performance, MCLs are expected to be achieved in all wells by 2030.

3.2.8.7 Recommendations

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

- Since TVOC concentrations in all plume core monitoring and extraction wells have been below the capture goal of 50 µg/L for four consecutive sampling rounds in 2011, it is recommended that a Petition for Shutdown of the treatment system be submitted to the regulators for review and approval during the Fall 2012. Following regulatory approval, the system will be shut down and maintained in an operationally ready mode for two to five years.
- Prior to receiving formal approval for shutdown, the system will continue to operate. Extraction well NS-1 will continue to operate in pulse pumping mode, one month on and one month off. Extraction well NS-2 will continue to operate full time. If concentrations above the capture goal of 50 µg/L TVOCs are observed in either the core monitoring wells or the extraction well, NS-1 will be put back into full-time operation.

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3.2.9 North Street East Pump and Treat System

This section summarizes the 2011 operational and monitoring well data for the OU III North Street East (NSE) Groundwater Pump and Treat System. The system began operation in June 2004 to provide capture and control of the downgradient portion of the OU I VOC plume, which has migrated beyond the BNL site boundary.

3.2.9.1 System Description

The NSE System consists of two extraction wells. The water is pumped through two 20,000-gallon GAC units and the treated water is discharged to four injection wells located on North Street. Both the North Street and NSE systems are located in the same building. The extraction well pump for NSE-1 operates at approximately 200 gpm; extraction well pump for NSE-2 operates at 100 gpm. A complete description of the system is contained in the *Operations and Maintenance Manual for the North Street/North Street East Offsite Groundwater Treatment Systems* (BNL 2004b).

3.2.9.2 Groundwater Monitoring

The monitoring network consists of 15 wells (**Figure 1-2**). The monitoring program was designed to monitor the VOC plume off site, south of the OU I South Boundary System, as well as the efficiency of the NSE groundwater remediation system. During 2011, the wells were sampled at the shutdown monitoring frequency that began in 2009 (sampled quarterly). The wells were sampled at least annually for tritium. See **Table 1-5** for details.

3.2.9.3 Monitoring Well Results

Figure 3.2.9-1 shows the extent of the VOC plume. The plume originated from the Current Landfill and former HWMF (sources in OU I). The higher concentration segment of the plume (greater than 10 µg/L TVOCs) is just south of the LIPA right-of-way and extends to extraction well NSE-1.

Figure 3.1-2 depicts the vertical distribution of VOCs within the deep Upper Glacial aquifer. The transect line for cross section A–A' is shown on **Figure 3.1-1**. **Figure 3.1-3** gives the historical trends in VOC concentrations for key core and bypass wells along the Current Landfill/former HWMF/NSE plume. **Appendix C** contains a complete set of 2011 analytical results for the 15 NSE program wells. A summary of key monitoring well data for 2011 follows:

- All monitoring wells in the plume have remained below the treatment system capture goal of 50 µg/L TVOCs from 2005 through 2011, except for one detection in well 000-478 (58 µg/L) in 2005. Also, individual VOCs for all monitoring wells were less than MCLs in 2011.
- The maximum plume TVOC concentration observed in 2011 was 10.5 µg/L in perimeter well 000-394 in March. The primary compounds identified in the sample were TCA at 3.1 µg/L and toluene at 2.5 µg/L. This well is located approximately 1,000 feet upgradient of NSE-1. The 10.5 µg/L detection is an historical high for this well. TVOC concentrations dropped off to 1.5 µg/L in the fourth quarter 2011.
- The maximum TVOC concentration observed in 2011 in plume core well 000-477 was 9.6 µg/L in May. The primary compounds identified in the sample were TCA at 3.9 µg/L and chloroform at 1.7 µg/L. This well is located approximately 250 feet upgradient of NSE-1. The **Figure 3.1-3** trend graph indicates that this well reached an historical high in 2009 and early 2010 (up to 47 µg/L TVOCs), but then dropped by the end of 2010 through 2011 to less than 5 µg/L TVOCs.
- TVOC concentrations in several core wells (000-478, 000-479, 000-481, 000-482, 000-483, 000-484, and 000-485) continued to remain low during 2011 with values less than 5 µg/L. Plume core well 000-480 is located in the center of the plume approximately 150 feet upgradient of NSE-1. The **Figure 3.1-3** trend graph indicates that TVOC concentrations in this well began

increasing in 2008 and maintained these elevated levels through 2010. TVOC concentrations began decreasing in 2011 to 5.7 µg/L in the first quarter.

As recommended in the *2009 Groundwater Status Report*, in January and February 2011, two temporary wells (NSE-VP-02-2010 and NSE-VP-03-2010) were installed upgradient of monitoring well 000-477 and extraction well NSE-1 to determine the extent of VOC concentrations in this area (**Figure 3.2.9-1**) (BNL 2010). Maximum TVOC concentrations detected were 70 µg/L in VP-02 at 160 feet bls. The primary VOCs included TCA at 42 µg/L, DCE at 18 µg/L, and chloroform at 8 µg/L. Maximum TVOCs detected in VP-03 were 35 µg/L. TVOC concentrations in plume perimeter well 000-137, and core well 000-138 remained very low during 2011, with concentrations below 5 µg/L. Plume core well 000-124 was also less than 5 µg/L TVOC through 2011.

- Plume bypass well 000-486 has not detected TVOC concentrations above 2 µg/L since it was installed in 2004.
- In 2011, the highest tritium concentration in the plume (730 pCi/L) was detected in well 000-137 in July. There have been no detections of tritium above 1,000 pCi/L in any of the NSE wells since 2005. Historically, the maximum tritium concentration in NSE monitoring wells was 8,200 pCi/L in well 000-215 (less than half of the DWS) in 1998.

3.2.9.4 System Operations

Influent, midpoint, and effluent samples from the GAC units have been sampled every month in 2011, and the extraction wells were sampled quarterly. All NSE system samples were analyzed for VOCs and the effluent is analyzed monthly for pH. During 2011, the extraction wells and system effluent were also analyzed quarterly and monthly for tritium, respectively. **Table 3.2.9-1** provides the effluent limitations for meeting the requirements of the SPDES equivalency permit.

3.2.9.5 System Operational Data

The system was operational throughout 2011 with temporary shutdowns due to, PLC issues, carbon change outs, and scheduled maintenance. During 2011, approximately two pounds of VOCs were removed. As per the recommendations in the *2009 Groundwater Status Report*, since October 2010, extraction well NSE-2 has been placed in standby mode with NSE-1 running full-time. See the pumpage report for 2011, **Table 2-3.**

January through September 2011

The system experienced shut down time for carbon change outs and injection well maintenance. During March, the system was down for the majority of the time due to for maintenance on the injection wells. The system required repair in September for a faulty wire at the NSE-1 extraction well. The system pumped and treated approximately 60 million gallons of water.

October through December 2011

The system operated normally with only one shut down due to maintenance. Extraction well NSE-1 was repaired in the end of October. In this quarter, the system treated approximately 15 million gallons of water.

Extraction Wells

During 2011, 67 million gallons were pumped and treated by the NSE system; **Table 2-2** contains the monthly pumping data for the two extraction wells. **Table 3.2.9-2** shows the monthly extraction well pumping rates. NSE-2 has been in standby mode in 2011. **Figure 3.2.9-2** plots the TVOC concentrations in the extraction wells. VOC concentrations for NSE-1 and NSE-2 are provided on

Table F-32. Steady TVOC concentration trends are noted for both wells during 2011, with concentrations below 10 µg/L in NSE-1 and below 3 µg/L in NSE-2 during the entire year.

Table 3.2.9-1.
OU III North Street East
2011 SPDES Equivalency Permit Levels

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

Notes:
ND = Not Detected above method detection limit of 0.50 µg/L.
Required effluent sampling freq. is monthly for VOCs and pH.

System Influent and Effluent

VOC concentrations for 2011 for the carbon treatment influent and effluent are summarized on **Tables F-33** and **F-34**. Influent TVOC concentrations have been at or below 15 µg/L since 2005. In February 2011, influent TVOC concentrations reached 6 µg/L, with individual VOCs below 5 µg/L. The carbon treatment system effectively removed VOCs from the influent groundwater resulting in all 2011 NSE effluent concentrations being below the regulatory limit specified in the equivalency permit. No tritium has been detected in the system effluent above 600 pCi/L since the system began operating in 2004.

Cumulative Mass Removal

The cumulative mass of VOCs removed by the treatment system versus time is shown on **Figure 3.2.9-3** and the supporting data is presented on **Table F-35**. During 2011, two pounds of VOCs were removed, with a cumulative total of 38 pounds of VOCs removed since system start-up in April 2004.

3.2.9.6 System Evaluation

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

The North Street East Pump and Treat System performance can be evaluated based on the major decisions identified for this system from the groundwater DQO process.

1. Were unexpected levels or types of contamination detected?

There were no unusual or unexpected concentrations of contaminants observed in monitoring or extraction wells associated with the NSE System in 2011. However, one of the two temporary wells (NSE-VP-02-2010) installed in the plume in January 2011 did detect higher concentrations of VOCs than expected, up to 70 µg/L TVOCs.

2. Has the downgradient migration of the plume been controlled?

Yes. The system has been in operation for seven years, and an analysis of the plume perimeter and bypass wells shows that there have been no significant increases in VOC concentrations in 2011, indicating that the plume has not grown and is controlled. TVOC concentrations in the monitoring wells between extraction wells NSE-1 and NSE-2 have been below 5 µg/L since 2007.

3. Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?

Even though the shutdown criteria of reaching less than 50 µg/L TVOCs for at least four consecutive sampling rounds has been met in the core monitoring and extraction wells, temporary well VP-02 detected TVOCs up to 70 µg/L upgradient of NSE-1. To further characterize the contamination in this area, an additional temporary well will be installed upgradient of VP-02. A monitoring well will also be installed at the location of VP-02 to monitor the higher VOC concentrations. As a result, extraction well NSE-1 cannot be shut down at this time.

As noted in **Section 3.2.9.3** above, monitoring well 000-477 has shown a declining trend in 2011. Since the core monitoring wells downgradient of NSE-1 have been below 5 µg/L since 2007, extraction well NSE-2 can remain shutdown and in standby mode.

3a. Are TVOC concentrations in plume core wells above or below 50 ug/L?
All core wells are below 50 µg/L TVOCs; however, temporary well VP-02 detected up to 70 µg/L. The new monitoring well will be installed at the location of VP-02 to monitor the higher VOC concentrations.

3b. Is there a significant concentration rebound in core wells and/or extraction wells following shutdown?
The system has not been shutdown, although it was in pulse pumping mode (one month on and one month off) from October 2006 through June 2009. During that time, there does not appear to be significant rebounding. Significant rebounding of the monitoring or extraction wells was not evident as a result of the shutdown of NSE-2 in 2011.

4. Has the groundwater cleanup goal of meeting MCLs been achieved?

MCLs have been achieved for individual VOCs in all 11 plume core wells in the four sampling rounds in 2011. However, temporary wells VP-02-2010 and VP-03-2010 installed in January and February 2011 detected up to 70 µg/L and 35 µg/L TVOCs, respectively. MCLs are expected to be achieved by 2030.

3.2.9.7 Recommendations

The following recommendations are made for the North Street East Pump and Treat System and groundwater monitoring program:

- Install an additional temporary well upgradient of NSE-VP-02-2010 in June 2012. Also in June 2012, install a new core monitoring well at the location of NSE-VP-02-2010.
- Extraction well NSE-1 will remain in full time operation due to elevated VOCs in upgradient temporary well NSE-VP-02-2010. The new monitoring well at this location will be used to evaluate when the treatment system can be shut down.
- Maintain extraction well NSE-2 in stand-by mode. If TVOC concentrations above the capture goal of 50 µg/L are observed in either the core monitoring wells or the extraction well, NSE-2 will be put back into full-time operation.
- Continue the shutdown monitoring frequency (sampled quarterly) for the NSE monitoring wells through 2012.

3.2.10 LIPA/Airport Pump and Treat System

This section summarizes the 2011 operational and monitoring well data for the OU III LIPA/Airport Groundwater Treatment System, and presents conclusions and recommendations for its future operation. The LIPA system was designed to provide capture and control of the downgradient portion of the plume of VOCs in the Upper Glacial aquifer that had migrated past the Industrial Park System before that system became operational in 1999. The Airport Treatment System was designed to capture the leading edge of the OU III and OU I/IV VOC plumes and to prevent further migration of the plumes, which have migrated past the LIPA extraction wells and the North Street extraction wells.

3.2.10.1 System Description

The three components of the LIPA/Airport Treatment System are as follows:

1. The Magothy extraction well (EW-4L) on Stratler Drive (**Figure 3.2.10-1**) addresses high-level VOCs identified in the Magothy aquifer immediately upgradient of this well on Carleton Drive. The capture goal for this well is 50 µg/L TVOCs.
2. The three LIPA extraction wells (EW-1L, EW-2L, and EW-3L) were installed to address high concentrations of VOCs in the Upper Glacial aquifer that had migrated past the Industrial Park System before that system became operational in 1999. The capture goal for these extraction wells is 50 µg/L TVOC.
3. Six extraction wells in the Airport System were installed to address the leading edge of the plumes and to prevent further migration of the plumes, which have migrated past the LIPA extraction wells and the North Street extraction wells. The sixth well (RW-6A) was added in 2007 to address concentrations of VOCs observed to the west of extraction well RTW-1A. The Airport system wells have a capture goal of 10 µg/L TVOC.

The water from the four LIPA wells is pumped to the treatment plant, about one mile south on Brookhaven [Town] Airport property, where it is combined with the water from the six airport extraction wells (RTW-1A through RW-6A) and treated via granular activated carbon. The treated water is released back to the ground via a series of shallow reinjection wells located on Brookhaven Airport and Dowling College property.

A more detailed description of this system is contained in the *Operations and Maintenance Manual for the LIPA/Airport Groundwater Treatment System* (BNL 2008a).

3.2.10.2 Groundwater Monitoring

Well Network

The monitoring network consists of 53 wells. There are 18 wells associated with the LIPA Upper Glacial portion of the plume that were installed to monitor the VOC plume off site, south of the OU III Industrial Park System. The Airport System network has 29 monitoring wells, which monitor the portions of the plume south of the LIPA and the North Street systems. The Magothy extraction well on Stratler Drive has six monitoring wells associated with its operation. All of these wells are used to monitor and evaluate the effectiveness and progress of the cleanup associated with these three components of the system. **Figure 1-2** and **3.2.10-1** identify the monitoring wells for these plumes.

Sampling Frequency and Analysis

The monitoring wells for LIPA are currently on a quarterly and semiannual sampling schedule for VOCs. The Airport wells are sampled quarterly for VOCs (**Table 1-5**).

3.2.10.3 Monitoring Well Results

The primary VOCs associated with these portions of the plume are carbon tetrachloride, TCA, TCE, and 1,1-dichloroethylene. Groundwater monitoring for these systems was initiated in 2004. Fourth-quarter 2011 well data are posted on **Figures 3.2-1, 3.2.10-1** and **3.2.10-2**. The complete analytical results are in **Appendix C.** Results for key monitoring wells and extraction wells are as follows:

- During 2011 TVOC concentrations for the Magothy extraction well EW-4L on Stratler Drive. ranged from 19-22 μg/L.
- Carbon tetrachloride is the primary VOC detected in this well. The Magothy monitoring wells associated with this portion of the plume show concentrations below 50 μg/L TVOC **Figure 3.2.10-3** plots the TVOC influent trends for the LIPA extraction wells.
- Two of the three Upper Glacial LIPA extraction wells, EW-1L and EW-3L, were shut down in October 2007. Well EW-2 was shutdown in 2010 based on recommendation in the 2009 Annual Groundwater Status Report. All three of the wells remained below 14 μg/L in 2011. This is consistent with monitoring well data associated with the LIPA system. (**Figure 3.2.10-6**)
- VOC concentrations in monitoring wells near the Airport System extraction wells are below AWQS on the western portion of this system, except for well 800-96 and 800-94. **Figure 3.2.10-4** plots the TVOC influent trends for the Airport extraction wells. Upgradient monitoring wells 800-94 and 800-95, approximately 1,500 feet north of wells RTW-1A, RTW-2A, and RTW-6A have historically shown TVOC concentrations of carbon tetrachloride ranging up to 100 μg/L. The TVOC concentrations in these wells have been showing a declining trend recently with well 800-94 ranging from 18 μg/L to ND and well 800-95 ranging from 35μg/L to 2 μg/L in 2011.
- Five of the six airport extraction wells had VOC concentrations below the capture goal of 10 μg/L throughout 2011. Extraction well RW-6A showed TVOC concentrations of 10 μg/L to 12 μg/L in 2011 and carbon tetrachloride exceeded AWQS of 5 μg/L
- Well 800-96 was installed as a western perimeter monitoring well for extraction well RTW-1A. Sampling of this well began in March 2004. No detections of carbon tetrachloride were found in this well until December 2005, when it was detected at 1.6 μg/L August 2006 the concentration increased to over 100 μg/L. During 2007 a new extraction well RW-6A and five new monitoring wells (800-126, 800-127, 800-128, 800-129, and 800-130) were installed to monitor and capture the contaminants in the vicinity of well 800-96 (**Figure 3.2.10-1**). Well 800-96 detected carbon tetrachloride concentrations ranging from 19 μg/L to 41 μg/L in 2011 (**Figure 3.2.10-6**). None of the monitoring wells installed downgradient of this area have shown carbon tetrachloride above AWQS.
- Well 800-92, located upgradient of extraction wells RTW-3A and RTW-4A **(Figure 3.2.10-1),** has shown an increasing trend of TVOCs for the past several years **(Figure 3.2.10-7)**. In 2011, the TVOC concentration ranged from 239 μg/L to 88μg/L. This is a slug of contamination that was south of the North Street extraction wells prior to the system start-up. These contaminants will be captured by the Airport extraction wells.
- Well 800-101 located directly upgradient of extraction well RTW-4A has shown an increasing TVOC concentration trend over the past several years. The concentrations ranged from 14 μg/L to 21 μg/L in 2011. This is above the capture goal of 10 μg/L for the Airport extraction wells.

3.2.10.4 System Operations

In 2011, the Airport extraction wells were sampled once per month and the LIPA extraction wells quarterly. The influent, midpoint, and effluent of the carbon units were sampled two times per month. All system samples were analyzed for VOCs. The Airport extraction wells are on a pulse-pumping schedule, being pumped one week per month, except for wells RTW-1A and RW-6A which are pumped on a full-time basis. RW-6A began full-time operations in September 2008 and RTW-4A which began full time operations in June 2011.

The following is a summary of the OU III Airport/LIPA Treatment System operations for 2011.

January – September 2011

The Airport/LIPA System was operational in the first three quarters with RTW-1A, RW-6A and RW-4L operating on a full-time basis. RTW-4A starting full time operations in June 2011. The remainder of the extraction wells at the Airport System were run one week per month on a pulse pumping schedule. In the first quarter the system was off for several days for maintenance work and a carbon change out. In March the pump was replaced at RTW-4A. The second quarter had several weeks of down time for EW-4L repair work and scheduled carbon change outs. The third quarter had one week of system down time due to communications problems in July which impacted the RTW-4A well.

October – December 2011

The Airport/LIPA system operated normally for the last quarter of 2011 with minimal down time due to scheduled maintenance and one carbon change-out.

Extraction Wells Operational Data

During 2011, approximately 245 million gallons were pumped and treated by the OU III Airport/LIPA System, with an average flow rate of 471 gpm (**Table 3.2.10-2). Table F-36** summarizes the system's mass removal. VOC concentrations for the airport and LIPA extractions wells are provided on **Table F-37.**

3.2.10.5 System Operational Data

System Influent and Effluent

VOC concentrations for the carbon influent and effluent in 2011 are summarized on **Tables F-38** and **F-39** respectively**.**

The carbon vessels for the system effectively removed the contaminants from the influent groundwater. 2011 system effluent data were below the regulatory limit specified in the SPDES equivalency permit, except for one pH reading that exceeded the upper limit by 0.2 SU in June. A completed NYSDEC *Report of Non-Compliance Event* form was submitted to the State **(Table 3.2.10-1).**

Cumulative Mass Removal

The mass of VOCs removed from the aquifer by the OU III Airport/LIPA Treatment System was calculated using the average flow rates for each monitoring period (**Table F-36**) in

Table 3.2.10-1
OU III LIPA/Airport Pump & Treat System
2011 SPDES Equivalency Permit Levels

Parameters	Permit Level (µg/L)	Max. Measured Value (µg/L)
pH	5.5–7.5 SU	5.6-7.7 SU
carbon tetrachloride	5	ND
chloroform	7	ND
1,1-dichloroethane	5	ND
1,1-dichloroethylene	5	ND
methylene chloride	5	ND
1,1,1-trichloroethane	5	ND
trichloroethylene	10	ND

Notes:
ND = Not detected above method detection limit of 0.50 µg/L.
Sampling required an a monthly basis

combination with the TVOC concentration in the carbon unit's influent, to calculate the pounds per month removed. The plot of cumulative mass of VOCs removed vs. time (**Figure 3.2.10-5**) shows that 17 pounds of VOCs were removed during 2011, with a total of 323 pounds removed since system start-up.

3.2.10.6 System Evaluation

The Airport Treatment System was designed to capture the leading edge of the OU III and OUI/IV VOC plumes. The extraction well (RW-6A) has shown carbon tetrachloride above AWQS since it was installed and began operations in November 2007. Some higher concentrations of VOCs have been detected upgradient of these wells. VOC concentrations in the LIPA wells are consistent with the groundwater modeling performed for the design of this system. **Table 3.2.10-1** shows maximum measured values and the values allowed under the SPDES equivalency permit.

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

1. Were unexpected levels or types of contamination detected?
No, there were no unusual or unexpected VOC concentrations observed in the monitoring wells of the LIPA/Airport Treatment System during 2011.

2. Has the downgradient migration of the plume been controlled?
Yes, based on the historical analytical data collected from the monitoring wells and the results of the *LIPA/Airport Pump Test Report* (Holzmacher 2004), the plumes are being controlled. The capture zones clearly show that the capture goal of 50 µg/L TVOC at the LIPA Upper Glacial and Magothy wells is being met (**Figure 3.0-1**). No TVOC concentrations above 10 µg/L have been detected in the bypass monitoring wells at the Airport. Based upon the data the plume migration is being controlled.

3. Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation
Yes, currently three LIPA wells are shutdown as they have reached their cleanup goals. Four of the six Airport extraction wells are being pulsed pumped.

4. Are TVOC concentrations in plume core wells above or below 50 ug/L for LIPA and 10 ug/L for the Airport ?
TVOC concentrations are below 50 µg/L for the LIPA project although it is expected that higher concentrations remain upgradient of well EW-4L and as a result this well will continue operations. Several Airport core wells are above 10 µg/L. In particular well 800-101 is now above 10 µg/L (21.3 µg/L in December 2011). This indicates the need to continue full time operation of Airport well RTW-4A.

4a. Is there a significant concentration rebound in core wells and/or extraction wells following shutdown?
No rebound has been observed at the LIPA wells since they were shutdown.

5. Has the groundwater cleanup goal of meeting MCLs been achieved?
No, the cleanup goal has not been met. Based on model results, MCLs are expected to be achieved by 2030 for the Upper Glacial aquifer, and in the Magothy aquifer by 2065, as required by the OU III ROD and ESD.

3.2.10.7 Recommendations

The following recommendations are made for the LIPA/Airport Pump and Treat System and groundwater monitoring program:

- Continue the airport extraction wells pulse-pumping schedule of pumping one week per month except for wells RTW-1A, RTW-4A and RW-6A, which will continue with full-time operations. If concentrations above the capture goal of 10 µg/L TVOCs are observed in any of the extraction wells or the monitoring wells adjacent to them, the well(s) will be put back into full-time operation.
- Based on the 21 µg/L TVOC concentration observed in monitoring well 800-101 in December 2011, RTW-4A will continue in full time operation in 2012.
- Maintain LIPA wells EW-1L, EW-2L and EW-3L in standby mode. These extraction wells will be restarted if TVOC concentrations rebound above the 50 µg/L capture goal in either the plume core monitoring wells or the extraction wells.
- A new monitoring well should be installed adjacent to well 800-59 that is screened about 40 feet deeper than this well. This will be used to monitor higher concentrations of VOCs identified in upgradient well 800-92.

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3.2.11 Magothy Aquifer

This section provides a brief summary of the Magothy Aquifer Groundwater Monitoring Program and the remedial approach for addressing VOC contamination. The 42 monitoring wells used to monitor the Magothy are shown on **Figure 3.2.11-1**.

Detailed descriptions of the monitoring well analytical results and remediation progress are presented in the following sections of this report: Western South Boundary, Middle Road, LIPA/Airport, North Street, North Street East, OU III South Boundary, Industrial Park and Industrial Park East. A brief summary of the results is provided on **Table 3.2.11-1**.

Table 3.2.11-1. Magothy Aquifer Contamination (Historical and 2011).

Location	Max. TVOC (in µg/L) 2011	Max. TVOC (in µg/L) Historical	Primary VOCs	Results
Western South Boundary on site	<5.0	<5.0	None	Magothy not impacted. Two monitoring wells serve as adequate outpost/sentinel wells for Suffolk County Water Authority William Floyd Well Field.
Middle Road and South Boundary on site	67	340	PCE, CCl_4	VOCs identified in upper 20 to 40 feet of Magothy at Middle Road area where brown clay is absent. VOCs not detected at South Boundary beneath the clay. Well 113-09 had 65 µg/L TVOC in November 2011, and well 113-19 had 67 µg/L in July 2011.
North Street off site	39	102	TCE	VOCs have been detected in localized areas in the upper 30 feet of the Magothy aquifer along North Street and downgradient near Vita Drive. Leading edge of contamination is at the eastern portion of the Airport system, with 21 µg/L TVOC in well 800-101, which is adjacent to Airport extraction well RTW-4A.
North Street East off site	13	30	1,1-DCA; 1,1-DCE	Low VOC concentrations have been detected at the BNL south boundary to North Street below the brown clay, at approximately 40 to 150 feet into the upper Magothy. 13 µg/L TVOC were detected in well 000-343 in August 2011. A new monitoring well was installed on the corner of Boxwood and Stratler Drives (MW-MAG):
Industrial Park East off site and south boundary	17	570	TCA, CCl_4	TVOC concentrations were less than 20 µg/L at the south boundary and off site in the Industrial Park, where brown clay is absent. Magothy and Upper Glacial contamination is contiguous in the Industrial Park. TVOC concentration of 17 µg/L was detected in well 122-05 in April 2011. This is the highest TVOC concentration identified in this area.
South of Carleton Drive off site	10	7,200	CCl_4	Historically high VOC concentrations just south of Carleton Drive where brown clay is absent. Contamination is contiguous between Magothy and Upper Glacial aquifer. Well 000-130 showed a TVOC concentration of 10 µg/L in February 2011.

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

1. Continued operation of the five extraction wells until cleanup objectives are met as part of the Upper Glacial treatment systems that provide capture of Magothy VOC contamination (Middle

Road, South Boundary [Magothy well currently in standby], Airport, Industrial Park East [currently in standby], and LIPA).

2. Continued evaluation of monitoring well data to ensure protectiveness. **Table 3.2.11-2** describes how each of the Magothy investigation areas is addressed by the DOE's selected Magothy aquifer remedy.

3. Institutional controls and five-year reviews.

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

Table 3.2.11-2. Magothy Remedy.

Area Investigated	Selected Remedy
Western South Boundary on-site area	Continue monitoring and evaluate data.
Middle Road and South Boundary on-site area	Continue operation of the Magothy extraction well at Middle Road, as well as the two Upper Glacial systems. Continue to monitor the three Magothy monitoring wells at Middle Road and three at the south boundary until cleanup goals are met.
North Street off-site area	Continue operation of the two existing Upper Glacial extraction wells on Sleepy Hollow Drive and North Street to prevent migration into the Magothy until cleanup objectives are met. The Airport extraction wells will capture contaminants that where past the extraction wells prior to system operation. Continue monitoring and evaluate data.
North Street East off-site area	Continue monitoring and evaluate data.
Industrial Park East off-site area and s. boundary	Continue operation of the Industrial Park East Magothy extraction well until cleanup objectives are achieved (this well is currently in standby as cleanup goals have been met). Continue monitoring and evaluate data.
South of Carlton Drive off-site area	Continue operation of the LIPA Magothy extraction well on Stratler Drive until cleanup goals are achieved. This will capture high concentrations of VOCs identified on Carleton Drive and prevent migration of high concentrations of VOCs through the hole in the brown clay and into the Magothy aquifer. Continue monitoring and data evaluation.

3.2.11.1 Monitoring Well Results

There are 42 wells in the Magothy monitoring program (**Figure 3.2.11-1**). **Figure 3.2.11-2** shows trend plots of several of the key monitoring wells. A discussion of some of the key wells follows.

Well 000-130: This well is on Carleton Drive and has historically had the highest concentrations of carbon tetrachloride observed off site related to BNL (over 7,000 µg/L). TVOC concentrations ranged from 4 µg/L to 10 µg/L in 2011. The higher concentrations of carbon tetrachloride observed historically in this well are being captured by the LIPA extraction well on Stratler Drive. A more detailed discussion is available in **Section 3.2.10**, LIPA/Airport Pump and Treat System.

Wells 000-249 and 000-250: These wells are in the Industrial Park near well UVB-1. Well 000-249 had TVOC concentrations ranging from 16 µg/L to 22 µg/L in 2011. Well 000-250 had VOC concentrations below AWQS in 2011. Any contaminants above the capture goal of 50 µg/L TVOC that migrate beyond the capture zone of this system, will be captured by the Stratler Drive extraction well.

Wells 000-425 and 000-460: These wells are adjacent to the LIPA Stratler Drive Magothy extraction well. Well 000-425 had TVOC concentrations ranging from 3 µg/L to 7 µg/L during 2011. Well 000-460, located east of the extraction well but within the capture zone, had TVOC concentrations ranging from 1 to 6µg/L in 2011.

Well 122-05: This well, located at the eastern edge of the OU III South Boundary System, showed TVOC concentrations up to 17 µg/L in 2011.

Well 113-09: This well is located at Middle Road, west of extraction well RW-1. It is screened near the Upper Glacial/Magothy interface. During 2011, TVOC concentrations of 65 µg/L were detected. Concentrations have been stable for the past few years in this well.

Well 000-343: Located south of the site boundary and between the OU III North Street and OU III North Street East systems, this well had TVOC concentrations up to 13µg/L in 2011.

Well 115-50: Located at the site boundary and between the OU I and OU III South Boundary systems, this well had VOC concentrations below AWQS in 2011.

Wells 000-427 and 000-429: These wells are located just south of the Industrial Park East System on Carleton Drive. In 2011, well 000-427 had TVOC concentrations up to 8 µg/L and well 000-429 had concentrations ranging from 14 µg/L to 40 µg/L in 2011, with carbon tetrachloride being the primary VOC detected.

Well 800-90: This well is located near Moriches-Middle Island Road upgradient of Airport extraction wells RTW-3 and RTW-4. It is screened at approximately 255 feet below grade. TVOC concentrations ranged from 23 µg/L to 38 µg/L in 2011. This is indicative of contamination that was already past the North Street extraction wells prior to operation, and will eventually be captured by the Airport extraction wells RTW-3A and RTW-4A. This contamination is also being observed in downgradient wells 800-99 and 800-101. The increasing VOC concentration in 800-101 has initiated the full time operation of the Airport extraction well RTW-4A in June 2011 (**Section 3.2.10**).

Well MW-MAG - This is a new monitoring well installed to provide downgradient monitoring for the leading edge of the Industrial Park East Magothy plume. The initial sample from this well showed all VOC concentrations below AWQS.

3.2.11.2 Recommendations

The following are recommendations for the Magothy groundwater monitoring program:

- Continue the current monitoring schedule for the Magothy monitoring program.
- Continue pumping the Magothy extraction wells at Western South Boundary, Middle Road, LIPA/Airport, North Street, North Street East, and Industrial Park. The IPE and South Boundary Magothy extraction wells are currently in standby as they have reached the cleanup goals (TVOC <50 µg/L) identified for shutdown of these wells.

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3.2.12 Central Monitoring

The OU III Remedial Investigation (RI) identified several low-level (less than 50 µg/L TVOC) source areas and nonpoint contaminant sources within the developed central areas of the BNL site. Because the sources are not large enough to warrant a dedicated monitoring program, they are monitored under the OU III Central Monitoring Program. In addition, this program includes wells 109-03 and 109-04, located near the BNL western site boundary. These wells were installed by the SCDHS to serve as sentinel wells for the SCWA William Floyd Parkway Well Field.

3.2.12.1 Groundwater Monitoring

Well Network

The monitoring well network is comprised of 12 wells (**Figure 3.2.12-1**). The well locations aid in defining the potential VOC plumes that extend downgradient from the central areas of the site. This network is also supplemented by data from Facility Monitoring program wells that monitor active research and support facilities (**Table 1-6**). Results from the Environmental Surveillance (ES) programs are provided in **Section 4**.

Sampling Frequency and Analysis

The wells are sampled and analyzed annually for VOCs, and wells 109-03 and 109-04 are analyzed quarterly for VOCs, gamma spectroscopy, tritium, and Sr-90 (**Table 1-5**).

3.2.12.2 Monitoring Well Results

Only two VOCs were detected in the OU III Central wells above AWQS. Well 065-02 had a TCA concentration of 8.9 µg/L and Well 076-317 had a PCE concentration of 6.8 µg/L, which are both above the AWQS of 5 µg/L for each compound. In many of the wells in the north-central developed portion of the site, the primary constituent is TCA. SCDHS wells 109-03 and 109-04 had no detections of VOCs above the AWQS during 2011. Radionuclides were not detected in any of the samples collected from wells 109-03 and 109-04 during 2011. VOC detections in well 065-05 have remained below the AWQS since October 2001 and well 084-05 has never had a VOC detection above the AWQS.

3.2.12.3 Groundwater Monitoring Program Evaluation

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

1. Is the contamination naturally attenuating as expected?

Yes, the contaminant plume is attenuating as expected. There are no significant source areas releasing VOCs to the groundwater in the central area of the site.

2. Has the groundwater cleanup goal of meeting MCLs been achieved?

No. Since 1997, the VOC concentrations in the central portion of the site have significantly decreased, as noted in TVOC plume comparison **Figure 3.2-3**. During 2011 two monitoring wells continued to contain VOC concentrations exceeding the AWQS; therefore, the OU III ROD objective of meeting MCLs by 2030 has not yet been met.

3.2.12.4 Recommendation

The following changes are recommended for the OU III Central Groundwater Monitoring Program:

- Sampling should be discontinued in wells 065-05 and 084-05 since VOC detections have been below AWQS for more than 10 years. The wells will remain in the water level program.

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3.2.13 Off-Site Monitoring

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

3.2.13.1 Groundwater Monitoring

Well Network

The network has 12 wells that monitor the off-site southwest downgradient extent of OU III (**Figure 1-2** and **3.2.13-1**). Some wells downgradient of the leading edge of the plumes serve as sentinel wells. These wells are screened in the deep portions of the Upper Glacial aquifer.

Sampling Frequency and Analysis

The wells are sampled annually and samples analyzed for VOCs (**Table 1-5**). Samples were collected in the fourth quarter of 2011.

3.2.13.2 Monitoring Well Results

The complete results for the monitoring wells in this program can be found in **Appendix C**. The horizontal extent of the off-site segment of the OU III VOCs is shown on **Figure 3.2-1**.

The monitoring wells in the OU III Off-Site Monitoring Program are perimeter and sentinel wells. In 2011, only well 800-52 had a VOC with a reported concentration above the AWQS. The concentration of TCA detected at well 800-52 was 5.4 µg/L, which is above the AWQS of 5 µg/L.

3.2.13.3 Groundwater Monitoring Program Evaluation

The evaluation of the OU III Off-Site Monitoring Program is based on these major decision rules established for this program using the groundwater DQO process.

1. Were unexpected levels or types of contamination detected?

No. Concentrations of contaminants detected were within historic levels and no unexpected contaminants were reported.

2. Is the contamination naturally attenuating as expected?

Yes, the low level VOCs are attenuating as expected. The observed VOC concentrations are less than the AWQS.

3. Has the groundwater cleanup goal of meeting MCLs been achieved?

No. One well, 800-52, had one VOC detection (TCA) above the AWQS.

3.2.13.4 Recommendation

No changes to the OU III Off-Site Groundwater Monitoring Program are warranted at this time.

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3.2.14 South Boundary Radionuclide Monitoring Program

The South Boundary Radionuclide Monitoring Program was initiated to confirm that radionuclides are not migrating south of the BNL site. The sampling was conducted in conjunction with the OU III South Boundary, Western South Boundary, and OU VI Programs. The eastern portions of the site south boundary is monitored for radionuclides as part of the OU V STP groundwater monitoring programs (**Section 3.4**). The OU I portion of the south boundary is discussed in **Section 3.1**.

3.2.14.1 Groundwater Monitoring

A network of 48 monitoring wells is used to monitor radionuclides from the OU III South Boundary, OU III Western South Boundary, and OU VI programs. The well locations along the southern property boundary are shown on **Figure 3.2.14-1**.

Sampling Frequency and Analysis

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

3.2.14.2 Monitoring Well Results

The radionuclide analytical results for the wells can be found in **Appendix C**. Only one monitoring well had a confirmed detection of a radionuclide during 2011. Well 121-13 had a detection of tritium at 430 pCi/L. The tritium DWS is 20,000 pCi/L. This is only approximately 2% of the groundwater standard and poses no health risk.

3.2.14.3 Groundwater Monitoring Program Evaluation

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

1. Were unexpected levels or types of contaminants detected?

No. There were no unexpected detections of contaminants in the South Boundary Radionuclide Groundwater Monitoring Program during 2011.

3.2.14.4 Recommendations

There are no recommended changes to the South Boundary Radionuclide Groundwater Monitoring Program.

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3.2.15 BGRR/WCF Strontium-90 Treatment System

The OU III Brookhaven Graphite Research Reactor (BGRR)/Waste Concentration Facility (WCF) Treatment System addresses the Sr-90 plumes in groundwater downgradient of these facilities. Some of the wells included in the OU III BGRR/WCF network are also monitored for tritium associated with the HFBR and g-2 plumes (**Sections 3.2.17** and **4.11**). These wells are sampled concurrently for these programs to avoid duplication of effort. The BGRR/WCF remedy consists of:

1. Operation of nine extraction wells using ion exchange to remove Sr-90, with on-site discharge of the clean water to dry wells,
2. Operation of the system to minimize plume growth and meet DWS by 2070,
3. Continued monitoring and evaluation of data to ensure protectiveness, and
4. Institutional controls and five-year reviews

The analytical results indicate three areas of elevated Sr-90: one extending south from the WCF area, one extending south of the BGRR Below Ground Ducts (BGD) and former Canal House, and one that is south of the former Pile Fan Sump (PFS) (**Figure 3.2.15-1**).

3.2.15.1 System Description

Operations for this treatment system began in January 2005. There are two extraction wells (SR-1 and SR-2) located south of the WCF, and three extraction wells (SR-3, SR-4, and SR-5) located south of the BGRR. As per the 2010 report recommendations, SR-4 and SR-5 are in a pulse pumping mode. Four extraction wells (SR-6, SR-7, SR-8, and SR-9) were installed in 2010 to address the higher Sr-90 concentrations located in the downgradient portion of the WCF plume (south and west of the HFBR) and began operation in 2011.

Groundwater from the extraction wells is transported to an ion exchange treatment system inside Building 855 (within the BNL Waste Management Facility). The vessels of ion exchange media are designed to treat groundwater contaminated with Sr-90 to below the 8 pCi/L DWS. In addition, the influent is also treated for low-level concentrations (less than 10 µg/L) of VOCs using liquid-phase activated carbon.

Effluent is recharged to the Upper Glacial aquifer via three drywells located approximately 850 feet west of Building 855. A SPDES equivalency permit regulates this discharge. A complete description of the system is included in the *Operations and Maintenance Manual for the Sr-90 BGRR/WCF/PFS Groundwater Treatment System* (BNL 2012b).

3.2.15.2 Groundwater Monitoring

Well Network

A network of 91 monitoring wells is used to monitor the Sr-90 plumes associated with the BGRR, WCF, and PFS areas. Five new monitoring wells were installed to monitoring upgradient and downgradient of the BGRR engineered cap, which was installed in 2011.

Sampling Frequency and Analysis

In 2011, the sampling frequency for all three of the Sr-90 plume segments, (BGRR, PFS and WCF) is in the O&M phase (annual) for most wells. The well samples are analyzed for Sr-90. As noted in **Table 1-5,** wells also serve dual purposes for other programs. Monitoring well results are tabulated in **Appendix C**. The results of temporary wells are provided on **Table 3.2.15-1**.

3.2.15.3 Monitoring Well/Temporary Well Results

The Sr-90 plume distribution map is shown on **Figure 3.2.15-1**. The distribution of Sr-90 throughout the BGRR, WCF, and PFS areas is depicted based on groundwater data obtained from the fourth-quarter 2011 and first-quarter 2012 sampling of the permanent and temporary wells. The following cross-sectional views are also provided:

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

In addition, historical Sr-90 concentration trends for key wells are plotted on **Figure 3.2.15-5**.

Historically, the highest overall Sr-90 concentration (3,150 pCi/L) occurred in 2003 in a temporary well installed approximately 185 feet south of Building 701, and slightly upgradient of the current location of extraction well SR-3. The highest historical Sr-90 concentration in the WCF area (1,560 pCi/L) occurred in 2003 in a temporary well installed immediately downgradient of the six former underground storage tanks (USTs A/B) and approximately 25 feet north of the WCF (Building 811). This area within the WCF is upgradient of the current location of extraction well SR-1. The highest historical Sr-90 concentration in the former PFS area (566 pCi/L) occurred in 1997 in a temporary well installed downgradient of the PFS.

The following is a summary of the 2011 monitoring data for the three Sr-90 plumes.

WCF Plume

Refer to **Figure 3.2.15-4** for a cross-sectional view of the WCF plume.

- In 2011, the highest Sr-90 concentration in the downgradient segment of this plume was 177 pCi/L in well 065-175, located approximately 120 feet northwest of extraction well SR-6 (see **Figure 3.2.15-1**).
- Sr-90 concentrations in the WCF source area continue to trend downward as can be seen in the data for well 065-175 (**Figure 3.2.15-5**). In addition, extraction wells SR-1 and SR-2 have also been showing a slow decline in Sr-90 concentrations (**Figure 3.2.15-9**).

BGRR Plume

Refer to **Figure 3.2.15-2** for a cross-sectional view of the BGRR plume.

- The Sr-90 concentration in source area well 075-664 significantly decreased to 25 pCi/L in October 2011 following a sharp spike in concentration up to 491 pCi/L in the October 2010 sample (see **Figure 3.2.15-5**). The high Sr-90 concentrations in this area are captured by extraction well SR-3. An engineered cap was installed during 2011 which extends out from Building 701 to cover previously identified areas of underground soil contamination including the BGDs and former Canal House. An analysis of the monthly Sr-90 sampling data from extraction well SR-3 (which is located approximately 185 feet downgradient of Building 701 and 120 feet downgradient of the BGDs) shows that there have been occasional increases in concentration dating back to the start-up of this well in 2005. It is suspected that these concentration increases may be related to periodic water table increases that liberate Sr-90 from the deep vadose zone. A trend of both Sr-90 concentrations from SR-3 and water table elevations from this area is provided in **Figure 3.2.15-6.** These trends were compared to see whether a correlation could be identified between significant water table elevation increases and Sr-90 increases in SR-3. The travel time of the nearest potential source to SR-3 (the BGD area) is approximately 3-4 years. While a few more years of monitoring data are needed to establish a positive correlation, it does appear that the significant water table elevation increases are followed by spikes in Sr-90 concentration that would fit within the 3-6 year travel time frame from the source to SR-3.

- Sr-90 concentrations in newly installed BGRR cap monitoring wells (065-401, 065-402, 075-699, 05-700, and 075-701) remained significantly below the DWS of 8 pCi/L, with the exception of well 075-700. Concentration in well 075-700 increased from 5 pCi/L to 27 pCi/L during 2011. This well is located approximately200 feet south of the former BGRR canal house.
- Sr-90 concentrations in monitoring wells 075-670 and 075-671, located in the downgradient area of this plume at Brookhaven Avenue, have continued to decline since a peak concentration of 82 pCi/L was observed in well 075-671 in 2009. The maximum concentration in this well in 2011 was 19 pCi/L (**Figure 3.2.15-5**).

Pile Fan Sump Plume

Refer to **Figure 3.2.15-3** for a cross-sectional view of the Pile-Fan Sump plume.

- Well 075-683 is located just north of Temple Place and is the southernmost monitoring point for the PFS plume. Sr-90 concentrations in this well decreased to 43 pCi/L in 2011 after having increased over several years to 90 pCi/L in 2010.
- Plume core well 065-37, located just downgradient of the PFS, detected 73 pCi/L of Sr-90 in October 2007. This was the highest concentration observed since the well was installed in 1997. Sr-90 concentrations in this well have shown a declining trend since that time-frame, with 19 pCi/L reported in 2011 (**Figure 3.2.15-5**).

3.2.15.4 System Operations

In accordance with the SPDES equivalency permit, the required frequency for Sr-90 and VOC sampling is monthly and the pH measurement is weekly. However, throughout 2011 while the system was operating, samples from the influent, effluent, and midpoint locations of the treatment system were collected twice a month in order to optimize clinoptilolite usage. All system samples were analyzed for Sr-90 and VOCs. The influent was also analyzed for tritium, and both the influent and effluent were analyzed weekly for pH. Sr-90 concentrations for the extraction wells in 2011 are summarized on **Table F-40**. System influent and effluent concentrations are summarized on **Tables F-41** and **F-42**. **Table F-43** contains the monthly Sr-90 removal totals for the system.

Operating details are given in the O&M manual for this system (BNL 2012b). Below is a summary of the system operations for 2011.

Table 3.2.15-2
BGRR Sr-90 Treatment System
2011 SPDES Equivalency Permit Levels

Parameter	Permit Level	Max. Measured Value
pH range	5.5–8.5 SU	6.0–7.8 SU
Sr-90	8.0 pCi/L	4.14
Chloroform	7.0 µg/L	0.53
1,1-Dichloroethane	5.0 µg/L	<0.5
Ethylbenzene	5.0 µg/L	<0.5
Methyl Chloride	5.0 µg/L	0.54
Methylene Chloride	5.0 µg/L	1.09
Toluene	5.0 µg/L	<0.5
1,2,3-Trichlorobenzene	5.0 µg/L	<0.5
1,1,1-Trichloroethane	5.0 µg/L	0.98
1,2,4-Trimethylbenzene	5.0 µg/L	<0.5
Xylene, total	10.0 µg/L	<0.5

Notes:
ND = Not detected above minimum detectable activity.
SU = Standard Units
Required sampling frequency is monthly for Sr-90 and VOCs, and weekly for pH.

January – September 2011

The system was off the majority of February due to a clinoptilolite vessel change-out, and part of March due to a bag filter change out. Wells SR-1 to SR-5 were off in April and May due to pipe repairs. Wells SR-3, SR-4 and SR-5 were off from June through September due to pressure problems and as work began to replace the rusted piping. Wells SR-6 to SR-9 were put on line and began regular operation in April. The system pumped a total of 7.5 million gallons for this period.

A persistent high pressure problem in wells SR-3, SR-4 and SR-5 during this period was due to significant clogging of the above grade piping on the roof of building 901. The piping for the roof was redesigned and all of the piping on the roof and to wells SR-3, SR-4 and SR-5 was replaced. The analysis, planning and redesign of the piping resulted in these wells being down for most of this operating period.

October – December 2011

Wells SR-3 to SR-5 began operating during this period after completion and testing of the replacement piping. Wells SR-6 to SR-9 operated full time. The system was off approximately 2 weeks due to bag filter change outs. The system pumped approximately 4 million gallons during this period.

Extraction Well Operational Data

During 2011, approximately 11.5 million gallons were treated by the treatment system, with an average flow rate, including maintenance down time, of 22 gpm. **Table 3.2.15-3** shows the monthly extraction well pumping rates while **Table F-40** shows Sr-90 concentrations.

3.2.15.5 System Operational Data

During 2011, influent concentrations of Sr-90 ranged from 25 pCi/L to 136 pCi/L, with the highest concentration observed in October. The highest influent tritium concentration during 2011 was 2,710 pCi/L in May (**Table F-41**). During 2011, Sr-90 was detected five times in the effluent samples, at concentrations ranging from 0.55 to 4.14 pCi/L (**Table F-42**). There were no VOCs or Sr-90 detected above the SPDES Equivalency Permit discharge limits in the 2011 influent or effluent samples (**Table 3.2.15-2**).

Cumulative Mass Removal

Average flow rates for each monitoring period were used, in combination with the Sr-90 influent concentrations, to calculate the number of milliCuries (mCi) removed. During 2011, the flow averaged 23 gpm. Approximately 2.6 mCi of Sr-90 was removed during 2011, for a total of 21.2 mCi removed since system start-up in 2005 (**Table F-43**). Cumulative mass removal of Sr-90 is shown on **Figure 3.2.15-7**.

Extraction Wells

Maximum Sr-90 concentrations in each of the extraction wells during 2011 were as follows:

- SR-1 88 pCi/L in December
- SR-2 42 pCi/L in March
- SR-3 695 pCi/L in May
- SR-4 9 pCi/L in May
- SR-5 32 pCi/L in May
- SR-6 164 pCi/L in May
- SR-7 228 pCi/L in April
- SR-8 166 pCi/L in April
- SR-9 42 pCi/L in October

Figures 3.2.15-8 and **3.2.15-9** show the Sr-90 concentrations over time for the extraction wells.

3.2.15.6 System Evaluation

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

1. Is there a continuing source of contamination? If present, has the source area been remediated or controlled?

WCF Plume: Based on source area monitoring and extraction well data, Sr-90 concentrations were as high as 177 pCi/L in 2011 but are slowly declining.

BGRR Plume: Yes. Sr-90 concentrations in source area monitoring wells and extraction well SR-3 have not demonstrated as significant a decline since system startup as expected. The source area is capped by the building and an engineered cap that was completed in 2011. It appears that water table fluctuations are flushing residual Sr-90 located beneath Building 701 (close to the water table) into the aquifer.

PFS Plume: Sr-90 concentrations in the source area have been showing a steady decline over the past several years.

2. Were unexpected levels or types of contamination detected?

WCF Plume: No. There were no unexpected levels of Sr-90 or other contaminants.

BGRR Plume: No. There were no unexpected levels of Sr-90 or other contaminants.

PFS Plume: No. There were no unexpected levels of Sr-90 or other contaminants.

3. *Has the downgradient migration of the plume been controlled?*

WCF Plume: The downgradient migration of the plume has been controlled with the addition of four new extraction wells in 2011. A small area of Sr-90 above DWS, which was south of the extraction well area prior to construction of the new wells. However, this Sr-90 is predicted to attenuate in accordance with the cleanup goal.

BGRR Plume: Extraction well SR-3 is controlling the downgradient migration of Sr-90 from the source area.

PFS Plume: Based on the Sr-90 concentrations detected in 2011, the plume is attenuating as projected.

4. *Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?*

WCF Plume: No. The cleanup goal of meeting the DWS in the aquifer has not yet been met. However, the system is capturing source area Sr-90 contamination immediately downgradient from the WCF.

BGRR Plume: Extraction well SR-3 is effectively controlling the source area and full time operation will continue. Sr-90 concentrations in SR-4 and SR-5 have declined to low levels and are currently in pulse pumping mode to aid in stimulating Sr-90 removal from the aquifer.

PFS Plume: This plume is not being actively remediated. The cleanup goal of meeting the DWS in the aquifer has not yet been met.

4a. Are the Sr-90 concentrations in the plume core wells above or below 8 pCi/L?

Sr-90 concentrations for individual core wells in all three of the Sr-90 plumes are above 8 pCi/L.

4b. Has there been a significant concentration rebound in core wells and/or extraction wells following shutdown?

Sr-90 concentration increases have been observed following maintenance shutdowns.

5. *Has the Groundwater Cleanup goal of meeting MCLs been achieved?*
The groundwater cleanup goal of meeting MCLs has not been achieved for these plumes.

3.2.15.7 Recommendations

The following are recommendations for the BGRR/WCF Groundwater Treatment System and Monitoring Program:

- Sr-90 concentrations in groundwater immediately down-gradient of the BGRR have not decreased as expected over the past six years. Because installation of the engineered cap has just recently been completed, BNL will continue to monitor the trends. If warranted, the feasibility of using remediation techniques (such as the applicability of additional source area stabilization/control techniques) will be assessed.
- Due to low Sr-90 concentrations in extraction wells SR-4 and SR-5, continue these wells in a pulse pumping mode (one month on and one month off).
- Install a new monitoring well immediately south and east of the Center for Functional Nanomaterials (Building 735) to monitor the leading edge of the BGRR Sr-90 plume. This recommendation from the *2010 Groundwater Status Report*, will be completed during the summer of 2012.
- Install a temporary well along Brookhaven Avenue south of the main entrance to the BNL Light Source (Building 725) to characterize the downgradient extent of the PFS plume in this area as recommended in the *2010 Groundwater Status Report* and install a permanent monitoring well based on the results. This work will be completed during the summer of 2012.
- Install up to eight temporary wells to characterize Sr-90 concentrations upgradient and to the east of WCF plume extraction wells SR-6, SR-7, SR-8, and SR-9 to enhance the monitoring program in these areas.
- Install a temporary well approximately 150 feet south of the former PFS to characterize the plume in this area.

3.2.16 Chemical/Animal Holes Strontium-90 Treatment System

This section summarizes the operational data from the OU III Chemical/Animal Holes Strontium-90 Treatment System for 2011, and gives conclusions and recommendations for future operation. This system began operation in February 2003.

3.2.16.1 System Description

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

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

1. Three extraction wells pumping into an ion exchange treatment system to remove Sr-90 from the extracted groundwater, and on-site discharge of the clean water into two drywells.
2. Operation of the system to minimize plume growth and meet DWS by 2040.
3. Continued monitoring and evaluation of the data to ensure protectiveness.

Details of operations are provided in the *Chemical/Animal Holes Strontium-90 Groundwater Treatment System Operation and Maintenance Manual* (BNL 2008b).

3.2.16.2 Groundwater Monitoring

Well Network

The Chemical/Animal Holes monitoring network consists of 31 wells. As recommended in the 2010 Groundwater Status Report, wells 106-24, 106-25 and 114-01 were dropped from the monitoring program since they have had no historical detections of Sr-90. Monitoring well 106-17 was also dropped since there have been no historical detections of Sr-90 above the DWS. **Figures 1-2** and **3.2.16-1** show the monitoring well locations.

Sampling Frequency and Analysis

The monitoring wells are sampled in accordance with the O&M phase (semiannual and annual) frequency. Twelve of the 31 monitoring wells were sampled semiannually for Sr-90; the remaining wells were sampled annually. The 11 semiannually sampled wells are plume core, perimeter or bypass detection wells to provide indications of plume changes.

3.2.16.3 Monitoring Well Results

Figure 3.2.16-1 shows the Sr-90 plume distribution. The plume depiction is derived from third quarter monitoring well data.

To date, the highest Sr-90 concentration observed in groundwater in this area was 4,720 pCi/L at well 106-99 in 2005. The areas of higher concentrations (>100 pCi/L) occur in very narrow bands. The first is an area at and immediately upgradient of EW-1. The second area, approximately 20 feet wide, begins just south of the Princeton Avenue firebreak and continues south for approximately 250 feet just upgradient of EW-3.

A summary of key monitoring well data for 2011 follows:

- The highest Sr-90 concentration observed in 2011 was 446 pCi/L in plume core well 106-16 during the first quarter sampling. This well is approximately 50 feet upgradient of EW-1 and began to rebound in late 2006 following two previous years of lower values (<250 pCi/L). However, Sr-90 concentrations in plume core well 106-99, slightly downgradient of 106-16, have remained relatively low (60 pCi/L in 2011) over the past six years despite reaching a historical high concentration for the entire plume of 4,720 pCi/L in 2005.

- Plume core wells 106-103, 106-104, and 106-105, located immediately downgradient of EW-1, only detected up to 9.3 pCi/L in 2011. This break in the plume is due to EW-1 achieving hydraulic control of the plume over the past several years.
- Plume core well 106-49, located in the centerline of the plume approximately 175 feet downgradient of extraction well EW-1, dropped to below the DWS with a detection of Sr-90 of 6.3 pCi/L in July 2011. The Sr-90 concentrations for this well are the lowest since 1999. This indicates that EW-1 is controlling Sr-90 from the source area and the trailing edge of the southerly segment of the plume continues to slowly move through this area. This is also supported by the declining trends in upgradient wells 106-103, 106-104, and 106-105.
- Plume perimeter well 106-48 has been showing average values of Sr-90 for 2008 and 2009 of approximately 30 pCi/L but dropped to 7 pCi/L in 2010. In 2011 the concentrations dropped below 5 pCi/L **(Figure 3.2.16-2)**. The data indicates an area of lower level Sr-90 concentrations originating from a source area location slightly to the west of previous contamination. As recommended in the 2009 Groundwater Status Report, nine temporary wells (i.e., Geoprobes) were installed in March and December 2010 adjacent to perimeter monitoring well 106-48 to determine the extent of Sr-90 contamination detected in this well. The maximum Sr-90 concentration detected was 85 pCi/L in a temporary well located immediately upgradient and to the west of well 106-48. The west perimeter of the plume was delineated as a result of this investigation.
- Plume core well 106-125, approximately 100 feet downgradient of well 106-49 and just upgradient of EW-2, detected 498 pCi/L of Sr-90 in October 2007, and dropped off to 29.6 pCi/L and 27.7 pCi/L in January and July 2011, respectively. Plume core well 106-119, located upgradient of the southern-most extraction well EW-3 averaged approximately 23 pCi/L of Sr-90 during 2011. See **Figure 3.2.16-3** for a cross section view of the plume.
- Plume perimeter wells 106-50, and 106-14, and 106-15 continue to bound the plume to the east and west respectively, since they have been below the DWS since 2006.
- Bypass wells 106-120, 106-121, and 106-122 are approximately 100 feet south of EW-3. Well 106-122 had detections of Sr-90 of 1.2 pCi/L and 2.6 pCi/L in January and July 2011, respectively.

The complete monitoring results for all wells in this program are in **Appendix C**.

3.2.16.4 System Operations

The Chemical/Animal Holes Strontium-90 Treatment System influent, effluent, and midpoint locations were sampled twice per month in 2011. These samples were analyzed for Sr-90 and the influent and effluent samples were analyzed for pH on a monthly basis (**Table 3.2.16-1**). The SPDES Equivalency Permit requires the effluent be sampled for Sr-90 monthly. All extraction wells are sampled monthly (**Table F-44)**. Extraction well EW-1 remained in a pulse-pumping mode for 2011 (one month on and one month off). Starting October 2011, the pumping rate of EW-2 was increased from 5 gpm to 10 gpm to increase the capture zone. Since Sr-90 concentrations in EW-3 have remained near or below the drinking water standard of 8 pCi/L since 2009, pulse pumping (one month on and one month off) of this extraction well began in October 2011.

Sr-90 concentrations for the system influent and effluent in 2011 are summarized on **Tables F-45** and **F-46**. **Table F-47** contains a summary of the monthly Sr-90 mass removal for the system.

Summarized below are the system operations data for 2011. Details for this system are given in the O&M manual.

Table 3.2.16-1.
OU III Chemical/Animal Holes Sr-90 Treatment System
2011 SPDES Equivalency Permit Levels

Parameter	Permit Level	Max. Measured Value
pH range (SU)	5.0–8.5	5.4–6.5
Sr-90 (pCi/L)	8.0	ND

Notes:
pCi/L = pico Curies per liter
SU = Standard Units
J = Estimated value
Required sampling frequencies are monthly for Sr-90 and pH.

January – September 2011
The system operated the majority of the time during this period. In September, extraction well EW-2 was off the majority of the month for repairs. From January through September, the treatment system pumped a total of 5.5 million gallons of water.

October – December 2011
The system operated normally for this quarter, with the exception of being off for several days due to electrical problems. The system pumped and treated a total of 1.6 million gallons of water this period.

3.2.16.5 System Operational Data

Sr-90 concentrations in EW-2 has decreased as expected since these wells became operational in November 2007. Upon start-up, EW-2 detected up to 139 pCi/L of Sr-90 and the concentration had steadily dropped to an average of 6 pCi/L for 2011. When EW-3 became operational, concentrations were already low at 13 pCi/L and averaged approximately 10 pCi/L for 2011. However, Sr-90 in EW-3 increased to 28 pCi/L in November 2011, indicating that the leading edge of the plume has arrived at this extraction well. This increase may also be attributable to pulse pumping since this well was off for the first time in October. Concentrations of Sr-90 fluctuated several times in EW-1, but averaged approximately 39 pCi/L for the year. Concentrations ranged from a low of 20 pCi/L to a high of 81 pCi/L in 2011. The fluctuations may also be attributable to pulse pumping. **Figure 3.2.16-4** presents the extraction well data over time. The 2011 analytical data show that influent Sr-90 concentrations ranged from 6 to 22 pCi/L (see **Table F-45**). The effluent samples did not detect any Sr-90. Approximately 7 million gallons of groundwater were processed through the system during 2011.

Cumulative Mass Removal
Average flow rates for each monitoring period were used, in combination with the Sr-90 concentration, to calculate the mCi removed. Flow averaged 13.2 gpm during 2011. **Table 3.2.16-2** shows the monthly extraction well pumping rates. The cumulative total mass of Sr-90 removed was approximately 0.33 mCi during 2011, with a total of approximately 4.4 mCi removed since 2003 (**Figure 3.2.16-5**).

3.2.16.6 System Evaluation

The Chemical/Animal Holes Sr-90 Treatment System performance can be evaluated based on the major decisions identified for this system as part of the DQO process.

1. Is there a continuing source of contamination? If present, has the source area been remediated or controlled?
In 2008, eight temporary wells were installed in the upgradient portion of the plume (upgradient of well 106-94) to help determine if there was a continuing source of Sr-90 contamination. The maximum Sr-90 concentration for each temporary well was near the top of the water table (30 to 34 feet bls). The maximum Sr-90 detection in these temporary wells was 190 pCi/L which gives the indication that there may be some residual contamination in the deeper vadose zone. Recent elevated Sr-90 detections slightly west of the main body of the plume indicate another minor source area further west. Additional characterization of the groundwater and soil in this area will be evaluated to rule out a continuing source.

2. Were unexpected levels or types of contamination detected?
There were no unexpected types of contamination detected in the plume in 2010. One concern however, is the continued elevated Sr-90 concentrations in upgradient well 106-16. As noted in question 1 above, additional evaluation for a potential continuing source will be performed.

3. Has the downgradient migration of the plume been controlled?
The monitoring data indicate that the plume is controlled by the three extraction wells. Monitoring of the three plume bypass wells will continue to provide verification. The travel time from EW-3 to these wells is approximately three years (**Figure 3.2.16-1**). Although the Sr-90 concentrations characterized to the west and upgradient of plume perimeter well 106-48 are not as elevated as the main body of the plume (up to 85 pCi/L in 2008), Sr-90 needs to be monitored since this segment of the plume will not be captured by the existing extraction wells. However, the groundwater model projects that these concentrations should attenuate to the DWS by 2040.

4*. Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?*
Based on groundwater monitoring data discussed in **Section 3.2.16.3**, significant contamination remains upgradient of extraction well EW-1. Core well 106-16 (upgradient of EW-1) continues to see elevated Sr-90 values. However, well EW-1 has been in pulse pumping mode (one month on and one month off) since 2008, and the concentrations in the monitoring wells immediately downgradient of EW-1 have remained low indicating that the plume is being captured.
Sr-90 concentrations in core well 106-125 (immediately upgradient of EW-2) have dropped off significantly over the last three years from a high of 498 pCi/L when it was installed in 2007 to less than 30 pCi/L in 2011. This indicates that this high concentration portion of the plume is has passed through this well and has been controlled by EW-2.

Sr-90 concentrations in EW-3 have remained low (at or below the drinking water standard of 8 pCi/L) for 2009 and 2010. However, Sr-90 concentrations in this well began increasing in late 2011, possibly due to implementing pulse pumping. Core well 106-119, immediately upgradient of EW-3 has remained less than 36 pCi/L since 2009. Based on these low concentrations, extraction well EW-3 should continue to be pulse pumped.

4a. Are Sr-90 concentrations in plume core wells above or below 8 pCi/L?
Sr-90 concentrations in six of 17 core wells were above 8 pCi/L in 2011.

4b. Is there a significant concentration rebound in core wells and/or extraction wells following shutdown?
The system was not shutdown in 2011.

5*. Has the groundwater cleanup goal of meeting drinking water standards been achieved?*
No. The drinking water standard has not been achieved for Sr-90 in all plume core wells. However, assuming there is no c ontinuing source of upgradient contamination, the DWS is expected to be achieved by 2040.

3.2.16.7 Recommendations

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

- Continue to operate extraction wells EW-1 and EW-3 in pulse pumping mode (one month on and one month off). If concentrations in either extraction well increase significantly, then they will be put back into full-time operation. Continue full time operation of EW-2.

- To determine if there is a continuing source of Sr-90 contamination upgradient of EW-1, characterization of the groundwater and soil in the area of the 2008 temporary wells will be performed in the summer of 2012. Following review of the data, if warranted, the feasibility of using remediation techniques (such as in-situ stabilization or source removal) will be assessed.
- Based on the 2010 temporary well data, install a new perimeter monitoring well in the summer of 2012 upgradient and to the west of well 106-48.
- Maintain the operations and maintenance phase monitoring well sampling frequency begun in 2009.

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3.2.17 HFBR Tritium Pump and Recharge System

In late 1996, tritium was detected in monitoring wells near the HFBR. The source of the release was traced to the HFBR spent fuel pool. In response, the fuel rods were removed and the spent fuel pool was drained. In May 1997, a three-well groundwater pump and recharge system was constructed on the Princeton Avenue firebreak road, approximately 3,700 feet downgradient of the HFBR to capture the leading edge of the tritium plume and assure that the plume would not migrate off site. Extracted water was recharged at the RA V recharge basin. The extraction system was placed on standby status in September 2000, as groundwater monitoring data demonstrated that the plume was attenuating to concentrations well below DWS in the vicinity of the Pump and Recharge extraction wells.

As described in the OU III ROD, the selected remedy to address the HFBR tritium plume included implementing monitoring and low-flow extraction programs to prevent or minimize the plume's growth. Beginning in June 2000 and ending April 2001, 20 low-flow extraction events removed 95,000 gallons of tritiated water with concentrations greater than 750,000 pCi/L. This water was sent off site for disposal.

The OU III ROD contingencies are defined as either a detection of tritium above 25,000 pCi/L in monitoring wells at the Chilled Water Facility Road, or above 20,000 pCi/L in monitoring wells along Weaver Drive. The OU III ROD contingency of exceeding 20,000 pCi/L at Weaver Drive was triggered with a detection of 21,000 pCi/L in November 2006. In 2007, new extraction well EW-16 was installed to supplement the three existing extraction wells and the system was restarted in November 2007 as per the ROD contingency.

Groundwater flow in the vicinity of the HFBR is primarily to the south (**Figures 2-2** and **2-3**).

3.2.17.1 System Description

As a result of the implementation of the ROD contingency described above, operation of the system resumed in November 2007 and includes the pumping of wells EW-16 and EW-11. Extraction well EW-16 was installed approximately 400 feet north of the existing pumping and recharge wells located on Princeton Avenue (**Figure 3.2.17-1**). Extraction wells EW-9, EW-10, and EW-11 are being sampled quarterly and EW-16 was sampled at a weekly frequency through June 2011. The sampling frequency was changed to monthly in July 2011.

For a complete description of the HFBR Tritium Pump and Recharge System, see the *Operations and Maintenance Manual for the High Flux Beam Reactor Tritium Plume Pump and Recharge System* (BNL 2009c).

3.2.17.2 Groundwater Monitoring

Well Network

A monitoring well network of 103 wells is used to evaluate the extent of the plume, monitor the source area, and verify the predicted attenuation of the plume (**Figure 1-2**). The permanent monitoring well network is supplemented with temporary wells. A total of 13 temporary wells were installed during the fourth quarter of 2011 and January 2012 (**Figure 3.2.17-1** and **Table 3.2.17-1)**.

Sampling Frequency and Analysis

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

3.2.17.3 Monitoring Well Results

The extent of the tritium plume is shown on **Figure 3.2.17-1**. This figure summarizes data collected from monitoring wells and supplemented with data obtained from 13 temporary wells **(Table 3.2.17-1)** during the fourth quarter of 2011 and January 2012. The temporary wells were installed to determine the location and magnitude of tritium concentrations in the downgradient portion of the plume. Specifically, the temporary wells were installed from just north of EW-16 to the Weaver Drive area (**Figure 3.2.17-1**). The data for these temporary wells is included in **Table 3.2.17-1**. **Appendix C** contains the complete set of monitoring well data. A north to south cross-sectional view of the plume centerline is shown on **Figure 3.2.17-2**. Tritium concentration trends for key monitoring wells are shown on **Figure 3.2.17-3**. This figure includes concentration trends for several locations where temporary wells have been repeated over the previous six years.

Background

Samples are collected from a network of seven monitoring wells north of the HFBR. There were no detections of tritium in these wells during 2011. The wells serve as early detection points in the event that groundwater flow shifts to a more northerly direction and toward supply wells 10, 11, and 12. Groundwater flow during 2011 was consistently to the south. Maintenance of the southerly flow in this area of the site is an ongoing goal of the BNL Water and Sanitary Planning Committee which meets regularly to discuss on-site pumping and recharge of groundwater. Supply wells 10 and 11 provided less than 25% of the lab's water supply in 2011 and did not have a significant impact on site wide groundwater flow directions. Remnants of the g-2 tritium plume are present in the vicinity of the HFBR, approximately 10 to 20 feet deeper than the HFBR plume. A characterization of the downgradient extent of the g-2 tritium plume was conducted again in 2011 and is summarized in **Section 4.2**.

A network of seven monitoring wells is used to evaluate the concentration of tritium downgradient of the RA V Recharge Basin (shown on **Figure 3.2.17-1)**. This basin receives discharge water from the HFBR Pumping wells. Tritium concentrations in these wells during 2011 were all significantly less than the 20,000 pCi/L DWS, with the highest concentration reported in well 076-172 at 318 pCi/L.

HFBR to Brookhaven Avenue

Elevated tritium concentrations directly downgradient of the HFBR have been observed to correlate with high water-table events resulting in water-table flushing of the unsaturated zone beneath the HFBR. There was a sharp rise in water-table elevation at the site during the first quarter of 2010 due to above average precipitation during the winter months. The water table was near a historical high elevation in May 2010, and has declined more than six feet since that time. It was expected that some of the remaining inventory of tritium in the unsaturated zone beneath the HFBR spent fuel pool would be mobilized by this water table increase. The HFBR source area wells were monitored in 2010 and 2011 for this possibility. Peak tritium concentrations through 2009 and the first half of 2010 remained below the 20,000 pCi/L DWS, however, several wells in this area were above the DWS during the fourth quarter of 2010. The highest tritium concentration observed in 2011 was 142,400 pCi/L in well 075-225 located just south of the HFBR on Cornell Avenue during July. The subsequent two quarterly sample rounds showed tritium at 45,100 pCi/L and 3,890 pCi/L respectively in this well. This short term increase in tritium concentrations appears to be the result of the high water table observed in early 2010. Several other wells in this area showed similar third quarter tritium increases followed by subsequent declining concentrations.

Based on the long-term trend (**Figure 3.2.17-4**), it is anticipated that peak tritium concentrations in these wells will eventually remain less than the 20,000 pCi/L DWS within the next several years.

The HFBR tritium plume as defined by the 20,000 pCi/L isocontour is depicted on **Figure 3.2.17-1.** The only remaining tritium concentrations above 20,000 pCi/L are located in a small area immediately south of the HFBR.

Brookhaven Avenue to Princeton Avenue Firebreak Road

The monitoring well network in this area was supplemented with 13 temporary wells to determine the extent of tritium concentrations remaining above the DWS. This area of contamination represents the remnant of the high concentration segment of the plume that BNL has been tracking since 2000/2001 when it was located in the vicinity of Temple Place and was subject to low-flow extraction remediation. The highest tritium concentration observed in this area in 2010 was 19,400 pCi/L in GP-297, located to the east of Weaver Drive. The highest concentration observed in 2011 was 15,100 pCi/L, again in temporary well GP-297. Based on several rounds of data the tritium concentrations in this area have largely attenuated to below DWS.

EW-16 is sampled on a weekly basis. Tritium concentrations slowly dropped off from 3,620 pCi/L during June of 2009, and have remained below 2,400 pCi/L since August of 2009. Since early 2011 they have remained below 1,500 pCi/L.

3.2.17.4 System Operations

Extraction wells EW-9, EW-10, and EW-11 were sampled quarterly, whereas EW-16 was sampled quarterly for VOCs and weekly for tritium in 2011. The influent, midpoint, and effluent of the carbon units were sampled twice per month, along with weekly pH readings. These samples were analyzed for VOCs and tritium. Extraction wells EW-11 and EW-16 are in full-time operation, while EW-9 and EW-10 are in standby mode. **Table 3.2.17-2** shows the 2011 SPDES equivalency permit levels. **Table F-48** shows the effluent VOC and tritium data.

The following is a summary of the OU III HFBR AOC 29 Tritium System operations for 2011:

January – September 2011

The system operated normally for the first three quarters. Down time was experienced due to scheduled maintenance, and electrical repairs to the control panel. During the first three quarters of 2011 approximately 67 million gallons of groundwater were pumped and recharged.

October – December 2011

The system operated normally during the last quarter of 2011. Approximately 21 million gallons of groundwater were pumped and recharged.

Extraction Well Operational Data

During 2011, approximately 88 million gallons of groundwater were pumped and recharged by the system, with an average flow rate of 170 gpm. **Table 3.2.17-3** shows the monthly extraction well pumping rates, whereas **Table F-49** shows VOC and tritium concentrations.

3.2.17.5 System Evaluation

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

1. Is there a continuing source of contamination? If present, has the source area been remediated or controlled?

Yes, some inventory of tritium remains in the unsaturated zone beneath the HFBR building. There was an increase in tritium concentrations in several monitoring wells immediately downgradient of the HFBR in 2011 resulting from the historical high water table in early

Table 3.2.17-2
OU III HFBR AOC 29 Tritium System
2011 SPDES Equivalency Permit Levels

Parameters	Permit Level (µg/L)	Max. Measured Value (µg/L)
pH	5.5–8.5 SU	5.7- 7.3 SU
Carbon tetrachloride	5	ND
Chloroform	7	.6
1,1-Dichloroethane	5	ND
1,2-Dichloroethane	0.6	ND
1,1-Dichloroethene	5	ND
Cis-1,2-Dichloroethylene	5	ND
Trans-1,2-Dichloroethylene	5	ND
Tetrachloroethylene	5	ND
1,1,1-Trichloroethane	5	ND
Trichloroethylene	5	ND

Note:
ND = Not detected above method detection limit of 0.50 µg/L.
SU = Standard Units

2010. Tritium concentrations are anticipated to decrease in response to the declining water table elevation since early 2010. The tritium inventory beneath the HFBR continues to decrease as evidenced by the steadily declining peak tritium concentrations in downgradient wells as seen in **Figure 3.2.17-4**.

2. Were unexpected levels or types of contamination detected?
No. There were no unusual or unexpected concentrations/types of contaminants observed in the monitoring wells or the extraction wells associated with the HFBR Tritium Pump and Recharge System during 2011. Increased tritium concentrations in several source area monitoring wells were expected based on the significant water table elevation increase in 2010.

3. Is the plume attenuating as expected?
Yes. Groundwater modeling conducted in 2007 to address the downgradient high concentration plume segment approaching Weaver Drive predicted that the pump and recharge system would operate until approximately 2011- 2013. Tritium, in what was formerly the downgradient high concentration segment of the plume, has remained below the DWS in all permanent and temporary wells since 2009. A comparison of the plume from 1997 to 2011 is provided in **Figure 3.2.17-5**.

4. Has the downgradient migration of the plume been controlled?
Yes. The downgradient segment of the plume has been successfully remediated by a combination of pumping and natural attenuation to levels below the DWS.

5. Can individual extraction wells or the entire treatment system be shut down or placed in pulse pumping operation?
Extraction wells EW-9 and EW-10 are currently in stand-by mode. The criteria for shutting down the remainder of the pump and recharge system (EW-11 and EW-16), as established in the 2008 Groundwater Status Report, have been met. This is based on the tritium concentrations remaining below the DWS in the vicinity of the downgradient segment of the plume from permanent and temporary well data obtained in 2010 and 2011

5a. Are tritium concentrations in plume core wells above or below the 20,000 pCi/L DWS in the downgradient segment of the plume.
Tritium concentrations in this area during 2011 were below the DWS.

5b. Is there a significant concentration rebound in core wells and/or extraction wells following shutdown?
There has not been a significant tritium concentration rebound in either well EW-9 or EW-10 since they were placed in standby mode.

6. Has the groundwater cleanup goal of meeting MCLs been achieved?
The downgradient portion of the plume has met cleanup goals. Tritium concentrations remain above the MCL immediately downgradient of the HFBR.

3.2.17.6 Recommendations

The following are recommendations for the HFBR AOC 29 Tritium Pump and Recharge System and monitoring program:

- Submit a petition to the regulatory agencies to shut down EW-16 and EW-11 based on the criteria as stated in *2008 Groundwater Status Report*:
    - Concentrations of tritium have decreased to less than 20,000 pCi/L in the monitoring wells at Weaver Drive

  - Concentrations from two rounds of temporary wells in the Weaver Drive area confirm that tritium concentrations in this area remain below the 20,000 pCi/L DWS, and
  - Tritium concentrations in EW-16 have been well below the DWS (below 1,500 pCi/L since 2011) since the system was restarted in 2007.
- Following the shutdown of EW-16 and EW-11, continue monitoring during 2013 and 2014.

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3.3 OPERABLE UNIT IV

This section summarizes the data from the Building 650 a nd Sump Outfall Strontium-90 Monitoring Program monitors a Sr-90 plume and offers conclusions and recommendations for monitoring.

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3.3.1 Building 650 and Sump Outfall Strontium-90 Monitoring Program

The Building 650 and Sump Outfall Strontium-90 Monitoring Program monitors a Sr-90 plume that derived from a remediated source area known as the former Building 650 Sump Outfall Area. This former source consisted of a depression at the terminus of a discharge pipe from the building. The pipe conveyed discharges from a concrete pad located approximately 1,200 feet to the west, where radioactively contaminated clothing and equipment were decontaminated beginning in 1959 (**Figure 3.3.1-1**).

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

3.3.1.1 Groundwater Monitoring

Well Network

The network consists of 22 wells used to monitor the Sr-90 concentrations originating from the former Building 650 sump outfall area (**Figure 1-2 and 3.3.1-1**).

Sampling Frequency and Analysis

During 2011, the wells were monitored either annually or semiannually, and the samples were analyzed for Sr-90 (**Table 1-5**).

3.3.1.2 Monitoring Well Results

The complete monitoring well radionuclide sampling results can be found in **Appendix C**. The Sr-90 plume continues to migrate southward from the former Building 650 sump outfall area and attenuate. The migration rate of Sr-90 in the aquifer, based on observing Sr-90 concentration changes in monitoring wells is approximately 20-40 feet per year. The locations of the monitoring wells and the Sr-90 concentrations are shown on **Figure 3.3.1-1**. The leading edge of the plume as defined by the 8 pCi/L DWS is presently located approximately 100 feet north of Brookhaven Avenue. Sr-90 concentrations in the source area continue to decrease as evidenced by data from wells 076-13 and 076-169 over the previous 14 years (**Figure 3.3.1-2**). During 2011, the highest Sr-90 concentration (32 pCi/L) was detected in well 076-24 during January. The highest concentrations within the plume are located approximately 300 feet to the north of Brookhaven Avenue.

The groundwater model for this plume was updated in 2010 with temporary well data obtained in 2009/2010. The updated model predicts that the plume will attenuate to below the 8 pCi/L DWS by approximately 2034. The leading edge of the plume, as defined by the DWS, is predicted to advance no further than approximately 250 feet south of Brookhaven Avenue.

3.3.1.3 Groundwater Monitoring Program Evaluation

The monitoring program can be evaluated based on the decision rules identified from the groundwater DQO process.

<u>1. Is there a continuing source of contamination? If present, has the source area been remediated or controlled?</u>

The source area was remediated in 2002. Based on the Sr-90 concentrations in source area monitoring wells any residual contamination that may remain at depth in the unsaturated zone above the water table appears to be minimal. The residual contamination continues to be flushed by the rising and falling of the water table and precipitation.

<u>2. Were unexpected levels or types of contamination detected?</u>

All Sr-90 detections in 2011 were within the expected concentration range.

3. Is the plume naturally attenuating as expected?
Yes. The observed data are consistent with the attenuation model in terms of the extent and magnitude of Sr-90 contamination in groundwater.

4. Has the groundwater cleanup goal of meeting MCLs been achieved?
No. The performance objective for this project is to achieve Sr-90 concentrations below the DWS of 8 pCi/L. There were four wells exceeding this limit in 2011 (076-24, 076-415, 076-169, and 076-181). Therefore, the performance objectives have yet to be achieved. The removal of contaminated soils in 2002 addressed the predominate source of groundwater contamination. The groundwater plume continues to degrade due to natural attenuation (i.e., radioactive decay and dispersion).

3.3.1.4 Recommendations

The following are recommendations for the Building 650 and Sump Outfall Strontium-90 Monitoring Program:

- Continue the current monitoring frequency stated in **Table 1-5**.
- Much of the downgradient portion of this plume is located within the planned BNL Solar Research Array. Continue to coordinate with project personnel to maintain access to monitoring wells and potential temporary wells.

3.4 OPERABLE UNIT V

3.4.1 Sewage Treatment Plant Monitoring Program

The Sewage Treatment Plant (STP) processes sanitary wastewater from BNL's research and support facilities. Treated effluent from the STP is discharged to the Peconic River under a NYSDEC SPDES permit. Historically, BNL's STP received discharges of contaminants from routine operations. Releases of low-level contaminants to groundwater (in particular, VOCs, metals, and radionuclides) occurred via the STP sand filter beds and discharges to the Peconic River. The OU V project monitors the identified groundwater contamination downgradient of the STP. Groundwater quality in the immediate vicinity of the STP is currently monitored under the Facility Monitoring Program, which is discussed in **Section 4.6** of this document. On March 10, 2012, BNL issued a *Draft Petition to Discontinue Operable Unit V Groundwater Monitoring* to the regulators for their review (BNL 2012c).

3.4.2 Groundwater Monitoring

Well Locations

A network of 19 monitoring wells was designed to track groundwater contamination downgradient of the STP, at the site boundary, and off site (**Figure 3.4-1**).

Sampling Frequency and Analysis

The wells are sampled annually for VOCs and tritium, and five wells are sampled annually for perchlorate (**Table 1-5)**.

3.4.3 Monitoring Well Results

The OU V wells were sampled once during 2011. **Appendix C** contains the complete data. During 2011, the highest VOC concentration associated with the contaminants released from the STP was 5.1 µg/L of TCE in off-site plume core well 000-122 located immediately north of the LIE. The concentration of TCE in well 000-122 has fluctuated between 3 µg/L and 5.2 µg/L since August of 2007. VOC concentrations in on-site plume core wells have remained at levels below the MCLs (**Figure 3.4-2**). It appears that this plume has reached an equilibrium state in the aquifer with the leading edge attenuating in the vicinity of 000-122 (based on the downgradient well data). The only individual VOCs that have been detected at levels exceeding MCLs since 2008 are TCE in well 000-122 during the November 2011 sampling event and toluene in well 600-27, also during the November 2011 sampling event. Toluene was detected in the sample from well 600-27 at 6.7 µg/L which is above the MCL of 5 µg/L. Based on the depth of this well, which is 250 feet bls, and no history of toluene concentrations exceeding the MCL of 5 µg/L in this area, this detection is believed to be the result of sample contamination and is not indicative of groundwater conditions.

There have been no significant changes in VOC concentrations over the past several years, other than a continued, gradual decline (**Figure 3.4-2**).

Monitoring for perchlorate began in August 2004 with the sampling of 34 OU V monitoring wells. The sampling program has gradually been reduced over the past few years in response to a decrease in perchlorate detections and concentrations. In 2011, only five wells were used to monitor for perchlorate. The results for these wells are shown in **Appendix C**. During 2011, perchlorate was detected in two of the wells (050-01 and 061-05), but at concentrations below the reporting limit of 4 µg/L. The NYSDOH Action Level for perchlorate in drinking water supply wells is 18 µg/L. The EPA published a Drinking Water Equivalent Level for perchlorate of 24.5 µg/L in January 2006.

Tritium has historically been detected at low concentrations in several on-site monitoring wells and off-site well 000-122. **Appendix C** contains the tritium results for 2011. During

2011, the maximum tritium concentration detected was 920 pCi/L in well 061-05; this is approximately one-twentieth of the 20,000 pCi/L DWS. Historically, the highest tritium concentration detected in the OU V monitoring wells was in well 050-02 at 3,320 pCi/L in 1997. Tritium concentrations have steadily declined since then.

3.4.4 Groundwater Monitoring Program Evaluation

The OU V Groundwater Monitoring Program can be evaluated in the context of basic decisions established for this program using the groundwater DQO process:

1. Is there a continuing source of contamination? If present, has the source area been remediated or controlled?
There is no continuing source for VOCs, perchlorate, or tritium in this area.

2. Were unexpected levels or types of contamination detected?
No. There were no unexpected contaminants detected.

3. Is the plume naturally attenuating as expected?
Yes. With the exception of TCE in well 000-122, all individual VOC concentrations are below the MCLs. Perchlorate detections were well below the NYSDOH Action Level of 18 µg/L and tritium concentrations well below the NYS AWQS of 20,000 pCi/L. The plume has attenuated as expected.

4. Have the groundwater cleanup goals of meeting MCLs been achieved?
The cleanup goal of achieving MCLs for the aquifer has been achieved except the area around well 000-122.

3.4.5 Recommendations

Based on the recommendations contained in the *Petition to Discontinue Operable Unit V Groundwater Monitoring*, the following actions will take place:

- Well 000-122 will be monitored annually for VOCs for an additional two years beginning in the fourth quarter of 2012. If the concentrations of VOCs decrease to below MCLs during that time period, BNL will recommend that monitoring for well 000-122 be discontinued.
- The monitoring of the remaining wells will be discontinued. The disposition of the monitoring wells is listed on **Table 3.4-1**. Once regulatory approval is granted, five wells will be scheduled for abandoning, the rest will continue to be used for water level measurements.

3.5 OPERABLE UNIT VI EDB PUMP AND TREAT SYSTEM

The OU VI EDB program monitors the extent of an ethylene dibromide (EDB) plume in groundwater extending from just south of the Long Island Expressway for approximately 4,000 feet. EDB was used during the 1970s as a fumigant for the BNL Biology Department's biology fields located in the southeastern portion of the site (**Figure 3.5-1**). 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. EDB has not been detected on BNL property since 2009.

3.5.1 System Description

A groundwater remediation system to address the off-site EDB plume began routine operations in August 2004. The OU VI EDB Treatment System consists of two extraction wells and two recharge wells (see **Figure 3.5-1**). A complete description of the system is included in the *Operations and Maintenance Manual for the OU VI EDB Groundwater Treatment System* (BNL 2004c).

3.5.2 Groundwater Monitoring

Well Locations

A network of 24 wells monitor the EDB plume from the BNL south boundary to locations on private property south of North Street (**Figure 3.5-1**).

Sampling Frequency and Analysis

The OU VI EDB plume monitoring program is in the O&M phase (**Table 1-8**). The sampling frequency for most of the plume core and perimeter wells is semiannual (**Table 1-5**). Core wells 000-178 and EDB-MW-01 2011, and bypass detection wells 000-508 and 000-519 were sampled at a quarterly sampling frequency for the year. The wells are analyzed for EDB according to EPA Method 504. Samples are also analyzed annually for VOCs using EPA Method 524.2. Several wells are incorporated into the OU III South Boundary Radionuclide monitoring program and analyzed for tritium annually (**Section 3.2.14**).

3.5.3 Monitoring Well Results

Appendix C contains the complete analytical results of the OU VI EDB monitoring well sampling program. The distribution of the EDB plume for the fourth quarter of 2011 is shown on **Figure 3.5-1**. The leading edge of the plume is being captured by extraction wells EW-1E and EW-2E. The plume is located in the deep Upper Glacial aquifer and is generally moving horizontally, as depicted on cross section M–M' (**Figure 3.5-2)**. A summary of key monitoring well data for 2011 follows:

- As seen in trend **Figure 3.5-3**, the EDB concentrations in core wells 000-283 and 000-284 have been declining over the past several years. However, EDB in well 000-178 has been increasing since late 2006, indicating movement of the plume south. This well is upgradient of EW-2E. The federal DWS for EDB is 0.05 µg/L.
- A new monitoring well (EDB-MW-01-2011) was installed in March 2011 upgradient and to the east of well 000-500 to monitor the eastern extent of the plume (**Figure 3.5.-1**). This well is located next to the treatment system building. The EDB concentrations ranged from a low of 0.475 µg/L in December to a high of 2.73 µg/L in April 2011. This was the highest EDB concentration observed in the plume in 2011. This well was originally intended to be a perimeter well, however based on the EDB concentrations detected, it is now considered a core well. As noted on **Figure 3.5-2** cross section, this well is screened just above the Gardiners Clay (between 135 and 145 feet bls).

- The trailing edge of the EDB plume is moving south, as evidenced by the reduction in concentrations over the past several years in upgradient plume core wells 000-110, 000-175, and 000-209.
- Plume perimeter well 000-500, in the southeastern portion of the plume, has shown increased EDB levels to above the DWS since 2007. During 2011, the maximum EDB concentration was 0.11 in December of 2011. This portion of the plume will be captured by EW-2E (**Figure 3.0-1**).
- Core well 000-507 has detected gradually increasing levels of EDB above the DWS since it was installed in 2005. In 2011, EDB concentrations reached 1.27 µg/L in December This well is immediately upgradient of the extraction wells.
- Plume bypass wells 000-501, 000-508, and 000-519 have not detected EDB since 2005.

As noted above, the southern migration of the plume is observed by analyzing the trends on **Figure 3.5-3**. Over the past five years, the EDB concentration has increased in well 000-178, indicating that the core of the plume is located between the extraction wells and wells 000-283 and 000-284. Comparing the plume's distribution from 1999 to 2011 (**Figure 3.5-4**), as well as the EDB concentrations in monitoring wells just south of North Street, helps to illustrate the southern movement of the plume. Overall, peak EDB concentrations declined from 7.6 µg/L in 2001 (in well 000-283) to 2.7 µg/L in 2011 (in new monitoring well EDB-MW-01 2011).

EDB was the only VOC detected above the MCL in any OU VI well in 2011 (**Appendix C**).

3.5.4 System Operational Data

In accordance with the recommendation in the *2010 Groundwater Status Report*, the sampling frequency of the extraction wells was reduced from monthly to quarterly starting in April 2011 (BNL 2011c). In conformance with the SPDES equivalency permit, the sampling frequency for the influent and effluent is monthly. All OU VI system samples were analyzed for VOCs and EDB, and the effluent sample was analyzed weekly for pH. **Table 3.5-1** provides the effluent limitations for meeting the requirements of the SPDES equivalency permit.

Table 3.5-1
OU VI EDB Pump & Treat System
2011 SPDES Equivalency Permit Levels

Parameters	Permit Limit	Max. Measured Value
pH (range)	5.0 – 8.5 SU	5.7 – 7.6 SU
ethylene dibromide	0.03 µg/L	<0.02 µg/L
chloroform	7.0 µg/L	1.5 µg/L
1,1-dichloroethene	5.0 µg/L	<0.50 µg/L
1,1,1-trichloroethane	5.0 µg/L	0.62 µg/L
methyl chloride	5.0 µg/L	0.55 µg/L
methylene chloride	5.0 µg/L	<0.50 µg/L

Notes:
Required sampling frequency is monthly for VOCs and weekly for pH.
SU = Standard Units

January – September 2011

The system operated with EW-1E running at an average flow rate of 175 gpm and EW-2E at 156 gpm through May. As per the recommendation in the *2010 Groundwater Status Report*, in June the set pumping rate of EW-2E was increased from 160 gpm to 195 gpm. The system was down sporadically during this period. From January through September, approximately 127 million gallons of water were treated.

October – December 2011

Approximately 37 million gallons of water were treated during this quarter. Well EW-2E was off most of December for replacement of the pump and motor.

Extraction Wells

During 2011, 164 million gallons were treated by the OU VI EDB System, with an average flow rate of approximately 323 gpm. **Table 2-2** contains the monthly pumping data for the two extraction wells, and **Table 3.5-2** shows the pumping rates. VOC concentrations for EW-1E (000-503) and EW-2E (000-504) are provided on **Table F-50**. In 2011 the extraction wells had a maximum detection of EDB of 0.055 µg/L in EW-1E in April. No other VOCs were detected in the extraction wells above the MCLs.

System Influent and Effluent

During 2011, OU VI EDB system discharge parameters were below the regulatory limit specified in the SPDES equivalency permit. Influent and effluent results are reported on **Tables F-51** and **F-52**, respectively. EDB was detected in most of the monthly sampling events of the influent throughout 2011, with a maximum concentration of 0.051 µg/L. There was one detection in the influent slightly above the standard for EDB in 2011.

Cumulative Mass Removal

No cumulative mass calculations were performed, based on the typically low detections of EDB historically below the federal DWS in the system influent. The four detections in 2011 were only slightly above the standard. Several low-level VOCs not attributable to BNL were detected; the results are potentially due to analytical lab contamination and were all below the AWQS.

3.5.5 System Evaluation

The OU VI EDB System was designed to capture and remediate the EDB plume as it travels south of BNL with the regional groundwater flow. Start-up of the system was initiated in August 2004, and it is planned to run for approximately 10 years until 2015. The system is operating as designed; no operating difficulties were experienced beyond normal maintenance, and no permit equivalencies have been exceeded.

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

1. Is there a continuing source of contamination? If present, has the source area been remediated or controlled?

No. Since there had been no detections of EDB in the biology fields above the federal DWS since mid-2003, sampling of this former source areas was discontinued in 2009.

2. Were unexpected levels or types of contamination detected?

The detections of EDB in new plume core well EDB-MW-01-2011 were not unexpected, however the elevated value of the detections (up to 2.73 µg/L) was not anticipated. Continued monitoring of this well and characterization of the eastern extent of the plume at this location is necessary.

3. Has the downgradient migration of the plume been controlled?

The hydraulic capture of the system is operating as designed. However, based on the EDB detection in the well noted in Decision 2 above, additional data are needed to help evaluate the eastern edge of the plume and whether it will be captured via the existing extraction wells. Assuming the extent of this contamination is not much further to the east, preliminary indications from reviewing the original capture zone analysis in the *2004 Startup and Pump Test Report* is that this portion of the plume would be captured by the extraction wells.

4. Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?

No, the system has not met all shutdown requirements.

4a. Are EDB concentrations in plume core wells above or below 0.05 μg/L?
In 2011, all nine plume core wells had concentrations greater than the 0.05 μg/L federal DWS.

4b. Is there a significant concentration rebound in core wells and/or extraction wells following shutdown?
To date, the OU VI EDB system has not been pulse pumped or shutdown.

5. Has the groundwater cleanup goal of meeting MCLs been achieved?
No. The federal DWS has not been achieved for EDB in plume core wells. It is expected to be achieved by 2030, as required by the OU VI ROD.

3.5.6 Recommendations

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

- Maintain routine operations of the treatment system.
- As recommended in the *2010 Groundwater Status Report*, install an additional perimeter monitoring well to the east of well EDB-MW-01-2011. The specific location will be dependent upon available property access.

3.6 SITE BACKGROUND MONITORING

Background water quality has been monitored since 1990. Historically, low levels of VOCs were routinely detected in several background wells that are screened in the deeper portions of the Upper Glacial aquifer. Background quality is defined as the quality of groundwater that is completely unaffected by BNL operations.

3.6.1 Groundwater Monitoring

Well Network

The 2011 program included 10 wells in the northwestern portion of the BNL property (**Figure 1-2**).

Sampling Frequency and Analysis

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

3.6.2 Monitoring Well Results

The complete groundwater analytical data for 2011 are provided in **Appendix C**. There were detections of low levels of several VOCs in the site background wells, all of which were below AWQS. The highest concentration detected was 0.25 μg/L of PCE in well 017-03.

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 Groundwater Monitoring Program Evaluation

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

1. Were unexpected levels or types of contamination detected?

No. There were no VOCs detected in site background wells above AWQS during 2011. Based on these results, there is no current impact to BNL groundwater quality from upgradient contaminant sources.

3.6.4 Recommendation

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

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

Parameter	Activity Range (pCi/L)	Contract-Required Detection Limit
Cesium-137	<MDA to 7.24	12
Gross alpha	<MDA to 2.66	1.5
Gross beta	<MDA to 6.41	4.0
Strontium-90	<MDA to 3.84	0.8
Tritium	<MDA	300

Note:
<MDA = Less than minimum detectable activity

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3.7 CURRENT AND FORMER LANDFILL GROUNDWATER MONITORING

Groundwater monitoring data from both the Current and Former Landfills are discussed in detail in the *BNL 2011 Environmental Monitoring Report, Current and Former Landfill Areas* (BNL 2012a). The complete groundwater monitoring results for these programs are included in **Appendix C**.

3.7.1 Current Landfill Summary

Groundwater data show that, in general, contaminant concentrations have been decreasing following the capping of the landfill in 1995. By the end of 2011, the landfill had been capped for 16 years. Groundwater quality has been slowly improving. The trend in the data suggests that the cap is effective in mitigating groundwater contamination. Groundwater monitoring wells for the Current Landfill are shown on **Figure 3.7-1**. The following is a summary of the results from the samples collected during 2011:

- VOCs; Benzene was detected in downgradient wells 087-11, 087-23, 087-27, and 088-110 at concentrations above the AWQS of 1 µg/L with a maximum concentration of 1.9 µg/L. Chloroethane was detected in wells 087-23 and 088-109 at concentrations above the AWQS (up to 26.4 µg/L). 1,1-Dichloroethane was also detected in one well, 088-109, at a concentration slightly above the AWQS of 5 µg/L (5.08 µg/L). During 2011, TVOC concentrations ranged up to 28.5 µg/L indicating that low level VOCs continue to emanate from the landfill. However, an analysis of the trends of VOCs indicate the concentrations are stable to decreasing.

- Concentrations of landfill water chemistry parameters and metals such as ammonia and iron continue to show concentrations in downgradient wells above the upgradient values. This suggests that leachate continues to emanate from the landfill, but at low levels.
- Tritium and Sr-90 continue to be detected in the wells downgradient of the Current Landfill, but at concentrations well below the DWS. These concentrations are consistent with historical observations. There have been no detections of radionuclides above the DWS since 1998.
- Since 1998, there have been no detections of VOCs, water chemistry parameters or radionuclides exceeding groundwater standards in wells 087-24, 088-22, and 088-23. These wells are all screened in the mid-to deep-Upper Glacial aquifer to monitor the vertical extent of contamination from the Current Landfill.
- Although low levels of contaminants continue to be detected, the landfill controls are effective at reducing the impact of the Current Landfill on groundwater quality as evidenced by the improving quality of groundwater downgradient of the landfill.

3.7.2 Current Landfill Recommendations

The groundwater monitoring well network is adequate at this time. Since there have been no detections of VOCs or water chemistry parameters since 1998 in wells 087-24, 088-22, and 088-23, it is recommended that the monitoring frequency for these wells be reduced from semiannually to annually.

3.7.3 Former Landfill Summary

Data show that contaminant concentrations decreased following the capping of the landfill in 1996. Contaminant concentrations downgradient of this landfill were relatively low prior to capping, primarily due to it being approximately 50 years old. The trend in the data suggests that the cap is effective in mitigating any remaining contamination from entering the groundwater. Based on VOC and Sr-90 concentration trends in downgradient wells, it appears that the landfill cap is performing as planned. Groundwater monitoring wells for the Former Landfill are shown on **Figure 3.7-2**. The following is a summary of the results from the samples collected during 2011:

- The Former Landfill Area is not a significant source of VOC contamination. No VOCs were detected above groundwater standards in 2011. VOC concentrations in the downgradient wells were at or near the minimum detectable limits.
- Landfill-leachate indicators in downgradient wells were detected at concentrations approximating those in the background monitoring wells, indicating that leachate generation is minimal to nonexistent.
- The Former Landfill Area no longer appears to be a source of Sr-90 contamination. Only trace amounts of Sr-90 were detected near the Former Landfill Area. The Sr-90 detected in wells 097-64, 106-44, 106-45 and 106-64 has been decreasing with time and is currently not above the DWS.
- The implemented landfill controls are effective, as evidenced by the improved quality of groundwater downgradient of the landfill.

3.7.4 Former Landfill Recommendations

No changes to the Former Landfill groundwater-monitoring program are warranted at this time.

4.0 FACILITY MONITORING PROGRAM SUMMARY

During 2011, the Facility Monitoring Program at BNL monitored the groundwater quality at 12 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 ten research and support facilities are monitored in accordance with DOE Orders 458.1 (Radiation Protection of the Public and the Environment) and 436.1 (Departmental Sustainability). These Orders require the Laboratory to establish environmental monitoring programs at facilities that can potentially impact environmental quality, and to demonstrate compliance with DOE requirements and the applicable federal, state, and local laws and regulations. BNL uses these monitoring data to determine whether current engineered and administrative controls effectively protect groundwater quality and whether additional corrective actions are needed.

During 2011, 134 groundwater monitoring wells were sampled during approximately 230 sampling events. BNL also installed 50 temporary wells to supplement the network of permanent monitoring wells. Approximately 400 groundwater samples were collected using the temporary wells. Information on groundwater quality at each of the monitored research and support facilities is described below. **Table 1-6** summarizes the Facility Monitoring Program by project. Complete analytical results from groundwater samples collected in 2011 are provided in **Appendix D**.

4.1 Alternating Gradient Synchrotron (AGS) Complex

The structures that constitute the AGS Complex include the AGS Ring, Linear Accelerator (Linac), Building 912, AGS Booster Beam Stop, 914 Transfer Tunnel, former g-2 experimental area, former E-20 Catcher, former U-Line Beam Target, and the J-10 Beam Stop. Activated soil has been created near a number of these areas as the result of secondary particles (primarily neutrons) produced at beam targets and beam stops. A number of radionuclides can be produced by the interaction of secondary particles with the soil that surrounds these experimental areas. Once produced in the soils, some of these radionuclides can be leached from the soils by rainwater, and carried to the groundwater. Of the radionuclides formed in the soil, only tritium (half-life = 12.3 years) and sodium-22 (half-life = 2.6 years) are detected in groundwater. Of these two radionuclides, tritium is more easily leached from the activated soils by rainwater and does not bind to soil particles. When tritium enters the water table, it migrates at the same rate as groundwater flow (approximately 0.75 feet per day). Sodium-22 does not leach out of the soil as readily as tritium, and migrates at a slower rate in the aquifer. The drinking water standard (DWS) for tritium is 20,000 pCi/L, and the standard for sodium-22 is 400 pCi/L.

To prevent rainwater from leaching these radionuclides from the soil, impermeable caps have been constructed over many of the activated soil shielding areas. Specifications for evaluating potential impacts to groundwater quality and the need for impermeable caps over beam loss areas are defined in the Standards Based Management System (SBMS) subject area entitled *Accelerator Safety*. BNL uses 53 groundwater monitoring wells to evaluate the impact of current and historical operations at the AGS beam stop and target areas. The locations of permanent monitoring wells are shown on **Figure 4-1**. The wells are routinely monitored for tritium because it is the best early indicator of a possible release (i.e., tritium is more leachable than sodium-22, and it migrates at the same rate as groundwater).

Following the 1999 installation of an improved monitoring well network at the AGS, BNL detected three tritium plumes that originated from the g-2 experimental area, the former U-Line beam stop, and the former E-20 Catcher. The subsequent installation of impermeable caps over these soil activation areas resulted in a reduction of tritium levels to less than the 20,000 pCi/L DWS in the former U-Line beam stop and E-20 Catcher areas. As discussed below, tritium continues to be detected downgradient of the g-2 (VQ-12 magnet) soil activation area at concentrations that exceed 20,000 pCi/L (**Section 4.2**).

4.1.1 AGS Building 912

Building 912 consists of five interconnected structures that have been used to house as many as four experimental beam lines (A, B, C, and D lines). Although these beam lines stopped operations in 2002, the building may be used for new experiments in the future.

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

4.1.1.1 AGS Building 912 Groundwater Monitoring

Well Network

Twenty-three shallow Upper Glacial aquifer wells are positioned upgradient and downgradient of Building 912 (**Figure 4-1**). Upgradient wells are positioned to monitor potential tritium contamination from sources such as the g-2 area and the former U-Line experimental area. The downgradient wells are positioned to monitor the significant (former) beam stop and target areas in Building 912. Sixteen of the downgradient wells are also used to track a section of the g-2 tritium plume that has migrated underneath Building 912 (**Section 4.2**).

Sampling Frequency and Analysis

During 2011, the 16 Building 912 wells that are used to track the g-2 tritium plume were sampled two times, whereas the remaining wells were sampled annually. The groundwater samples were analyzed for tritium (**Table 1-6**).

4.1.1.2 AGS Building 912 Monitoring Well Results

As in past years, low-level tritium contamination that is traceable to the g-2 source area continues to be detected in wells located downgradient of Building 912 (**Figure 4-8**). During 2011, tritium from the g-2 area was detected in five wells downgradient of Building 912 (065-122, 065-321, 065-322, 065-323, and 065-324), with a maximum concentration of 7,050 pCi/L found in a sample from well 065-122 in March 2011. The groundwater monitoring results for the remainder of the Building 912 area wells suggest that tritium is not being released in appreciable amounts from activated soil beneath the experimental floor. Although low levels of tritium (maximum concentration of 270 pCi/L) were detected in three wells located downgradient of Building 912 (065-125, 065-126, 065-195), with the close proximity of the defined centerline of the g-2 plume, it is unclear whether some of this tritium originated from the g-2 source area.

4.1.1.3 AGS Building 912 Groundwater Monitoring Program Evaluation

The 2011 monitoring data were evaluated using the following Data Quality Objective statement.

Is there a continuing source of contamination? If present, has the source been remediated or controlled?

Activated soils are present below the floor slab at Building 912. As noted above, in areas not impacted by the g-2 tritium plume, only trace to low levels of tritium were detected in the Building 912 area groundwater monitoring wells. If this tritium originates from Building 912, these results indicate that the building and associated stormwater management operations are effectively preventing significant rainwater infiltration into the activated soil below the experimental hall.

4.1.1.4 AGS Building 912 Recommendations

The following is recommended for the AGS Building 912 groundwater monitoring program:

- For 2012, ten of the Building 912 wells used to track the g-2 tritium plume will continue to be sampled semiannually, and the remainder of the Building 912 monitoring wells will be sampled annually.

4.1.2 AGS Booster Beam Stop

The AGS Booster is a circular accelerator that is connected to the northwest portion of the main AGS Ring and to the Linear Accelerator (Linac). The AGS Booster, which has been in operation since 1994, and is used to accelerate protons and heavy ions before injecting them into the main AGS ring. In order to dispose of the beam during studies, a beam stop system was originally constructed at the 10 to 11 o'clock portion of the Booster. In 1999, the beam stop was repositioned to the south side (6 o'clock section) of the Booster ring to accommodate the construction of the NASA Space Radiation Laboratory (NSRL) tunnel.

Although internal shielding around the beam stop was designed to keep secondary particle interactions with the soil to very low levels, a geomembrane cap was constructed over the original beam stop region to prevent stormwater infiltration into the activated soil. When the beam stop was repositioned to the 6 o'clock region of the Booster, a coated concrete cap was constructed over the new beam stop area.

4.1.2.1 AGS Booster Groundwater Monitoring

Well Network

Two shallow Upper Glacial aquifer monitoring wells (064-51 and 064-52) are used to monitor the Booster beam stop area (**Figure 4-1**).

Sampling Frequency and Analysis

During 2011, the Booster area wells were sampled one time, and the samples were analyzed for tritium (**Table 1-6**).

4.1.2.2 AGS Booster Monitoring Well Results

Although low levels of tritium were detected in the Booster area wells during 2001 and 2002 (up to 1,340 pCi/L in well 064-52), tritium has not been detected in the Booster area wells since that time (**Figure 4-2**).

4.1.2.3 AGS Booster Groundwater Monitoring Program Evaluation

The 2011 monitoring data were evaluated using the following Data Quality Objective statement.

Is there a continuing source of contamination? If present, has the source been remediated or controlled?

Activated soil shielding is present in the areas of the current and former Booster beam stops. The low levels of tritium detected in groundwater during 2001 and 2002 near the Booster were related to a short-term uncovering of activated soil shielding near the former booster beam stop area during the construction of the tunnel leading from the Booster to the NSRL facility. This work, which began in September 1999 and was completed by October 1999, allowed rainwater to infiltrate the low-level activated soil shielding.[1] Tritium has not been detected in the Booster area monitoring wells since 2002.

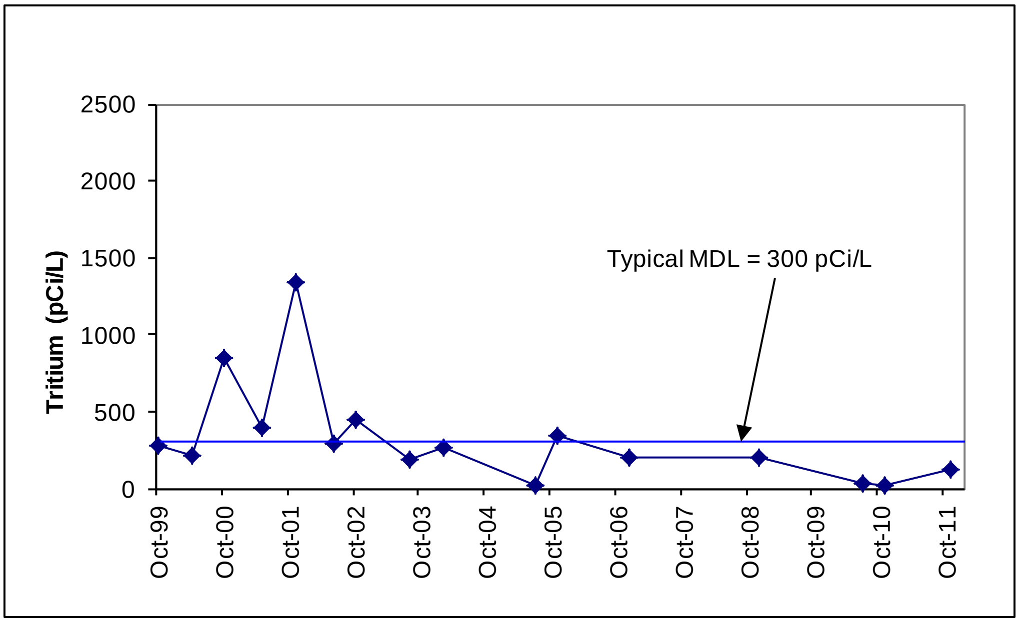
4.1.2.4 AGS Booster Recommendation

The following is recommended for the AGS Booster groundwater monitoring program:

[1] Before construction of the NSRL tunnel commenced, soil samples were collected by drilling through the tunnel wall near the former booster beam stop to verify that the tritium and sodium-22 levels were within acceptable limits for worker safety and environmental protection.

- For 2012, the monitoring frequency for the Booster area monitoring wells will continue to be annually.

Figure 4-2.
AGS Booster Beam Stop
Maximum Tritium Concentrations in Downgradient Wells 064-51 and 064-52



4.1.3 NASA Space Radiation Laboratory (NSRL)

The NSRL is jointly managed by the U.S. Department of Energy's Office of Science and NASA's Johnson Space Center. The NSRL employs beams of heavy ions extracted from Brookhaven's Booster accelerator for radiobiology studies. NSRL became operational during summer 2003. Although the secondary particle interactions with the surrounding soil shielding are expected to result in only a minor level of soil activation, a geomembrane cap was constructed over the entire length of the beam line and the beam stop region to prevent stormwater infiltration into the soil shielding.

4.1.3.1 NSRL Groundwater Monitoring

Well Network

This facility is monitored by two shallow Upper Glacial aquifer monitoring wells (054-08 and 054-191) located immediately downgradient of the NSRL (**Figure 4-1**).

Sampling Frequency and Analysis

The NSRL area wells were monitored one time during 2011, and the samples were analyzed for tritium (**Table 1-6**).

4.1.3.2 NSRL Monitoring Well Results

Groundwater monitoring at the NSRL facility began in late 2002. From 2002 through 2009, tritium was not detected in the groundwater downgradient of NSRL. Although analytical results for the November 2010 groundwater sample from well 054-191 had a reported concentration of 210 +/- 160 pCi/L, with a detection limit of 120 pCi/L, given the level of analytical uncertainty in the reported value, it is unclear whether this was a positive detection of tritium. During 2011, tritium was not detected in either well 054-08 or 054-191. Gamma spectroscopy analyses of the sample from well 054-191 also indicated that Na-22 was not present in the groundwater.

4.1.3.3 NSRL Groundwater Monitoring Program Evaluation

The 2011 monitoring data were evaluated using the following Data Quality Objective statement.

Is there a continuing source of contamination? If present, has the source been remediated or controlled?

Activated soil shielding is being protected by an impermeable cap. Based on monitoring conducted to date, NSRL beam line operations have not impacted groundwater quality in the area.

4.1.3.4 NSRL Recommendation

The following is recommended for the NSRL groundwater monitoring program:

- For 2012, the monitoring frequency for the NSRL wells will continue to be annually.

4.1.4 Former AGS E-20 Catcher

The E-20 Catcher was used from 1984 to 1999, and was located at the 5 o'clock position of the AGS ring (**Figure 4-1**). The E-20 Catcher was a minimum aperture area of the AGS ring, and was used to pick up or "scrape" protons that moved out of acceptable pathways.

Like other beam loss areas in the AGS complex, the soil surrounding the former E-20 Catcher became activated by the interaction with secondary particles. In late 1999 and early 2000, tritium and sodium-22 levels in groundwater were found to exceed the DWS, with concentrations of 40,400 pCi/L and 704 pCi/L, respectively. In April 2000, a temporary impermeable cap was installed over the E-20 Catcher soil activation area. A permanent cap was constructed by October 2000. Tritium and sodium-22 concentrations dropped to below the DWS soon after the cap was installed.

4.1.4.1 Former AGS E-20 Catcher Groundwater Monitoring

Well Network

To verify the effectiveness of the impermeable cap over the former E-20 Catcher, the area is monitored by three shallow Upper Glacial aquifer wells (064-55, 064-56, and 064-80). These wells are approximately 100 feet downgradient of the E-20 Catcher (**Figure 4-1**).

Sampling Frequency and Analysis

During 2011, the former E-20 Catcher wells were monitored one time, and the samples were analyzed for tritium (**Table 1-6**). Since 2002, groundwater samples from this area have only been analyzed for tritium.

4.1.4.2 Former AGS E-20 Catcher Monitoring Well Results

Following the installation of the cap in 2000, tritium and sodium-22 concentrations decreased to levels below applicable DWSs (**Figure 4-3**). During 2011, the maximum observed tritium concentration was 450 pCi/L, detected in well 064-55.

4.1.4.3 Former AGS E-20 Catcher Groundwater Monitoring Program Evaluation

The 2011 monitoring data were evaluated using the following Data Quality Objective statement.

Is there a continuing source of contamination? If present, has the source been remediated or controlled?

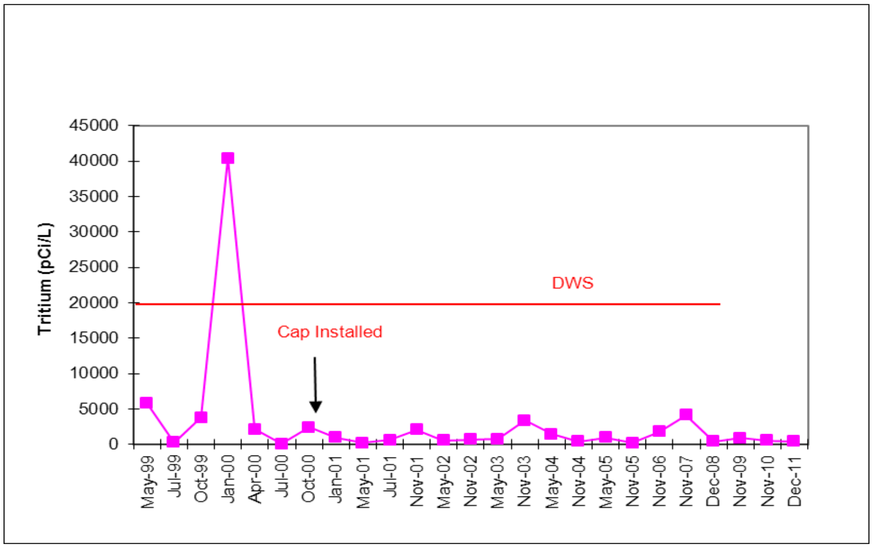
Activated soil shielding at the former E-20 Catcher is being protected by an impermeable cap. The reduction in tritium concentrations since the impermeable cap was constructed in 2000 indicates that the cap has been effective in preventing rainwater infiltration into the activated soil that surrounds this portion of the AGS tunnel.

4.1.4.4 Former AGS E-20 Catcher Recommendation

The following is recommended for the AGS E-20 Catcher groundwater monitoring program:

- For 2012, the monitoring frequency for the former E-20 Catcher wells will continue to be annually.

Figure 4-3.
Former AGS E-20 Catcher
Maximum Tritium Concentrations in Downgradient Temporary and Permanent Monitoring Wells



4.1.5 AGS Building 914

Building 914 houses the beam transfer line between the AGS Ring and the Booster. Due to beam loss near the extraction (kicker) magnet, the extraction area of Building 914 is heavily shielded with iron. Because the extraction area is housed in a large building, most soil activation is expected to be below the floor of the building, where it is protected from rainwater infiltration.

4.1.5.1 AGS Building 914 Groundwater Monitoring

Well Network

Groundwater quality downgradient of the AGS Building 914 transfer line area is monitored by shallow Upper Glacial aquifer wells 064-03, 064-53, and 064-54 (**Figure 4-1**).

Sampling Frequency and Analysis

During 2011, the AGS Building 914 area wells were monitored one time and samples were analyzed for tritium (**Table 1-6**).

4.1.5.2 AGS Building 914 Monitoring Well Results

Low levels of tritium (up to 1,000 pCi/L) are periodically detected in the groundwater downgradient of the Building 914 (**Figure 4-4**). During 2011, tritium was detected downgradient monitoring well 064-54 at a concentration of 230 pCi/L.

4.1.5.3 AGS Building 914 Groundwater Monitoring Program Evaluation

The 2011 monitoring data were evaluated using the following Data Quality Objective statement.

Is there a continuing source of contamination? If present, has the source been remediated or controlled?

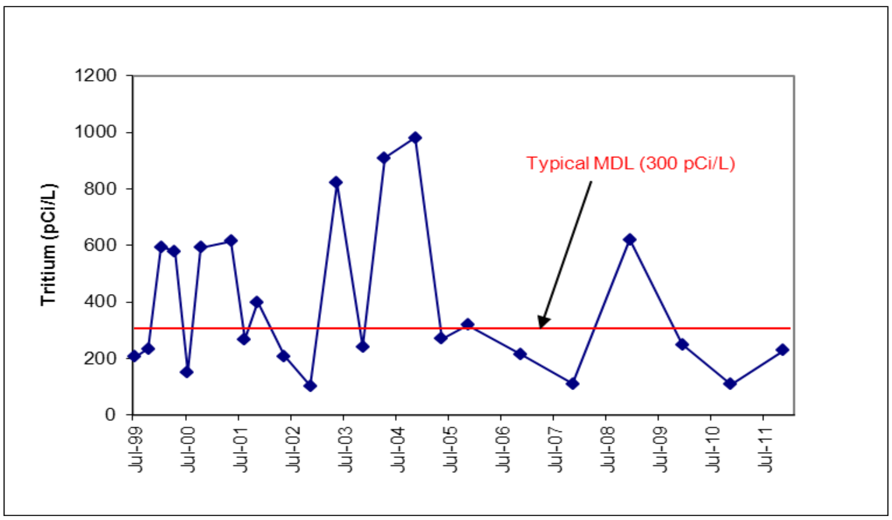
Although there are periodic detections of low levels of tritium in the groundwater (<1,000 pCi/L), the low levels suggest that the building structure and associated stormwater controls are effectively preventing significant rainwater infiltration into activated soil below the building. Continued surveillance of groundwater quality in the Building 914 area is required.

4.1.5.4 AGS Building 914 Recommendation

The following is recommended for the AGS Building 914 groundwater monitoring program:

- For 2012, the monitoring frequency for the AGS Building 914 area wells will continue to be annually.

Figure 4-4.
AGS Building 914 Transfer Tunnel
Maximum Tritium Concentrations in Downgradient Wells



4.1.6 Former g-2 Beam Stop

The g-2 experiment operated from April 1997 until April 2001. The g-2 Beam Stop is composed of iron and is covered by soil. Like other beam loss areas in the AGS complex, the g-2 beam stop was an area where the soil surrounding the stop became activated by the interaction with secondary particles. To prevent rainwater from infiltrating the soil surrounding the beam stop, BNL installed a gunite cap over the stop area before the start of beam line operations.

In November 1999, tritium and sodium-22 were detected in groundwater monitoring wells approximately 250 feet downgradient of the g-2 experimental area. A groundwater investigation revealed a narrow plume of tritium with a maximum tritium concentration of 1,800,000 pCi/L. Sodium-22 was also detected, but at a maximum concentration of only 60 pCi/L, or 15 percent of the 400 pCi/L DWS.

Following the discovery, an investigation into the source of the contamination revealed that the tritium originated from activated soil shielding adjacent to the g-2 experiment's VQ-12 magnet. There was no evidence that any of the tritium originated from the beam stop area. The VQ-12 magnet section of the beam line was not a designed beam loss area, and the gunite cap installed over the nearby beam stop did not protect the VQ-12 area. In December 1999, an impermeable cap was installed over the VQ-12 soil activation area. This cap was joined to the previously installed beam stop cap. In September

2000, the activated soil shielding and associated tritium plume were designated as new sub-Area of Concern 16T. The selected remedial actions for the g-2 tritium source area and plume are documented in a ROD that was signed in May 2007 (BNL 2007b). The monitoring program for the VQ-12 source area and g-2 tritium plume are described in **Section 4.2**.

4.1.6.1 Former g-2 Beam Stop Groundwater Monitoring

Well Network

Groundwater quality downgradient of the former g-2 beam stop is monitored using wells 054-67, 054-68, 054-125, and 054-126 (**Figure 4-1**). These wells are cross gradient of the VQ-12 source area monitoring wells described in **Section 4.2**.

Sampling Frequency and Analysis

During 2011, the former g-2 Beam Stop wells were monitored annually, and the samples were analyzed for tritium (**Table 1-6**).

4.1.6.2 Former g-2 Beam Stop Monitoring Well Results

During 2011, a trace level of tritium was detected in downgradient monitoring well 054-68 at a concentration of 190 +/- 100 pCi/L (with a MDA of 120 pCi/L).

4.1.6.3 Former g-2 Beam Stop Groundwater Monitoring Program Evaluation

The 2011 monitoring data were evaluated using the following Data Quality Objective statement.

Is there a continuing source of contamination? If present, has the source been remediated or controlled?

Monitoring of wells downgradient of the former g-2 Beam Stop indicates that the cap is effectively preventing rainwater from infiltrating the activated soil shielding.

4.1.6.4 Former g-2 Beam Stop Recommendation

The following is recommended for the former g-2 Beam Stop groundwater monitoring program:

- During 2012, the former g-2 Beam Stop area wells will continue to be monitored on an annual basis.

4.1.7 AGS J-10 Beam Stop

In 1998, BNL established a new beam stop at the J-10 (12 o’clock) section of the AGS Ring, replacing E-20 as the preferred repository for any beam that might be lost in the AGS Ring (**Figure 4-1**). The J-10 Beam Stop area of the AGS Ring is covered by layers of soil-crete (a sand and concrete mixture), which reduce the ability of rainwater to infiltrate the potentially activated soil shielding. BNL also constructed a gunite cap over a small section of the J-10 region that did not have a soil-crete cover before beam stop operations began.

4.1.7.1 AGS J-10 Beam Stop Groundwater Monitoring

Well Network

The monitoring well network for the J-10 Beam Stop consists of upgradient well 054-62 and downgradient wells 054-63 and 054-64 (**Figure 4-1**).

Sampling Frequency and Analysis

During 2011, the three J-10 Beam Stop wells were monitored one time and the samples were analyzed for tritium (**Table 1-6**).

4.1.7.2 AGS J-10 Beam Stop Monitoring Well Results

Although low levels of tritium (up to 1,000 pCi/L) have been routinely detected in groundwater downgradient of the J-10 beam stop since 2001, tritium was not detected in either of the downgradient wells during 2011 (**Figure 4-5**).

4.1.7.3 AGS J-10 Beam Stop Monitoring Program Evaluation

The 2011 monitoring data were evaluated using the following Data Quality Objective statement.

Is there a continuing source of contamination? If present, has the source been remediated or controlled?

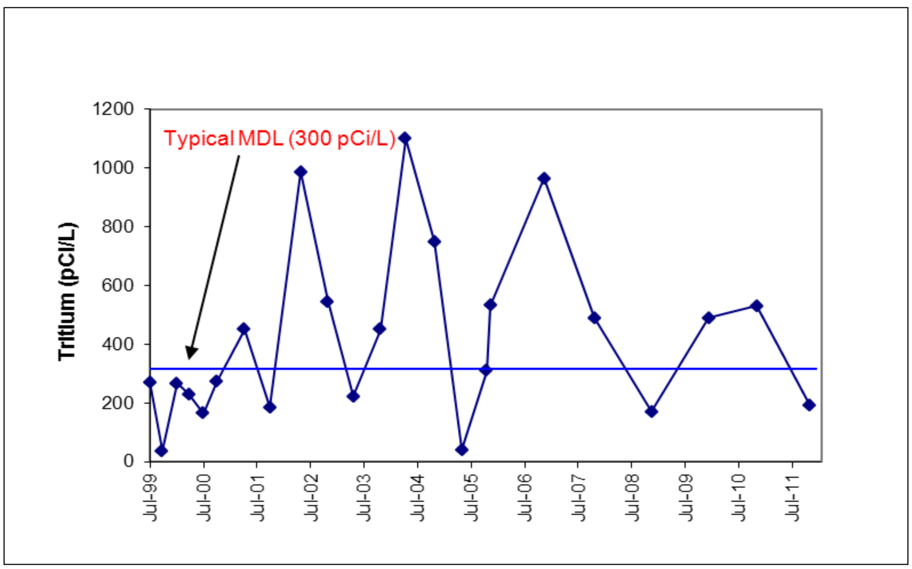
Groundwater monitoring results indicate that the engineered controls in place at J-10 are preventing significant rainwater infiltration into the activated soil shielding. However, the occasional detection of low levels of tritium (up to 1,000 pCi/L), indicates some water is infiltrating through the activated soil shielding. Continued groundwater monitoring is required to verify the long-term effectiveness of the controls.

4.1.7.4 AGS J-10 Beam Stop Recommendation

The following is recommended for the AGS J-10 Beam Stop groundwater monitoring program:

- During 2012, the J-10 Beam Stop area wells will continue to be sampled on an annual basis.

Figure 4-5.
AGS J-10 Beam Stop
Maximum Tritium Concentrations in Downgradient Wells



4.1.8 Former AGS U-Line Beam Target and Stop Areas

The U-Line beam target area was in operation from 1974 through 1986. The entire assembly was in a ground-level tunnel covered with an earthen berm. Although the U-Line beam target has not been in operation since 1986, the associated tunnel, shielding, and overlying soil remain in place. The former U-Line target and beam stop are areas where secondary particles interacted with soil surrounding the tunnel.

In late 1999, BNL installed monitoring wells downgradient of the target area to evaluate whether residual activated soil shielding was impacting groundwater quality. Subsequent monitoring found low levels of tritium and sodium-22, but at concentrations well below the applicable DWS. In early 2000, BNL installed temporary wells downgradient of the former U-Line beam stop, which is approximately

200 feet north of the target area. Tritium was detected at concentrations up to 71,600 pCi/L. Sodium-22 was not detected in any of the samples. During 2000, an impermeable cap was installed over the former U-Line beam stop soil activation area to prevent rainwater infiltration and the continued leaching of radionuclides out of the soil shielding.

4.1.8.1 Former AGS U-Line Groundwater Monitoring

Well Network

The former U-Line area is monitored by one upgradient well (054-127), three downgradient wells that monitor the former U-Line target area (054-66, 054-129, and 054-130), and three wells that monitor the former U-Line beam stop area (054-128, 054-168, and 054-169) (**Figure 4-1**).

Sampling Frequency and Analysis

During 2011, the former U-Line area wells were monitored one time, and the samples were analyzed for tritium (**Table 1-6**).

4.1.8.2 Former AGS U-Line Groundwater Monitoring Well Results

Former U-Line Target Area

Although low levels of tritium have been routinely detected in wells downgradient of the former U-line target since 2000, no tritium was detected in the groundwater during 2011 (**Figure 4-6**).

Former U-Line Beam Stop Area

Since the cap was installed over the former U-line beam stop in 2000, tritium concentrations in downgradient wells have been well below the 20,000 pCi/L DWS (**Figure 4-7**). During 2011, only trace levels of tritium were detected in two, with a maximum concentration of 171 pCi/L.

4.1.8.3 Former AGS U-Line Groundwater Monitoring Program Evaluation

The 2011 monitoring data were evaluated using the following Data Quality Objective statement.

Is there a continuing source of contamination? If present, has the source been remediated or controlled?

The significant decrease in tritium concentrations in groundwater since 2000 indicates that the impermeable cap installed over the former U-Line Beam Stop has been effective in stopping rainwater infiltration into the residual activated soil. Monitoring of the groundwater downgradient of the former U-Line target indicates that only low levels of tritium are being periodically released.

4.1.8.4 Former AGS U-Line Recommendation

The following is recommended for the former AGS U-Line groundwater monitoring program:

- For 2012, the former U-Line area wells will continue to be monitored for tritium on an annual basis.

4.2 g-2 Tritium Source Area and Groundwater Plume

In November 1999, tritium was detected in the groundwater near the g-2 experiment at concentrations above the 20,000 pCi/L DWS. Sodium-22 was also detected in the groundwater, but at concentrations well below the 400 pCi/L DWS. An investigation into the source of the contamination revealed that the tritium and sodium-22 originated from activated soil shielding located adjacent to the g-2 target building, where approximately five percent of the beam was inadvertently striking one of the beam line magnets (magnet VQ-12). Rainwater was able to infiltrate the activated soils and carry the tritium and sodium-22 into the groundwater. To prevent additional rainwater infiltration into the activated soil shielding, a concrete cap was constructed over the area in December 1999. Other corrective actions included refocusing the beam and improved beam loss monitoring to reduce additional soil activation, stormwater management improvements, and additional groundwater monitoring. The g-2 experiment was decommissioned in April 2001.

Figure 4-6.
Former AGS U-Line Beam Target
Maximum Tritium Concentrations in Downgradient Wells

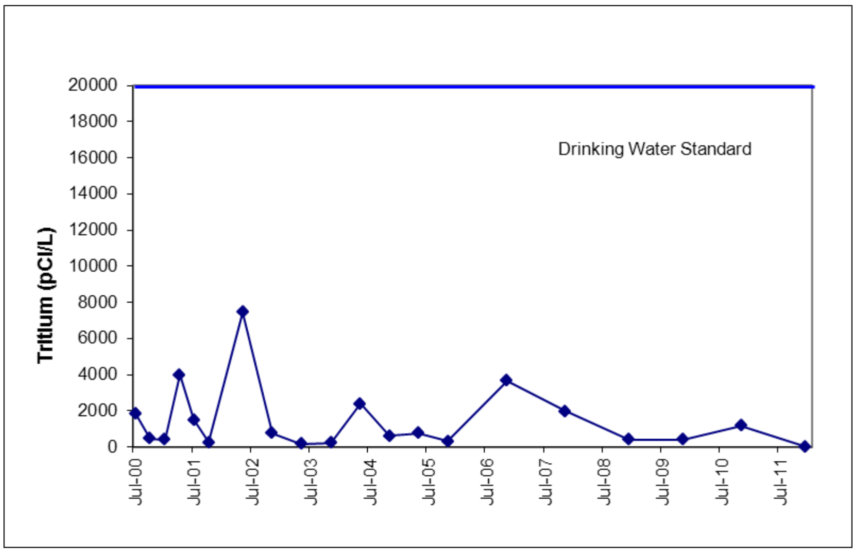
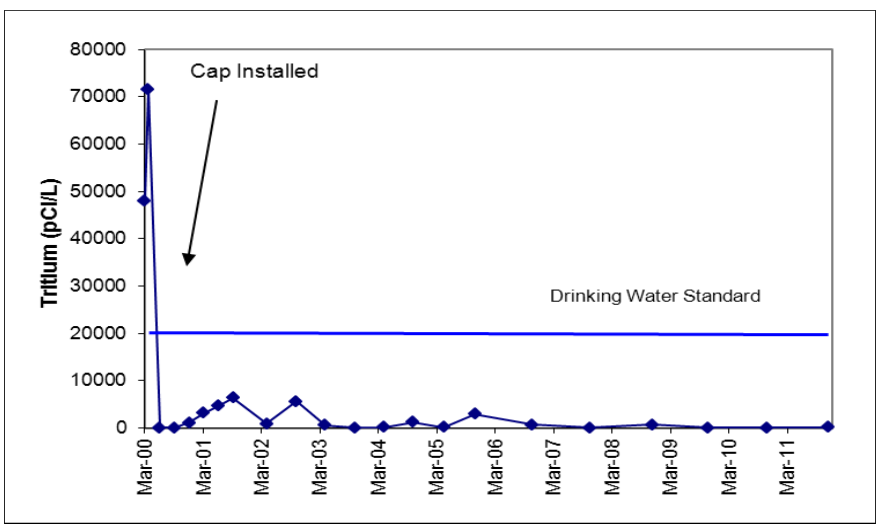


Figure 4-7.
Former AGS U-Line Beam Stop
Maximum Tritium Concentrations in Downgradient Wells



Following the concurrence from the NYSDEC, a ROD was signed by the DOE and EPA in early 2007 (BNL 2007a). This ROD requires continued routine inspection and maintenance of the impermeable cap, groundwater monitoring of the source area to verify the continued effectiveness of the stormwater controls, and monitoring the tritium plume until it attenuates to less than the 20,000 pCi/L DWS. Monitoring of the source area will continue for as long as the activated soils have the potential to impact groundwater quality. Contingency actions have been developed and implemented if tritium levels exceeding 1,000,000 pCi/L are detected within the plume, or if the tritium plume does not attenuate to less than 20,000 pCi/L before reaching Brookhaven Avenue. In December 2011, tritium was detected above the 20,000 pCi/L trigger level in several temporary wells installed south of Brookhaven Avenue, with a maximum concentration of 58,600 pCi/L. In response to exceeding the ROD trigger, BNL informed the regulatory agencies about the monitoring results and recommended re-installing temporary wells south of Brookhaven Avenue in June 2012 to re-characterize this plume segment. BNL will then evaluate whether additional actions are required.

4.2.1 g-2 Tritium Source Area and Plume Groundwater Monitoring

Well Network

The g-2 tritium plume is currently monitored in two general areas: the source area (including the area to the east of Building 912), and the downgradient segments of the plume currently located south of the National Synchrotron Light Source (NSLS). Monitoring of the source area is accomplished using six wells immediately downgradient of the VQ-12 source (054-07, 054-124, 054-126, 054-184, 054-185, and 064-95) and 12 wells east of Building 912 (065-02, 065-121, 065-122, 065-123, 065-124, 065-173, 065-193, 065-194, 065-321, 065-322, 065-323, and 065-324). Monitoring of the downgradient sections of the tritium plume located south of the NSLS is accomplished using temporary wells (**Figures 4-8** and **4-9**).

Sampling Frequency and Analysis

During 2011, the wells located immediately downgradient of the g-2 VQ-12 source area were monitored quarterly, and the samples were analyzed for tritium (**Table 1-6**). Two times during the year, samples from the four wells (054-07, 054-184, 054-185, and 064-95) located immediately downgradient of the source area were also analyzed for sodium-22. The wells located east of Building 912 were sampled two times during the year.

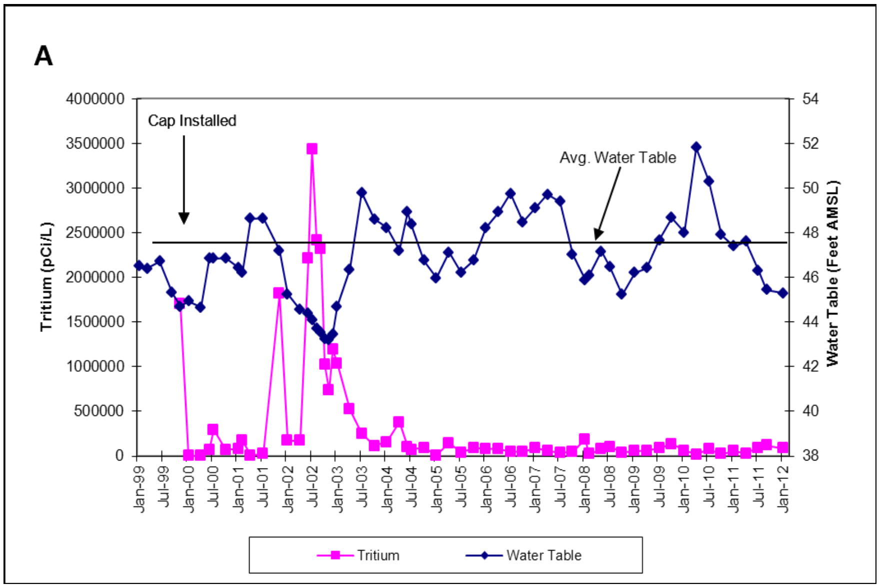
During the 4th Quarter of 2011 and 1st Quarter of 2012, nine temporary wells were installed to track the downgradient portion of the g-2 plume in the vicinity of the NSLS and an area south of Brookhaven Avenue. (**Figure 4-8**).

4.2.2 g-2 Tritium Source Area and Plume Monitoring Well Results

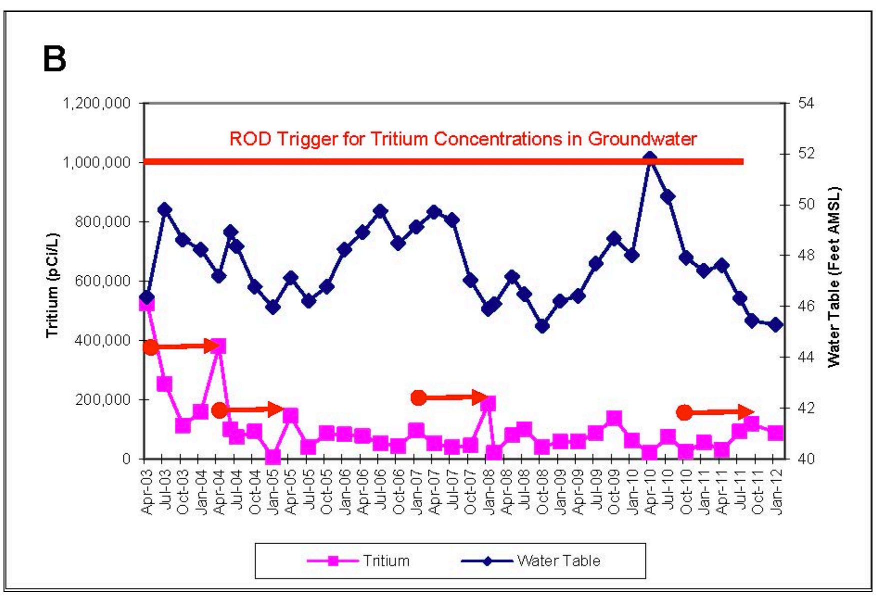
Source Area Monitoring Results

Monitoring data indicate that high levels of tritium have entered the groundwater as a series of short-term releases (**Figure 4-10**). Following the initial releases of tritium that occurred prior to cap installation in December 1999, subsequent periodic releases, characterized by short-term spikes in tritium concentrations, appear to be related to changes in the water-table elevation. As the water table rises, residual tritium is flushed from the vadose (unsaturated) zone close to the water table. Water levels during the spring of 2010 were the highest observed in almost 50 years of record for the BNL site, to a level of approximately 52 feet above mean sea level (or approximately 4 feet above average). Groundwater travel time from the source area to the first set of source area monitoring wells is approximately one year. Elevated tritium concentrations were observed in the source area monitoring wells starting in July 2011, with concentrations up to 91,800 pCi/L in well 054-185. By September 2011, tritium concentrations increased to 119,000 pCi/L in source area monitoring well 054-184. During the first two quarters of 2012, the maximum tritium concentrations were 88,200 pCi/L and 51,699 pCi/L, respectively. The overall reductions in tritium concentrations since 2003 suggest that the amount of residual tritium that is available to be flushed out of the deep vadose zone is decreasing. During the 1st and 3rd Quarters of 2011, samples from four source area wells were also analyzed for sodium-22. The maximum sodium-22 concentration was 30.7 pCi/L, detected in a sample from well 054-185. The DWS for sodium-22 is 400 pCi/L.

Figure 4-10. g-2 Tritium Source Area
Maximum Tritium Concentrations in Downgradient Wells
A: Maximum tritium concentrations observed from 1999 through January 2012 in groundwater downgradient of the VQ-12 source area. The travel time from the source area to the first set of downgradient monitoring wells is approximately one year.



B: Comparison of January 2003–January 2012 results to the ROD trigger level. Red arrows represent approximately 1 year of travel time from the source area to the first set of downgradient monitoring wells.



Downgradient Areas of the Plume

The extent of the g-2 tritium plume during the 4th Quarter of 2011 and 1st Quarter of 2012 is depicted on **Figure 4-8**. **Figure 4-9** provides a cross-sectional view of the plume. Monitoring of the downgradient areas of the plume is accomplished using temporary wells. As described in **Section 4.1.1.2**, tritium contamination that is traceable to the g-2 source area continues to be detected in monitoring wells located downgradient of AGS Building 912. During 2011, the maximum concentration immediately downgradient of Building 912 was 7,050 pCi/L in a sample from well 065-122 collected in March.

Between December 2011 and February 2012, eight temporary wells were installed to track the downgradient portion of the g-2 plume (**Figure 4-8**). Sample results for the temporary wells are summarized on **Tables 4.2-1** and **4.2-2**. The downgradient portion of the tritium plume (as defined by concentrations >20,000 pCi/L) is breaking up into discrete segments. The downgradient portion of the g-2 plume is located entirely to the south of the NSLS (Geoprobe Transect F). In the temporary wells installed south of Brookhaven Avenue, tritium levels exceeded the 20,000 DWS in well G2-GP-111 at 58,600 pCi/L and in well G2-GP-112 at 27,100 pCi/L. The detection of tritium at concentrations >20,000 pCi/L south of Brookhaven Avenue triggered the contingency action defined in the ROD.

4.2.3 g-2 Tritium Source Area and Plume Groundwater Monitoring Program Evaluation

The 2011 monitoring data were evaluated using the following Data Quality Objective statements.

1. *Is there a continuing source of contamination? If present, has the source been remediated or controlled?*

Although tritium continues to be detected in the groundwater downgradient of the g-2 source area at concentrations that exceed the 20,000 pCi/L DWS, the reduction in tritium concentrations since 2003 indicates that the cap is effectively preventing rainwater from infiltrating the activated soil shielding. As discussed previously, a comparison of tritium levels in the source area monitoring wells and water-table elevation data suggests that the periodic natural fluctuations in the water table have released residual tritium from the deep vadose zone (i.e., unsaturated soil immediately above the water table). There appears to be good correlation between high tritium concentrations detected in monitoring wells immediately downgradient of the source area, and the water-table elevation about one year before the sampling (**Figure 4-10**). It is believed that this tritium was mobilized to the deep vadose zone soil close to the water table before the cap was constructed in December 1999. Once the cap was in place, the lack of additional rainwater infiltration kept the tritium in the vadose zone from migrating into the groundwater until the significant rise in water table mobilized it.

2. *Were unexpected levels of tritium detected?*

The observed tritium levels in the source area monitoring wells are consistent with previous surveillance results. Over time, the amount of tritium remaining in the vadose zone near the water table is expected to continue to decrease by means of the water table flushing mechanism and by natural radioactive decay. The detection of tritium south of Brookhaven Avenue at concentrations above the 20,000 pCi/L DWS is not consistent with the model prediction presented in the g-2 Focused Feasibility Study (BNL, 2006).

3. *Is the plume naturally attenuating as expected?*

The detection of tritium south of Brookhaven Avenue at concentrations >20,000 pCi/L is not consistent with g-2 Focused Feasibility Study model predictions of decay and dispersion effects on the plume segments with distance from the source area. Based upon previous observations of the natural attenuation of tritium in the Upper Glacial aquifer, the tritium concentrations observed in December 2011 (maximum of 58,600 pCi/L) are expected to attenuate to less than 20,000 pCi/L within a short distance south of Brookhaven Avenue. As part of the ROD contingency action for the detection of tritium at concentrations >20,000 pCi/L south of Brookhaven Avenue, additional temporary wells will be installed south of Brookhaven Avenue during the summer of 2012 to verify the expected rate of attenuation (**Section 4.2.4**).

4. Has the groundwater cleanup goal of meeting MCLs been achieved?
Not at this time.

4.2.4 g-2 Tritium Source Area and Plume Recommendations

As required by the ROD, BNL will continue to conduct routine inspections of the g-2 cap, monitor groundwater quality downgradient of the source area, and monitor the downgradient plume segments until tritium levels drop below the 20,000 pCi/L DWS. The following are recommended for the g-2 Tritium Source Area and Plume groundwater monitoring program:

- During 2012, the monitoring wells immediately downgradient of the source area will continue to be sampled quarterly for tritium. Because sodium-22 concentrations have been consistently well below the 400 pCi/L DWS, gamma spectroscopy analyses will be reduced from semiannually to annually. The Building 912 area wells will continue to be sampled semiannually for tritium.
- During the summer of 2012, the downgradient segment of the g-2 plume located south of Brookhaven Avenue will be monitored by re-installing Transect G Geoprobe wells G2-GP-111 and G2-GP-112, and by installing additional temporary wells along newly established Geoprobe transects H and I, which will be located approximately 150 and 250 feet downgradient of Geoprobe Transect G. If tritium concentrations in these wells are found to exceed 20,000 pCi/L additional temporary wells will be installed during the 4th Quarter of 2012 to evaluate the continued attenuation of the plume. Based upon the monitoring results, BNL will evaluate whether additional actions are required to limit plume growth. This evaluation will be submitted to the regulators in the fall of 2012.

4.3 Brookhaven Linac Isotope Producer (BLIP)

When the Brookhaven Linac Isotope Producer (BLIP) is operating, the Linac delivers a beam of protons that strike a series of targets in the BLIP target vessel, positioned 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 300-gallon, closed-loop primary cooling system. During irradiation, several radionuclides are produced in the cooling water, and the soil immediately outside the tank is activated by the production of secondary particles at the target.

As part of a 1985 redesign of the vessel, leak detection devices were installed and the open space between the water-filled shaft and the vessel's outer wall became a secondary containment system for the primary vessel. The BLIP target vessel system conforms to Suffolk County Article 12 requirements, and is registered with the SCDHS. The BLIP facility also has a 500-gallon UST for storing 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 the 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 the groundwater approximately 40 feet downgradient of the BLIP target vessel. Due to the activation of the soil shielding surrounding the BLIP target vessel and the detection of tritium and sodium-22 in groundwater, the BLIP facility was designated as sub-AOC 16K under the IAG.

In 1998, BNL made improvements to the stormwater management program at BLIP in an effort to prevent additional rainwater infiltration into the activated soil below the building. The BLIP building's roof drains were redirected away from the building, existing paved areas on the south side of the building were resealed, and a gunite cap was installed on the remaining three sides of the building. In May and June 2000, BNL undertook additional protective measures by injecting colloidal silica grout (also known as a Viscous Liquid Barrier) into the activated soil. The grout reduces the permeability of the soil, thus further reducing the ability of rainwater to leach tritium and sodium-22 from the activated soils should the primary stormwater controls fail.

In late 2004, BNL also constructed a new protective cap over the beam line that runs from the Linac to the BLIP facility. The new cap was installed because direct soil measurements and beam loss calculations indicated that the tritium and sodium-22 concentrations in soils surrounding these beam lines could result in stormwater leachate concentrations that exceed the criteria described in the *Accelerator Safety* SBMS (Standards Based Management System) subject area.[2]

Following concurrence from the NYSDEC, a ROD was signed by the DOE and EPA in early 2007 (BNL 2007a). This ROD requires continued routine inspection and maintenance of the impermeable cap, and groundwater monitoring to verify the continued effectiveness of the stormwater controls. Maintenance of the cap and groundwater monitoring will continue for as long as the activated soils have the potential to impact groundwater quality.

4.3.1 BLIP Groundwater Monitoring

Well Network

The monitoring well network for the BLIP facility consists of one upgradient (054-61) and five downgradient wells (064-47, 064-48, 064-49, 064-50, and 064-67). These wells provide a means of verifying that the engineered and administrative controls described above are effective in protecting groundwater quality (**Figure 4-1**).

Sampling Frequency and Analysis

During 2011, one upgradient (064-46) and two downgradient wells (064-49 and 064-50) were sampled once, and the three wells located immediately downgradient of the BLIP (064-47, 064-48, 064-67) were monitored twice. The groundwater samples were analyzed for tritium (**Table 1-6**).

4.3.2 BLIP Monitoring Well Results

Monitoring data collected from January 1999 to July 2000 indicated that the initial corrective actions taken during 1998 were highly effective in preventing the release of tritium and sodium-22 from the activated soil surrounding the BLIP target vessel. Prior to May 2000, tritium and sodium-22 concentrations in wells directly downgradient of BLIP were <3,000 pCi/L and <5 pCi/L, respectively. However, significant increases in tritium concentrations were observed in groundwater samples collected after the silica grout injection took place in late May and early June 2000 (**Figure 4-11**). It was determined that tritium in the soil pore water near the target vessel was displaced by the grout. Tritium concentrations in the groundwater immediately downgradient of BLIP increased to 56,500 pCi/L by October 2000. By December 2000, tritium concentrations dropped to below 20,000 pCi/L, and remained below this level throughout 2001 and 2002. From 2003 through January 2006, there were several short-duration periods when tritium concentrations once again exceeded 20,000 pCi/L. Since April 2006, tritium levels have remained below the 20,000 pCi/L DWS. During 2011, the maximum tritium concentration was 2,000 pCi/L.

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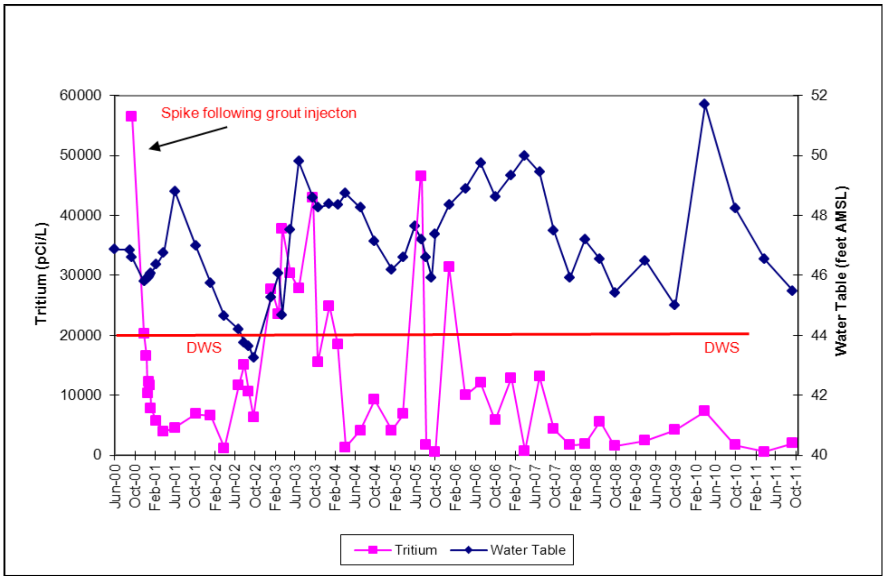
[2] The BNL *Accelerator Safety* SBMS subject area requires stormwater controls where rainwater infiltration into activated soil shielding could result in leachate concentrations that exceed five percent of the drinking water standard for tritium (i.e., 1,000 pCi/L) or 25 percent of the drinking water standard for sodium-22 (i.e., 100 pCi/L).

Figure 4-11.
BLIP Facility
Tritium Concentrations vs. Water-Table Position, in Wells 40 Feet Downgradient



Note: Approximate groundwater travel time from directly below the BLIP target to the first set of monitoring wells (e.g., well 064-67) is approximately 89 days, based on a distance of 40 feet and groundwater velocity of 0.45 ft/day.

4.3.3 BLIP Groundwater Monitoring Program Evaluation

The 2011 monitoring data were evaluated using the following Data Quality Objective statements.

Is there a continuing source of contamination? If present, has the source been remediated or controlled?

Although tritium continues to be detected in the groundwater downgradient of BLIP, the tritium concentrations have remained below the 20,000 pCi/L DWS since early 2006. The BLIP cap is in good condition, and is effectively controlling stormwater infiltration. Although direct inspection of the silica grout is not possible, it is expected to be in good condition and would be effective in preventing significant leaching of tritium from the activation zone should the primary stormwater controls fail. The short-term concentration increases observed in 2005 and 2006 correlated to increases in the elevation of the water table (**Figure 4-11**). As the water table rises, older tritium that had leached from the soil before the cap was installed in 1998 or that was released during the grout injection project is flushed from the soil close to the water table. The amount of tritium remaining in the vadose zone close to the water table is expected to decline over time, due to this flushing mechanism and by natural radioactive decay. Although the water table has increased to nearly 50 feet AMSL several times since 2006, with the highest level observed during 2010, there has not been a corresponding increase in tritium concentrations in groundwater. This suggests that the amount of tritium available to be flushed from the deep vadose zone by fluctuations in water-table position has decreased.

Were unexpected levels of contamination detected?

The observed tritium levels are consistent with previous surveillance results.

Has the groundwater cleanup goal of meeting MCLs been achieved?
Yes. However, the activated soil shielding below the BLIP facility needs to be protected from rainwater infiltration. Therefore, the cap needs to be maintained and groundwater surveillance is required to verify continued effectiveness of the stormwater controls.

4.3.4 BLIP Recommendation

As required by the ROD, BNL will continue to conduct routine inspections of the cap, and to monitor groundwater quality downgradient of the BLIP facility. The following is recommended for the BLIP groundwater monitoring program:

- Because tritium levels in groundwater have been continuously below the 20,000 pCi/L DWS since January 2006, the monitoring frequency for downgradient monitoring wells 064-47, 064-48, and 064-67 will continue to be semiannually.
- Sampling frequency for upgradient well 064-46 will continue to be annually. The routine sampling of downgradient wells 064-49 and 064-50 will be discontinued starting in 2013.

4.4 Relativistic Heavy Ion Collider (RHIC)

Beam line interactions at the Relativistic Heavy Ion Collider (RHIC) Collimators and Beam Stops produce secondary particles that interact with soil surrounding the 8 o'clock and 10 o'clock portions of the RHIC tunnel and the W-Line Stop (**Figure 4-12**). These interactions result in the production of tritium and sodium-22, which can be leached out of the soil by rainwater. Although the level of soil activation is expected to be minor, before RHIC operations began in 2000 BNL installed impermeable caps over these beam loss areas to prevent potential impact to groundwater quality.

4.4.1 RHIC Groundwater Monitoring

Well Network
Thirteen shallow wells are used to verify that the 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 are in the collimator area, and one well is downgradient of the W-Line Beam Stop (**Figure 4-12**). As part of BNL's Environmental Surveillance program, surface water samples are also collected from the Peconic River, both upstream (location HY) and downstream (location HV) of the beam stop area (**Figure 4-12**). These monitoring results are used to verify that potentially contaminated groundwater is not entering the Peconic River stream bed as base flow during high water-table conditions.

Sampling Frequency and Analysis
During 2011, groundwater samples were collected from the RHIC monitoring wells on a semiannual schedule, and the samples were analyzed for tritium (**Table 1-6**). Routine analysis for sodium-22 was dropped from the groundwater monitoring program in 2002 because tritium is the best indicator of possible cap failure (i.e., tritium is more leachable than sodium-22, and it migrates at the same rate as groundwater). Surface water samples were collected quarterly, and were analyzed for tritium and gamma emitting radionuclides (such as sodium-22).

4.4.2 RHIC Monitoring Well Results

During 2011, tritium was not detected in any of the RHIC monitoring wells. Furthermore, no tritium or sodium-22 was detected in surface water samples from downstream location HV.

4.4.3 RHIC Groundwater Monitoring Program Evaluation

The 2011 monitoring data were evaluated using the following Data Quality Objective statement.

Has the source of potential contamination been controlled?

Groundwater and surface water monitoring data continue to demonstrate that the impermeable caps installed over the RHIC Beam Stop and Collimator areas are effectively preventing rainwater infiltration into the activated soil shielding.

4.4.4 RHIC Recommendation

The following is recommended for the RHIC groundwater monitoring program:

- During 2012, groundwater samples will continue to be collected on a semiannual basis. Surface water samples will also continue to be collected quarterly as part of the Environmental Surveillance program.

4.5 Brookhaven Medical Research Reactor (BMRR)

The Brookhaven Medical Research Reactor (BMRR) was a 3-megawatt light water reactor that was used for biomedical research. Research operations at the BMRR ended in December 2000. All spent fuel was removed in 2003 and the primary cooling water system was drained. BNL is preparing plans to permanently decommission the facility.

When it was operating, the BMRR primary cooling water system contained 2,550 gallons of water that contained approximately 5 curies (Ci) of tritium. Unlike the HFBR, the BMRR does not have a spent fuel storage canal or pressurized imbedded piping systems that contained radioactive liquids. Historically, fuel elements that required storage were either stored within the reactor vessel, or they were transferred to the HFBR spent fuel canal. The BMRR primary cooling water system piping is fully exposed in the containment structure and was accessible for routine visual inspections while it was operating.

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 20,000 pCi/L DWS. The highest observed tritium concentration since the start of groundwater monitoring was 17,100 pCi/L in October 1999. The tritium currently detected in groundwater is believed to have originated from the historical discharge of small amounts of BMRR primary cooling water to a basement floor drain and sump system that may have leaked. Although the last discharge of primary cooling water to the floor drain system occurred in 1987, the floor drains continued to be used for secondary (non-radioactive) cooling water until 1997. The infiltration of this water may have promoted the movement of residual tritium from the soil surrounding the floor drain piping system to the groundwater. The floor drains were permanently sealed in 1998.

4.5.1 BMRR Groundwater Monitoring

Well Network

The monitoring well network for the BMRR facility consists of one upgradient and three downgradient wells (**Figure 4-13**). Samples collected from the four groundwater monitoring wells are used to determine whether residual tritium in the soils below the BMRR is continuing to impact groundwater quality.

Sampling Frequency and Analysis

The BMRR wells are currently sampled once every two years. Samples were not collected in 2011. Sampling will next occur during 2012, and the samples will be analyzed for tritium, gamma emitting radionuclides, gross alpha, and gross beta.

4.5.2 BMRR Monitoring Well Results

Monitoring conducted since 1997 has shown that tritium concentrations in the BMRR wells have always been below the 20,000 pCi/L DWS (**Figure 4-14**). During the last sample period in 2010, the maximum tritium concentration was 3,790 pCi/L detected in downgradient well 084-13. Furthermore, gamma, gross alpha, and gross beta analyses have not indicated the presence of any other reactor-related radionuclides.

4.5.3 BMRR Groundwater Monitoring Program Evaluation

Monitoring data were evaluated using the following Data Quality Objective statement.

Is there a continuing source of contamination? If present, has the source been remediated or controlled?

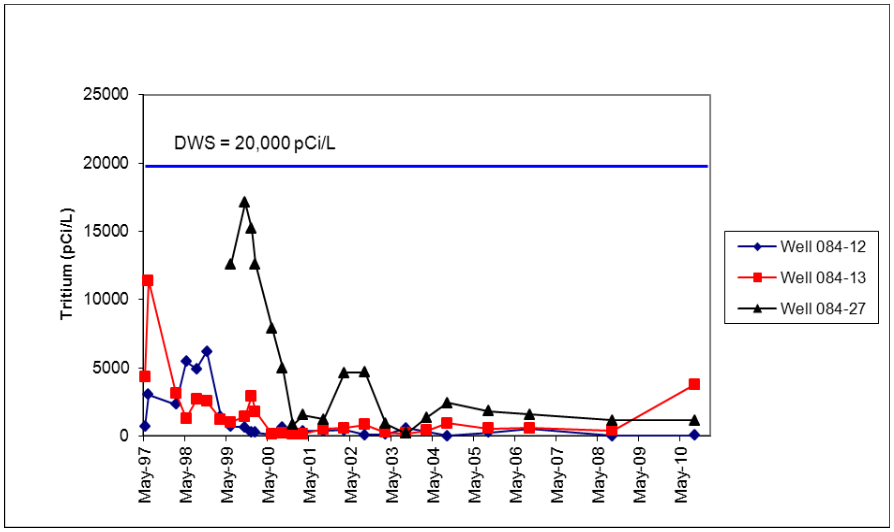
The continued detection of low levels of tritium in the BMRR monitoring wells indicates that residual contamination remains in the vadose zone soils below the facility. However, tritium concentrations in groundwater have never exceeded the 20,000 pCi/L DWS, and have been <5,000 pCi/L since September 2000. The BMRR structure is effectively preventing rainwater infiltration into the underlying soils, and therefore reducing the movement of residual tritium from the soil to the groundwater.

4.5.4 BMRR Recommendation

The following is recommended for the BMRR groundwater monitoring program:

- The monitoring frequency for the BMRR wells will continue to be once every two years, with the next set of samples being collected in 2012.

Figure 4-14.
BMRR
Tritium Concentrations in Downgradient Wells



4.6 Sewage Treatment Plant (STP)

The STP processes sanitary wastewater from BNL research and support facilities. Treated effluent from the STP is discharged to the Peconic River under a NYSDEC SPDES permit (NY-0005835). On average, 0.5 million gallons per day (MGD) of waste water are processed during the summer and 0.3 MGD of water are processed during the rest of the year. Before discharge into the Peconic River, the sanitary waste stream is fully treated by: 1) primary clarification to remove settleable solids and floatable materials; 2) aerobic oxidation for secondary removal of the biological matter and nitrification of ammonia; 3) secondary clarification; 4) sand filtration for final effluent polishing; and 5) ultraviolet disinfection for bacterial control. Oxygen levels are regulated during the treatment process to remove nitrogen biologically, using nitrate-bound oxygen for respiration.

Wastewater from the STP clarifier is released to the sand filter beds, where water percolates through 3 feet of sand before being recovered by an underlying clay tile drain system, which transports the water to the discharge point at the Peconic River (SPDES Outfall 001). Approximately 15 percent of the water released to the filter beds is either lost to evaporation or to direct groundwater recharge. At the present time, six sand filter beds are used in rotation.

Two emergency hold-up ponds are located east of the sand filter bed area. The hold-up ponds are used to store sanitary waste in the event of mechanical problems at the plant or if the influent contains contaminants in concentrations exceeding BNL administrative limits and/or SPDES permit effluent release criteria. The hold-up ponds have a combined holding capacity of nearly 6 million gallons of water, and provide BNL with the ability to divert all sanitary system effluent for approximately one week. The hold-up ponds are equipped with fabric-reinforced plastic liners that are heat-welded along all seams. In 2001, improvements were made with the addition of new primary liners and a leak detection system. The older liners now serve as secondary containment.

4.6.1 STP Groundwater

Well Network

In addition to the comprehensive influent and effluent monitoring program at the STP, the groundwater monitoring program is designed to provide a secondary means of verifying that STP operations are not impacting groundwater quality. Six wells (038-02, 038-03, 039-07, 039-08, 039-86, and 039-87) are used to monitor groundwater quality in the filter bed area, and three wells (039-88, 039-89, and 039-90) are monitored in the holding pond area (**Figure 4-15**).

Sampling Frequency and Analysis

The six STP Filter Bed and three Holding Pond area monitoring wells are sampled annually. The samples from the Filter Bed area wells are analyzed for VOCs, anions (sulfate, chloride, and nitrate), metals, tritium, gross alpha, gross beta, and gamma emitting radionuclides and the wells positioned downgradient of the holding ponds were analyzed for VOCs, tritium, gross alpha, gross beta, and gamma emitting radionuclides (**Table 1-6**).

4.6.2 STP Monitoring Well Results

Radiological Analyses

Although most gross alpha and gross beta levels in samples collected from the STP wells were generally typical of ambient (background) levels, elevated concentrations continue to be detected in Filter Bed area well 038-02, with gross alpha and beta levels in unfiltered samples of 13.8 pCi/L and 15.2 pCi/L, respectively. It is likely that these elevated levels are due to natural clay minerals entrained in the samples. To quantify the effect that entrained silt and clay particles have on gross alpha and beta concentrations, filtered samples were collected from well 038-02. Analytical results indicate that the filtered samples had significantly lower gross alpha and gross beta concentrations of <1.1 pCi/L and 1.1 pCi/L, respectively. Tritium was not detected in any of the STP area wells, and no BNL-related gamma emitting radionuclides were detected.

Non-Radiological Analyses

All water quality and most metals concentrations were below the applicable AWQS. Slightly elevated aluminum, iron, sodium, manganese, and thallium were periodically detected in unfiltered groundwater samples collected from three filter bed area wells at concentrations slightly above the applicable AWQS, with maximum concentrations of 11.4 mg/L for aluminum, 15.1 mg/L for iron, 41.8 mg/L for sodium, 0.48 mg/L for manganese, and 0.00055 mg/L for thallium. The AWQS for aluminum, iron, manganese and thallium are 0.2 mg/L, 0.3 mg/L, 20 mg/L, 0.3 mg/L, and 0.0005 mg/L, respectively. Significantly lower aluminum, iron and thallium levels were observed in filtered groundwater samples from these wells, indicating that the elevated concentrations of these metals are the result of entrained silt and clay particles. Low levels of nitrates continue to be detected in many of the STP Filter Bed area wells, with a maximum concentration of 5.6 mg/L detected in monitoring well 039-08. The AWQS for nitrate is 10 mg/L. No VOCs were detected above the AWQS in any of the STP monitoring wells.

4.6.3 STP Groundwater Monitoring Program Evaluation

The 2011 monitoring data were evaluated using the following Data Quality Objective statement.

Is there a continuing source of contamination? If present, has the source been remediated or controlled?

Monitoring results for 2011 indicate that STP operations are not having a significant impact on groundwater quality, and that the BNL administrative and engineered controls designed to prevent the discharge of chemicals and radionuclides to the sanitary system continue to be effective.

4.6.4 STP Recommendation

No changes to monitoring frequency or analyses are proposed for 2012.

4.7 Motor Pool Maintenance Area

The Motor Pool (Building 423) and Site Maintenance facility (Building 326) are attached structures located along West Princeton Avenue (**Figure 4-16**). The Motor Pool area consists of a five-bay automotive repair shop, which includes office and storage spaces. The Site Maintenance facility provides office space, supply storage, locker room, and lunchroom facilities for custodial, grounds, and heavy equipment personnel. Both facilities have been used continuously since 1947.

Potential environmental concerns at the Motor Pool include 1) the use of USTs to store gasoline, diesel fuel, and waste oil, 2) hydraulic fluids used for lift stations, and 3) the use of solvents for parts cleaning. In August 1989, the gasoline and waste oil USTs, pump islands, and associated piping were upgraded to conform to Suffolk County Article 12 requirements for secondary containment, leak detection devices, and overfill alarms. Following the removal of the old USTs, there were no obvious signs of soil contamination. The present tank inventory includes two 8,000-gallon USTs used to store unleaded gasoline, one 260-gallon above ground storage tank used for waste oil, and one 3,000-gallon UST for No. 2 fuel oil. The Motor Pool facility has five vehicle-lift stations. The hydraulic fluid reservoirs for the lifts are located above ground.

Since 1996, several small-scale hydraulic oil and diesel oil spills have been remediated at the Motor Pool. The only known environmental concern associated with the Site Maintenance facility (Building 326) was the December 1996 discovery of an old oil spill directly south of the building. In an effort to investigate the potential impact that this spill had on groundwater quality, four wells were installed downgradient of the spill site. Although the solvent TCA was detected in the groundwater at concentrations above the AWQS, petroleum hydrocarbons were not detected.

4.7.1 Motor Pool Maintenance Area Groundwater Monitoring

Well Network

The Motor Pool facility's groundwater monitoring program for the UST area is designed to confirm that the current engineered and institutional controls are effective in preventing contamination of the aquifer, and to evaluate continued impacts from historical spills. Two shallow Upper Glacial aquifer wells (102-05 and 102-06) are used to monitor for potential contaminant releases from the UST area (**Figure 4-16**). Groundwater quality downgradient of Building 423 and Building 326 is monitored using four wells (102-10, 102-11, 102-12, and 102-13). The program is designed to periodically assess existing solvent contamination that resulted from historical vehicle maintenance operations, and to confirm that the current engineered and institutional controls are effective in preventing additional contamination of the aquifer.

Sampling Frequency and Analysis

During 2011, the two UST area wells were monitored semiannually, and the samples were analyzed for VOCs (**Table 1-6**). The wells were also checked for the presence of floating petroleum hydrocarbons during these sample periods. The Building 423/326 area wells were monitored annually, and the samples were analyzed for VOCs.

4.7.2 Motor Pool Monitoring Well Results

Underground Storage Tank Area

During 2011, no gasoline-related products were detected in groundwater downgradient of the gasoline UST area.

Building 423/326 Area

During 2011, all VOC concentrations were below the 5 µg/L NYS AWQS (**Figure 4-17**). The highest VOC concentrations were detected in well 102-12, with TCA at 3.2 µg/L and DCA at 3.3 µg/L.

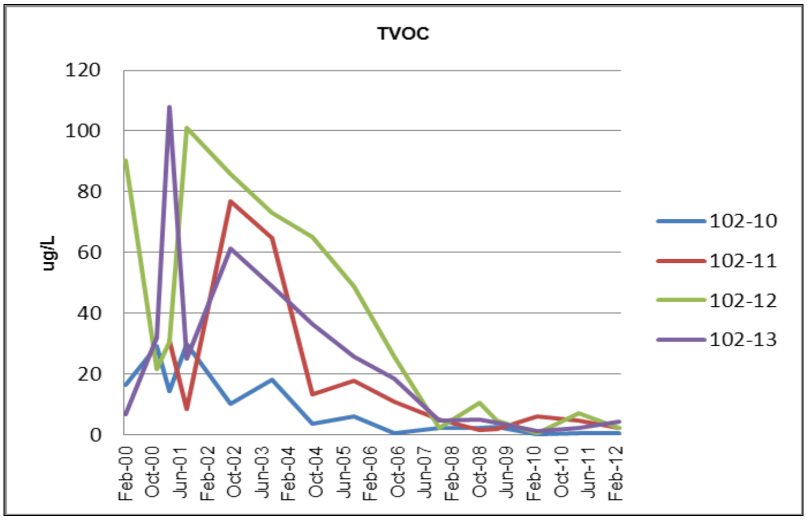
4.7.3 Motor Pool Groundwater Monitoring Program Evaluation

The 2010 monitoring data were evaluated using the following Data Quality Objective statement.

Is there a continuing source of contamination? If present, has the source been remediated or controlled?

Although small-scale solvent and gasoline releases from vehicle maintenance operations have impacted groundwater quality in the Motor Pool area, there has been a steady decrease in VOC concentrations over the past several years. During 2011, all VOC concentration in groundwater were below the AWQS, and there were no reported gasoline or motor oil losses or spills that could further affect groundwater quality. Furthermore, all waste oils and used solvents generated from current operations are being properly stored and recycled. The gasoline USTs have electronic leak detection systems, and there is a daily product reconciliation (i.e., an accounting of the volume of gasoline stored in USTs and volume of gasoline sold).

Figure 4-17.
Motor Pool Building 423/326 Area
TVOC Concentration Trends in Downgradient Wells



4.7.4 Motor Pool Recommendation

No changes to the monitoring program are proposed for 2012.

4.8 On-Site Service Station

Building 630 is a commercial automobile service station, privately operated under a contract with BNL. The station was built in 1966, and is used for automobile repair and gasoline sales. Potential environmental concerns at the Service Station include the use of USTs for the storage of gasoline and waste oil, hydraulic fluids used for lift stations, and the use of solvents for parts cleaning. When the Service Station was built in 1966, the UST inventory consisted of one 6,000-gallon and two 8,000-gallon tanks for storing gasoline, and one 500-gallon tank for used motor oil. In August 1989, the USTs, pump islands, and associated piping were upgraded to conform to Suffolk County Article 12 requirements for secondary containment, leak detection devices, and overfill alarms. During the removal of the old USTs, there were no obvious signs of soil contamination.

The current tank inventory includes three 8,000-gallon USTs for storing unleaded gasoline and one 500-gallon UST used for waste oil. The facility has three hydraulic vehicle-lift stations.

Groundwater quality in the Service Station area has been impacted by historical small-scale spills of oils, gasoline, and solvents, and by carbon tetrachloride contamination associated with a nearby UST that was used as part of a science experiment conducted in the 1950s. In April 1998, BNL removed a UST from an area approximately 200 feet northwest (upgradient) of the service station. Although there were indications that the tank was releasing small quantities of carbon tetrachloride before its removal, a significant increase in carbon tetrachloride concentrations in groundwater indicated that additional amounts of this chemical were inadvertently released during the excavation and removal process. BNL remediated the carbon tetrachloride plume, and the treatment system was decommissioned in 2010 (**Section 3.2.1**).

4.8.1 Service Station Groundwater Monitoring

Well Network

The service station's groundwater monitoring program is designed to confirm that the current engineered and institutional controls in place are effective in preventing contamination of the aquifer and to evaluate continued impacts from historical spills. Four wells are used to monitor for potential contaminant releases (**Figure 4-18**).

Sampling Frequency and Analysis

During 2011, the service station facility wells were monitored two times, and the samples were analyzed for VOCs (**Table 1-6**). Three of the wells near the gasoline USTs were also checked semiannually for the presence of floating petroleum hydrocarbons.

4.8.2 Service Station Monitoring Well Results

During 2011, low levels of carbon tetrachloride (and its breakdown product, chloroform) continued to be detected in the Service Station monitoring wells. The maximum carbon tetrachloride and chloroform concentrations were 19 μg/L and 1.7 μg/L, respectively. The AWQS for carbon tetrachloride and chloroform are 5 μg/L and 7 μg/L, respectively. Compared to 2000, when carbon tetrachloride concentrations approached 4,500 μg/L, the reduction in carbon tetrachloride levels reflects the effectiveness of the groundwater remediation system. The treatment system achieved its cleanup objectives and was shut down and placed in standby mode in August 2004, and was fully decommissioned in 2010 (**Section 3.2.1**).

Historically, groundwater quality at the Service Station has been affected by a variety of VOCs that appeared to be related to historical vehicle maintenance and refueling operations. During 2011, high levels of VOCs were detected in downgradient well 085-17, with a TVOC concentration of 1,229 μg/L during the 4th Quarter (**Figure 4-19**). The VOCs consisted primarily of xylenes (total) at 740 μg/L, 1,2,4-trimethylbenzene at 240 μg/L, 1,3,5-trimethylbenzene at 71μg/L, and the solvent PCE at a concentration of 19 μg/L. (Note: TVOC concentrations in well 085-17 decreased to 269 μg/L by the 1st Quarter of 2012.) VOC concentrations were significantly lower in downgradient wells 085-236 and 085-237, with TVOC concentrations of 3.6 μg/L and 3 μg/L, respectively (**Figures 4-20** and **4-21**). As in previous years, no floating product was detected in the wells. Previous monitoring conducted as part of the Carbon Tetrachloride cleanup project demonstrated that the petroleum-related compounds breakdown to nearly non-detectable levels within a short distance downgradient of the Service Station area.

4.8.3 Service Station Groundwater Monitoring Program Evaluation

The 2011 monitoring data were evaluated using the following Data Quality Objective statement.

Is there a continuing source of contamination? If present, has the source been remediated or controlled?

During 2011, VOCs continued to be detected in the groundwater at concentrations greater than the applicable AWQS. There were no reported gasoline or motor oil losses or spills that could affect groundwater quality, and all waste oils and used solvents generated from current operations are being properly stored and recycled. The gasoline USTs have electronic leak detection systems, and there is a daily product reconciliation (i.e., an accounting of the volume of gasoline stored in USTs and volume of gasoline sold). It is believed that the petroleum hydrocarbon-related compounds and solvents that have been detected in groundwater originated from historical vehicle maintenance operations before improved chemical storage and handling controls were implemented in the 1980s.

Figure 4-19.
Service Station
Trend of Service Station-Related VOCs in Downgradient Well 085-17

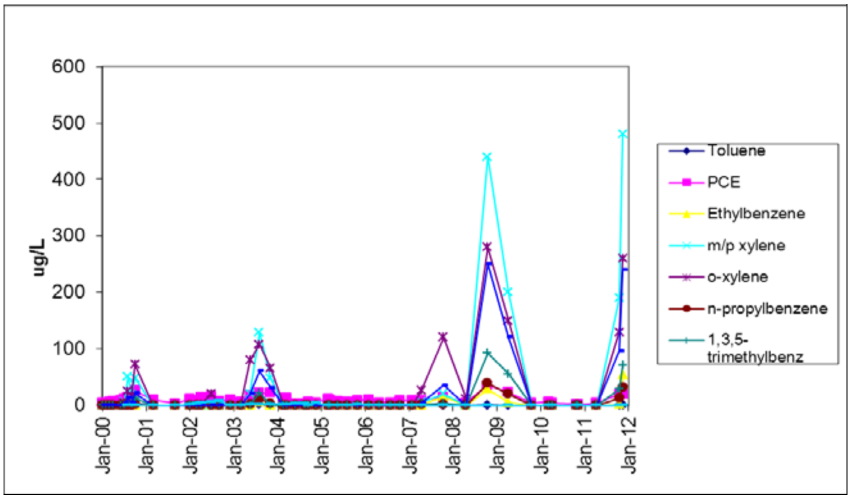


Figure 4-20.
Service Station
Trend of Service Station-Related VOCs in Downgradient Well 085-236

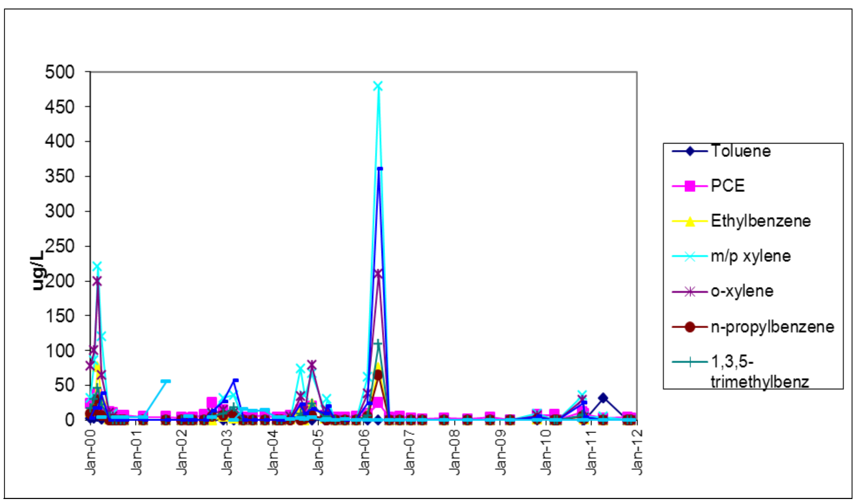
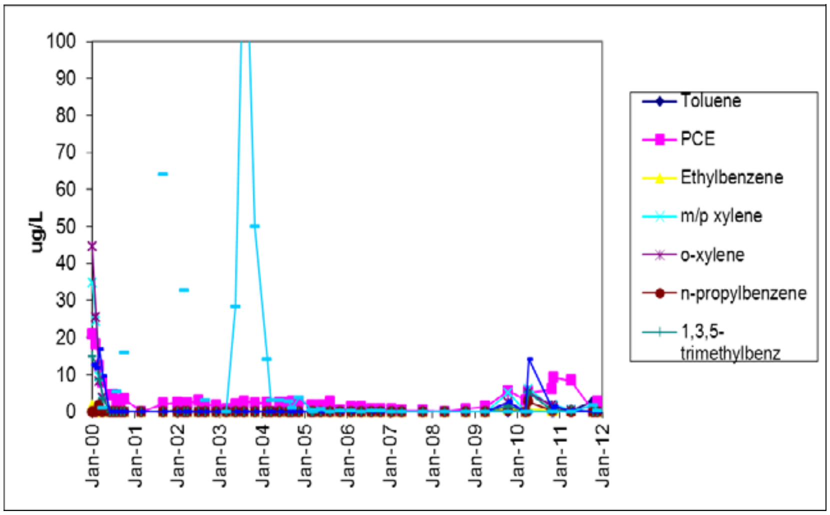


Figure 4-21.
Service Station
Trend of Service Station-Related VOCs in Downgradient Well 085-237



4.8.4 Service Station Recommendation

No changes to the monitoring program are proposed for 2012.

4.9 Major Petroleum Facility (MPF) Area

The MPF is the holding area for fuel oil used at the Central Steam Facility (CSF). The fuel oil is held in a network of seven above ground storage tanks, which have a combined capacity of up to 1.7 million gallons of No. 6 fuel oil and 60,000 gallons of No. 2 fuel oil. The tanks are connected to the CSF by above ground pipelines that have secondary containment and leak detection devices. The fuel storage tanks are positioned in bermed containment areas that have a capacity to hold >110 percent of the volume of the largest tank located there. The bermed areas have bentonite clay liners consisting of either Environmat™ (bentonite clay sandwiched between geotextile material) or bentonite clay mixed into the native soil to form an impervious soil/clay layer. As of December 1996, the fuel-unloading operations were consolidated to one centralized building that has secondary containment features. The MPF is operated under NYSDEC Permit #1-1700 and, as required by law, a Spill Prevention Control and Countermeasures (SPCC) Plan and a Facility Response Plan have been developed for the facility. Groundwater quality near the MPF has been impacted by several oil and solvent spills: 1) the 1977 fuel oil/solvent spill east of the MPF that was remediated under the IAG (**Section 3.3.1**); and 2) solvent spills near the CSF.

4.9.1 MPF Groundwater Monitoring

Well Network

Eight shallow Upper Glacial aquifer wells are used to confirm that the engineered and institutional controls in place are effective in preventing contamination of the aquifer (**Figure 4-22**).

Sampling Frequency and Analysis

Groundwater contaminants from the fuel oil products stored at the MPF can travel both as free product and in dissolved form with advective groundwater flow. Historically, the Special License Conditions for the MPF required semiannual sampling for SVOCs and monthly monitoring for floating petroleum. Samples were also periodically tested for VOCs as part of the Facility Monitoring Program. In 2002, NYSDEC expanded the required list of routine analyses to include VOCs, including testing for MTBE (**Table 1-6**). MTBE was a common gasoline additive until January 2004, and it was occasionally introduced to fuel oil as a contaminant during the storage and transportation process.

4.9.2 MPF Monitoring Well Results

During 2011, the MPF wells were monitored monthly for the presence of floating petroleum, and were sampled in April and October. The groundwater samples were analyzed for SVOCs and VOCs. As in the past, no SVOCs were detected, and no floating product was observed. A number of VOCs not associated with fuel storage activities continued to be detected in some of the MPF area wells. As in past years, the highest VOC concentrations were detected in well 076-380 with PCE concentrations of 69 μg/L during the 2nd Quarter of 2011 (**Figure 4-23**). PCE was also detected in well 076-18 at concentrations of 23 μg/L during the 4th Quarter of 2011. The NYS AWQS for PCE is 5 μg/L. The PCE is believed to have originated from documented historical spills near the CSF building; and its presence in groundwater is not the result of current CSF or MPF operations.

4.9.3 MPF Groundwater Monitoring Program Evaluation

The 2011 monitoring data were evaluated using the following Data Quality Objective statement.

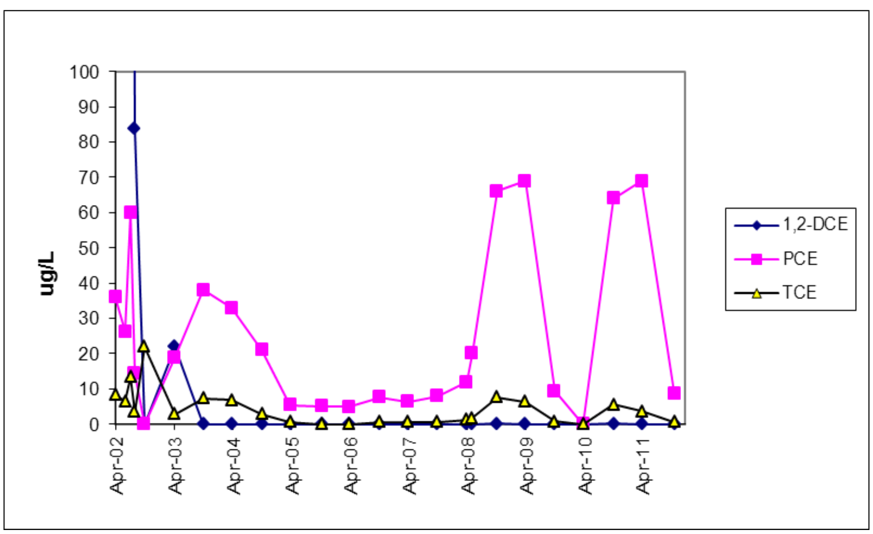
Are the potential sources of contamination being controlled?

Groundwater monitoring at the MPF continues to show that fuel storage and distribution operations are not impacting groundwater quality. The PCE that continues to be detected in the groundwater in 2011 is likely to have originated from historical solvent spills near the Central Steam Facility (Building 610). The historical nature of this contamination is supported by: 1) degreasing agents such as PCE have not been used at the CSF in many years, 2) PCE has been detected in several MPF area wells since the early 1990s, and 3) breakdown products of PCE have been detected. A number of historical spill sites near the CSF were identified in the late 1990s, and the contaminated soil was excavated in accordance with regulatory requirements.

4.9.4 MPF Recommendation

For 2012, monitoring will continue as required by the NYS operating permit.

Figure 4-23.
Major Petroleum Facility
VOC Concentrations in Downgradient Well 076-380



4.10 Waste Management Facility (WMF)

The WMF is designed to safely handle, repackage, and temporarily store BNL-derived wastes prior to shipment to off-site disposal or treatment facilities. The WMF is a state-of-the-art facility, with administrative and engineered controls that meet all applicable federal, state, and local environmental protection requirements. The WMF consists of four buildings: the Operations Building, Reclamation Building (for radioactive waste), RCRA Building, and the Mixed Waste Building.

Groundwater monitoring is a requirement of the RCRA Part B permit issued for WMF operations. The groundwater monitoring program for the WMF is designed to supplement the engineered and institutional controls by providing additional means of detecting potential contaminant releases from the facility. Because of the close proximity of the WMF to BNL potable supply wells 11 and 12, it is imperative that the engineered and institutional controls implemented at the WMF are effective in ensuring that waste handling operations do not degrade the quality of the soil and groundwater in this area.

4.10.1 WMF Groundwater Monitoring

Well Network

Groundwater quality at the WMF is currently monitored using seven shallow Upper Glacial aquifer wells. Five of the downgradient monitoring wells were installed in late 2007 and incorporated into the monitoring program in February 2008. The new wells are positioned downgradient of the buildings based on the current southeast groundwater flow direction. Two wells (055-03 and 055-10) are used to monitor background water quality, and the five newly installed wells monitor groundwater quality downgradient of the three main waste handling and storage facilities. Wells 066-220 and 066-221 are located downgradient of the RCRA Building, wells 066-222 and 066-223 are located downgradient of the Reclamation Building, and well 066-224 is located downgradient of the Mixed Waste Building. The rest of the older wells are being maintained for the collection of water-level data, and the possible future collection of groundwater samples. Locations of the monitoring wells are shown on **Figure 4-24**.

Sampling Frequency and Analysis

During 2011, the WMF wells were sampled in February and August. Groundwater samples were analyzed twice for VOCs, tritium, gamma spectroscopy, gross alpha, and gross beta, and one time for metals and anions (e.g., chlorides, sulfates, and nitrates) (**Table 1-6**). A complete set of monitoring data and groundwater flow maps are presented in the *2011 Groundwater Monitoring Report for the Waste Management Facility* (BNL 2012).

4.10.2 WMF Monitoring Well Results

Radiological Analyses

Gross alpha and beta levels in samples from both upgradient and downgradient monitoring wells were consistent with background concentrations, and no BNL-related, gamma-emitting radionuclides or tritium were identified.

Non-Radiological Analyses

All anions (chlorides, sulfates, and nitrates) and most metals concentrations were below applicable ambient water quality or drinking water standards. As in previous years, sodium was detected at concentrations above the 20 mg/L AWQS in upgradient well 055-03 at concentration of 25.4 mg/L, and in four of the five downgradient wells (066-220, 066-221, 066-222, and 066-223) at concentrations up to 86.1 mg/L. The elevated sodium concentrations are likely the result of road salting operations. Although trace levels of several VOCs (e.g., chloroform) continue to be detected in a number of the WMF's upgradient and downgradient wells, all concentrations continue to be below the AWQS.

4.10.3 WMF Groundwater Monitoring Program Evaluation

The 2011 monitoring data were evaluated using the following Data Quality Objective statement.

Are potential sources of contamination within the WMF being controlled?

Groundwater monitoring results for 2011 were consistent with previous years' monitoring, and continued to show that WMF operations are not affecting groundwater quality. There were no outdoor or indoor spills at the facility that could have impacted soil or groundwater quality.

4.10.4 WMF Recommendation

For 2012, monitoring will continue as required by the RCRA Part B Permit.

4.11 Building 801

In early December 2001, approximately 8,000 gallons of stormwater seeped into the basement of Building 801. Analysis of the floodwater indicated that the water contained Cs-137 (up to 784 pCi/L), Sr-90 (594 pCi/L), and tritium (25,000 pCi/L). It is believed that the floodwater became contaminated when it came into contact with the basement floor, which contains residual contamination from historical radiological spills. When the floodwater was pumped from the basement on March 8, 2002, approximately 4,950 gallons of contaminated water were removed. Taking into account possible losses due to evaporation, estimates were that several gallons of contaminated floodwater might have seeped into the soil below Building 801. To evaluate the potential impact of such a release to groundwater quality, BNL installed a new monitoring well immediately downgradient of the building and monitored several nearby wells.

4.11.1 Building 801 Groundwater Monitoring

Well Network

Four downgradient wells are used to evaluate potential impacts to groundwater from the 2001 floodwater event. Well 065-169 is approximately 10 feet south of Building 801, whereas wells 065-37 and 065-170 are approximately 80 feet downgradient of the building (**Figure 3.2.15-1**). These wells were installed in 1999 to monitor historical releases from the Waste Concentration Facility and the former Pile Fan Sump area. Well 065-37 is screened close to the water table, whereas wells 065-169 and 065-170 are screened approximately 10 feet below the water table. In order to monitor groundwater quality at the water table directly downgradient of Building 801, well 065-325 was installed in October 2002.

Sampling Frequency and Analysis

During 2011, well 065-325 was monitored one time under the facility monitoring program, and the samples were analyzed for Sr-90 and gamma emitting radionuclides (**Table 1-6**). Monitoring wells 065-37, 065-169 and 065-170 were sampled one time under the CERCLA program, and the samples were analyzed for Sr-90 and gamma emitting radionuclides (**Table 1-5**).

4.11.2 Building 801 Monitoring Well Results

During 2011, the Sr-90 concentrations in samples collected from shallow groundwater monitoring wells 065-37 and 065-325 were consistent with pre-December 2001 values, with a maximum Sr-90 concentration of 50.3 pCi/L detected in well 065-325 (**Figure 4-25**). Much lower levels of Sr-90 continue to be detected in slightly deeper wells 065-169 and 065-170, with a maximum concentration of 0.3 pCi/L.

4.11.3 Building 801 Groundwater Monitoring Program Evaluation

The 2011 monitoring data were evaluated using the following Data Quality Objective statement.

Is there a continuing source of contamination? If present, has the source been remediated or controlled?

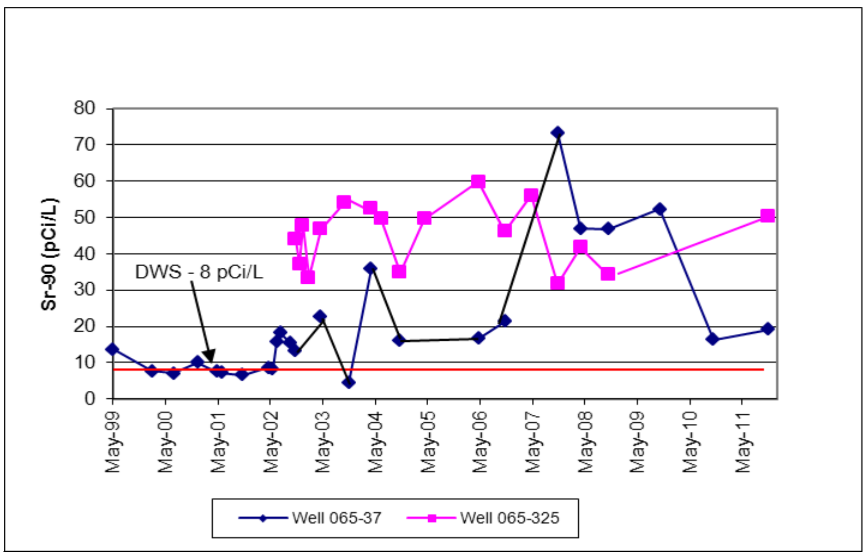
During 2011, Sr-90 concentrations in samples collected from shallow groundwater downgradient of Building 801 were consistent with pre-December 2001 values. It is estimated that starting from the December 2001 Building 801 floodwater release, it could take approximately 3 to 8 years for Sr-90 and approximately 100 years for Cs-137 to migrate to the closest downgradient well (065-325). Although Sr-90 concentrations in well 065-37 increased during 2007 through 2009, to a maximum of 73 pCi/L (**Figure 4-25**), the concentrations are generally consistent with those observed in well 065-325. Detecting any new groundwater impacts from this release will be difficult to identify, as the local groundwater was already contaminated with Sr-90 from legacy releases from Building 801 and/or the nearby former Pile Fan Sump (**Section 3.2.15**).

4.11.4 Building 801 Recommendations

The following is recommended for the Building 801 groundwater monitoring program:

- For 2012, the Building 801 monitoring wells will continue to be monitored annually.

Figure 4-25.
Building 801
Sr-90 Concentration Trends in Downgradient Wells 065-37 and 065-325.



4.12 National Synchrotron Light Source II (NSLS-II)

The NSLS-II is a new electron accelerator. Portions of the new NSLS-II facility will undergo start-up testing starting in the spring of 2012, with full beam line operations expected to start in 2014. High-energy particle interactions in water, air, and soil can produce radioactivity from spallation reactions or neutron capture in nitrogen, oxygen, or other materials. In high-energy proton accelerators, such as BNL's AGS, BLIP and RHIC, these interactions can produce significant activation of the soil shielding. However, electron accelerators such as the NSLS-II have significantly reduced potential for environmental impacts, and can produce only about 1 to 5 percent of the induced activity of a proton accelerator. As required by the BNL Standards-Based Management System (SBMS) *Accelerator Safety* subject area, analyses have been conducted to estimate the rate of formation of tritium and sodium-22 in the surrounding soils during the operation of the NSLS-II's Linac, Booster, and Storage Ring. The results of these analyses indicate that interactions of neutrons with the soils below the tunnel floor and surrounding soil shielding (berm) have the potential to create very low levels of tritium and sodium-22 in the soil. However, because the soil beneath the concrete floor will not be exposed to rainfall, the potential leaching of radioactive isotopes from the soil to the water table at these locations will be minimal. There is also the potential to create very low levels of tritium in the water used to cool the magnets and other accelerator components.

4.12.1 NSLS-II Groundwater Monitoring

Well Network

During 2011, BNL installed four downgradient monitoring wells (NSLSII-MW-01 through NSLSII-MW-04) to evaluate the effectiveness of the engineered and operational controls designed to protect groundwater quality (**Figure 4-26**). The wells located at the NSLS-II are biased toward detecting contamination originating from activated soils associated with the facility's Linac/Booster area (**Figure 4-26**). The wells are located as close as possible to these potential source areas to enable early detection of contaminant releases. The monitoring network installed in 2011 is considered adequate for meeting the monitoring requirements under DOE Order 458.1, Radiation Protection of the Public and Environment.

Sampling Frequency and Analysis

During 2011, NSLS-II monitoring wells were sampled one time, and the samples were analyzed for tritium and gamma emitting radionuclides (**Table 1-5**). These samples were collected to evaluate baseline or pre-operational tritium and sodium-22 levels in the shallow groundwater beneath the NSLS-II's Linac/Booster facility.

4.12.2 NSLS-II Monitoring Well Results

No tritium or sodium-22 were detected in the pre-operational samples collected during 2011.

4.12.3 NSLS-II Groundwater Monitoring Program Evaluation

The 2011 monitoring data were evaluated using the following Data Quality Objective statement.

Are the engineered and operational controls effective at preventing or reducing the leaching of radionuclides from activated soils to the groundwater?

The focus of the NSLS-II groundwater surveillance program for 2011 was the collection of pre-operation samples to establish baseline values for tritium and sodium-22.

4.12.4 NSLS-II Recommendations

For 2012, the NSLS-II monitoring wells will be monitored annually. The emphasis of the surveillance program will be for detecting tritium in the groundwater because it is more mobile than sodium-22 and has a longer half-life (12.3 years compared to 2.6 years for sodium-22). Therefore, tritium's presence in groundwater would be a better early indicator of a failure in an operational or engineered control.

4.13 Building 452 Freon-11 Source Area and Groundwater Plume

In early April 2011, BNL detected the refrigerant Freon-11 (trichlorofluoromethane) in a shallow groundwater monitoring well located in the former Building 96 area. The Freon-11 concentration in well 085-378 was 46 µg/L. The AWQS for this compound is 5 µg/L. From April through early August, 2011, BNL installed 41 temporary groundwater monitoring wells and analyzed 312 groundwater samples to characterize the vertical and horizontal extent of Freon-11 in the groundwater (**Tables 4.13-1 through 4.13-7**). The plume was found to extend from the site maintenance facility Building 452 area approximately 600 feet downgradient to former Building 96 groundwater extraction well RTW-1 (**Figure 4-27**). At its maximum, the plume is approximately 300 feet wide. The maximum Freon-11 concentration detected in the plume during the characterization effort was 36,000 µg/L in a temporary well B452-GP-01, installed approximately 100 feet downgradient of Building 452. Low levels of Freon-11 started to be routinely detected in Building 96 extraction well RTW-1 in late 2010, and during 2011, reached a maximum concentration of 8.1 µg/L in June. Based upon the length of the plume and groundwater flow rates, it is believed that the release occurred 2 to 3 years ago.

To remediate this plume, BNL installed new extraction well EW-18 to intercept the area of highest Freon-11 concentrations. Building 96 extraction well RTW-1 is positioned to capture the downgradient portion of the plume.

4.13.1 Building 452 Groundwater Monitoring

Well Network

The monitoring well network for the Building 452 program consists of 14 wells, all of which are screened in the shallow portion of the Upper Glacial aquifer. Seven of the wells (085-43, 085-73, 085-380, 085-381, 085-382, 085-383, and 085-384) monitor the Building 452 source area. The remaining seven wells (085-385, 085-386, 085-387, 085-388, 095-313, 095-314 and 095-315) monitor the downgradient portions of the plume (**Figure 4-27**). The monitoring wells will be used to monitor the plume configuration and the effectiveness of the remediation system.

Sampling Frequency and Analysis

During 2011, Building 452 monitoring wells were sampled one time (December), and the samples were analyzed for VOCs (**Table 1-6**).

4.13.2 Building 452 Monitoring Well Results

During 2011, BNL installed 41 temporary groundwater monitoring wells and analyzed approximately 350 groundwater samples to characterize the vertical and horizontal extent of Freon-11 in the groundwater (**Figure 4-27** and **Figure 4-28**). Following plume characterization, 12 new permanent monitoring wells were installed to allow for long-term surveillance of the plume and verify the effectiveness of the remediation system. Results of the initial sampling of the permanent wells in December were consistent with the earlier temporary well characterization of the plume. The highest Freon-11 concentration detected in the permanent wells was 38,800 µg/L was detected in source area well 085-382.

In January 2012, temporary well B96-TW-01-2012 was installed to characterize the Building 96 plume in the vicinity of recirculation well RTW-2 (**Figure 3.2.2-1**). Freon-11 was detected in this temporary well at concentrations up to 270 µg/L. This segment of Freon-11 contamination is likely to have migrated past Building 96 extraction well RTW-1 while the well was shut down in August and September 2010. Although low levels of Freon-11 started to be detected in recirculation well RTW-2 in late 2011 (up to 3.1 µg/L), the high concentration zone of Freon-11 detected in B96-TW-01-2012 was at a depth approximately 10 feet below RTW-2's extraction screen. Freon-11 that cannot be treated by RTW-2 will ultimately be captured by the Middle Road groundwater treatment system.

4.13.3 Building 452 Groundwater Monitoring Program Evaluation

The 2011 monitoring data were evaluated using the following Data Quality Objective statement.

1. *Is there a continuing source of contamination? If present, has the source been remediated or controlled?*

High concentrations of Freon-11 continue to be detected in source area monitoring wells. Long-term monitoring is required to determine whether additional source controls are required.

2. Have the groundwater cleanup objectives been met?

The cleanup objectives have not been met at this time. The new Freon-11 treatment system began startup testing in April 2012, and full-time operation began in June 2012. Groundwater modeling indicates that the Freon-11 plume can be successfully remediated in approximately 2 to 5 years from the start of treatment system operations based upon the assumption that there is no longer a significant continuing release of Freon-11 from the source area soils.

4.13.4 Building 452 Recommendations

The following is recommended for the Building 452 groundwater monitoring program:

- For 2012, the Building 452 monitoring wells will be monitored quarterly.
- The Freon-11 treatment system will be monitored in accordance with the SPDES equivalency permit.
- During 2012, soil samples will be collected near the Building 452 source area to evaluate residual Freon-11 concentrations in the vadose soils.

5.0 SUMMARY OF RECOMMENDATIONS

This section is provided as a quick reference to all of the recommendations included in **Sections 3** and **4**. The recommendations are sequenced as they appear in **Sections 3** and **4**. **Table 5-1** summarizes the changes to the monitoring well sampling programs.

5.1 OU I South Boundary Pump and Treat System

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

- A petition to shut down the system will be submitted to the regulators during the fourth quarter of 2012 provided core well concentrations remain below the capture goal.
- Continue pulse pumping of the extraction wells (one month on and one month off).

5.2 Carbon Tetrachloride Pump and Treat System

The following is the recommendation for the former OU III Carbon Tetrachloride Groundwater Remediation System and monitoring program:

- The following well abandonment and reassignment to other programs will end the carbon tetrachloride groundwater monitoring program.
  - Since VOC concentrations have been below MCLs for four or more sampling events, it is recommended that the following wells be dropped from the monitoring program and abandoned: 085-162, 085-163, 085-98, 095-279, 095-280, 095-300, 095-42, 095-53, 095-90, and 095-277.
  - Since the VOC concentrations have been below the MCLs for four or more sampling events, it is recommended that the following wells be dropped from the Carbon Tetrachloride monitoring program and continue to be monitored by the On-Site Service Station monitoring program: 085-236 and 085-237, 085-17 (**Section 4.8**).
  - Since the carbon tetrachloride concentrations have been below the MCLs for four or more sampling events, it is recommended that the following wells be dropped from the Carbon Tetrachloride monitoring program and added to the Middle Road monitoring program since the constituents of concern detected in these wells affects the long term operation of that treatment system: 104-11, 104-36, 105-23, 105-42 (**Section 3.2.3**).
  - Well 085-13 will be maintained as a water level well for the Magothy aquifer and no longer sampled for VOCs.

5.3 Building 96 Air Stripping System

The following are recommendations for the OU III Building 96 Groundwater Remediation System and monitoring program:

- Maintain full time operation of treatment well RTW-1, RTW-2, and RTW-3. Maintain a monthly sampling frequency of the influent and effluent for each well.
- Since TVOC concentrations are below 50 µg/L in temporary well B96-TW03-2012 and the extraction well, place RTW-4 in standby mode. Maintain a monthly sampling frequency of the influent and effluent associated with well RTW-4. Restart the well if extraction or monitoring well data indicate that TVOC concentrations exceed 50 µg/L.

- Continue to monitor the PCE concentrations in the Freon-11 monitoring well 095-313 quarterly, and include it in the Building 96 monitoring program. After review of the data in 2012, the need for further characterization will be evaluated.
- Since there have been no detections of hexavalent chromium above the SPDES discharge limit of 100 µg/L in 2010 and 2011, reduce the frequency of monitoring for total chromium and hexavalent chromium in the monitoring wells from quarterly to annually.
- Continue to analyze for total chromium and hexavalent chromium in the effluent associated with RTW-1 two times per month.
- Continue to maintain the RTW-1 resin treatment in standby mode, and if concentrations of hexavalent chromium in the influent increase to over 50 µg/L (an administrative limit established that is half of the SPDES limit of 100 µg/L), treatment would resume.

5.4 Middle Road Pump and Treat System

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

- Maintain the routine O&M monitoring frequency that is currently in effect.
- Maintain extraction wells RW-4, RW-5 and RW-6 in standby mode. Restart the wells if extraction or monitoring well data indicate that TVOC concentrations exceed the 50 µg/L capture goal. Maintain a minimum pumping rate of 250 gpm on well RW-2. The system's extraction wells will continue to be sampled on a quarterly basis.
- Evaluate the monitoring data and perform additional groundwater modeling to determine if an additional extraction well to the west of extraction well RW-1 is needed.

5.5 OU III South Boundary Pump and Treat System

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

- Based on the monitoring results from well SB-MW01-2011 and the results from monitoring well 121-43, an additional extraction well is being installed near EW-4 but at a greater depth.
- Maintain wells EW-6, EW-7, EW-8, and EW-12 in standby mode. The system's extraction wells will continue to be sampled on a quarterly basis. The wells will be restarted if extraction or monitoring well data indicate TVOC concentrations exceed the 50 µg/L capture goal.
- Maintain the routine O&M monitoring frequency implemented last year.
- Perform additional groundwater characterization in the Industrial Park south of well 121-43 to evaluate the extent of downgradient migration of the VOC plume beneath EW-4.

5.6 Western South Boundary Pump and Treat System

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

- Continue full-time operation of extraction well WSB-1, and pulse pumping of WSB-2 at the schedule of one month on and two months off. This process will continue and any changes to the VOC concentrations in the influent and the monitoring wells will be evaluated.

- Install a monitoring well at the Middle Road in June 2012 to monitor the downgradient extent of the Freon-12 observed in well 103-15.
- Based on the data from the new monitoring well, determine the need to update the groundwater model to determine the migration and attenuation of the Freon-12 contamination.
- Maintain the routine O&M monitoring frequency.

5.7 Industrial Park In-Well Air Stripping System

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

- Maintain the O&M monitoring frequency of quarterly (shutdown sampling frequency). Monthly recovery well sampling will continue, and if TVOC concentrations greater than 50 µg/L are observed, wells UVB-1, UVB-2 or UVB-7 will be restarted.
- The additional data collection from the temporary well between well UVB-5 and UVB-6 as well as the new monitoring well and quarterly well sampling will be used to evaluate whether the criteria for system shutdown of TVOC concentrations less than 50 µg/L in core monitoring wells and extraction wells has been met. A petition to shut down this system will be submitted to the regulators if these criteria are met. If the new monitoring well has TVOC concentrations above the capture goal then wells UVB-3 and UVB-4 will be put on a monthly pulse pumping schedule of one month on and one month off and UVB-5 and UVB-6 will be shut down.
- If all TVOC concentrations are below 50 µg/L in the new monitoring well and the vertical profile well then a Petition for Shutdown will be submitted in the Fall of 2012.

5.8 Industrial Park East Pump and Treat System

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

- Continue the current post shutdown groundwater monitoring schedule.
- Since no rebound in concentrations in core monitoring wells has been observed since system shutdown in December 2009 and because they remain below MCLs a Petition for Closure of this project will be submitted to the regulators in the Fall of 2012.

5.9 North Street Pump and Treat System

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

- Since TVOC concentrations in all plume core monitoring and extraction wells have been below the capture goal of 50 µg/L for four consecutive sampling rounds in 2011, it is recommended that a Petition for Shutdown of the treatment system be submitted to the regulators for review and approval during the Fall 2012. Following regulatory approval, the system will be shut down and maintained in an operationally ready mode for two to five years.
- Prior to receiving formal approval for shutdown, the system will continue to operate. Extraction well NS-1 will continue to operate in pulse pumping mode, one month on and one month off. Extraction well NS-2 will continue to operate full time. If concentrations above the capture goal of 50 µg/L TVOCs are observed in either the core monitoring wells or the extraction well, NS-1 will be put back into full-time operation.

5.10 North Street East Pump and Treat System

The following are the recommendations for the North Street East Pump and Treat System and groundwater monitoring program:

- Install an additional temporary well upgradient of NSE-VP-02-2010 in June 2012. Also in June 2012, install a new core monitoring well at the location of NSE-VP-02-2010.
- Extraction well NSE-1 will remain in full time operation due to elevated VOCs in upgradient temporary well NSE-VP-02-2010. The new monitoring well at this location will be used to evaluate when the treatment system can be shut down.
- Maintain extraction well NSE-2 in stand-by mode. If TVOC concentrations above the capture goal of 50 µg/L are observed in either the core monitoring wells or the extraction well, NSE-2 will be put back into full-time operation.
- Continue the shutdown monitoring frequency (sampled quarterly) for the NSE monitoring wells through 2012.

5.11 LIPA/Airport Pump and Treat System

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

- Continue the airport extraction wells pulse-pumping schedule of pumping one week per month except for wells RTW-1A, RTW-4A and RW-6A, which will continue with full-time operations. If concentrations above the capture goal of 10 µg/L TVOCs are observed in any of the extraction wells or the monitoring wells adjacent to them, the well(s) will be put back into full-time operation.
- Based on the 21 µg/L TVOC concentration observed in monitoring well 800-101 in December 2011, RTW-4A will continue in full time operation in 2012.
- Maintain LIPA wells EW-1L, EW-2L and EW-3L in standby mode. These extraction wells will be restarted if TVOC concentrations rebound above the 50 µg/L capture goal in either the plume core monitoring wells or the extraction wells.
- A new monitoring well should be installed adjacent to well 800-59 that is screened about 40 feet deeper than this well. This will be used to monitor higher concentrations of VOCs identified in upgradient well 800-92.

5.12 Magothy Monitoring

The following are recommendations for the Magothy groundwater monitoring program:

- Continue the current monitoring schedule for the Magothy monitoring program.
- Continue pumping the Magothy extraction wells at Western South Boundary, Middle Road, LIPA/Airport, North Street, North Street East, and Industrial Park. The IPE and South Boundary Magothy extraction wells are currently in standby as they have reached the cleanup goals (TVOC <50 µg/L) identified for shutdown of these wells.

5.13 Central Monitoring

The following change is recommended for the OU III Central Groundwater Monitoring Program:

- Sampling should be discontinued in wells 065-05 and 084-05 since VOC detections have been below AWQS for more than 10 years. The wells will remain in the water level program.

5.14 Off-Site Monitoring

No changes to the OU III Off-Site Groundwater Monitoring Program are warranted at this time.

5.15 South Boundary Radionuclide Monitoring Program

There are no recommended changes to the South Boundary Radionuclide groundwater monitoring program.

5.16 BGRR/WCF Strontium-90 Treatment System

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

- Sr-90 concentrations in groundwater immediately down-gradient of the BGRR have not decreased as expected over the past six years. Because installation of the engineered cap has just recently been completed, BNL will continue to monitor the trends. If warranted, the feasibility of using remediation techniques (such as the applicability of additional source area stabilization/control techniques) will be assessed.
- Due to low Sr-90 concentrations in extraction wells SR-4 and SR-5, continue these wells in a pulse pumping mode (one month on and one month off).
- Install a new monitoring well immediately south and east of the Center for Functional Nanomaterials (Building 735) to monitor the leading edge of the BGRR Sr-90 plume. This recommendation from the 2010 Groundwater Status Report, will be completed during the summer of 2012.
- Install a temporary well along Brookhaven Avenue south of the main entrance to the BNL Light Source (Building 725) to characterize the downgradient extent of the PFS plume in this area as recommended in the *2010 Groundwater Status Report* and install a permanent monitoring well based on the results. This work will be completed during the summer of 2012.
- Install up to eight temporary wells to characterize Sr-90 concentrations upgradient and to the east of WCF plume extraction wells SR-6, SR-7, SR-8, and SR-9 to enhance the monitoring program in these areas.
- Install a temporary well approximately 150 feet south of the former PFS to characterize the plume in this area.

5.17 Chemical/Animal Holes Strontium-90 Treatment System

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

- Continue to operate extraction wells EW-1 and EW-3 in pulse pumping mode (one month on and one month off). If concentrations in either extraction well increase significantly, then they will be put back into full-time operation. Continue full time operation of EW-2.

- To determine if there is a continuing source of Sr-90 contamination upgradient of EW-1, characterization of the groundwater and soil in the area of the 2008 temporary wells will be performed in the summer of 2012. Following review of the data, if warranted, the feasibility of using remediation techniques (such as in-situ stabilization or source removal) will be assessed.
- Based on the 2010 temporary well data, install a new perimeter monitoring well in the summer of 2012 upgradient and to the west of well 106-48.
- Maintain the operations and maintenance phase monitoring well sampling frequency begun in 2009.

5.18 HFBR Tritium Pump and Recharge System

The following are recommendations for the HFBR AOC 29 Tritium Pump and Recharge System and monitoring program:

- Submit a petition to the regulatory agencies to shut down EW-16 and EW-11 based on the criteria as stated in *2008 Groundwater Status Report*:
    - Concentrations of tritium have decreased to less than 20,000 pCi/L in the monitoring wells at Weaver Drive
    - Concentrations from two rounds of temporary wells in the Weaver Drive area confirm that tritium concentrations in this area remain below the 20,000 pCi/L DWS, and
    - Tritium concentrations in EW-16 have been well below the DWS (below 1,500 pCi/L since 2011) since the system was restarted in 2007.
- Following the shutdown of EW-16 and EW-11, continue monitoring during 2013 and 2014.

5.19 Building 650 (Sump Outfall) Strontium-90 Monitoring

The following are recommendations for the Building 650 and Sump Outfall Strontium-90 Monitoring Program:

- Continue the current monitoring frequency stated in **Table 1-5**.
- Much of the downgradient portion of this plume is located within the planned BNL Solar Research Array. Continue to coordinate with project personnel to maintain access to monitoring wells and potential temporary wells.

5.20 Operable Unit V

Based on the recommendations contained in the *Petition to Discontinue Operable Unit V Groundwater Monitoring*, the following actions will take place:

- Well 000-122 will be monitored annually for VOCs for an additional two years beginning in the fourth quarter of 2012. If the concentrations of VOCs decrease to below MCLs during that time period, BNL will recommend that monitoring for well 000-122 be discontinued.
- The monitoring of the remaining wells will be discontinued. The disposition of the monitoring wells is listed on **Table 3.4-1**. Once regulatory approval is granted, five wells will be scheduled for abandoning; the rest will continue to be used for water level measurements.

5.21 Operable Unit VI EDB Pump and Treat System

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

- Maintain routine operations of the treatment system.
- As recommended in the *2010 Groundwater Status Report*, install an additional perimeter monitoring well to the east of well EDB-MW-01-2011. The specific location will be dependent upon available property access.

5.22 Site Background Monitoring

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

5.23 Current Landfill Groundwater Monitoring

The following recommendation is made for the Current Landfill groundwater monitoring program:

- Since there have been no detections of VOCs or water chemistry parameters since 1998 in wells 087-24, 088-22, and 088-23, it is recommended that the monitoring frequency for these wells be reduced from semiannually to annually.

5.24 Former Landfill Groundwater Monitoring

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

5.25 Alternating Gradient Synchrotron (AGS) Complex

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

5.26 g-2 Tritium Source Area and Groundwater Plume

As required by the ROD, BNL will continue to conduct routine inspections of the g-2 cap, monitor groundwater quality downgradient of the source area, and monitor the downgradient plume segments until tritium levels drop below the 20,000 pCi/L DWS. The following are recommended for the g-2 Tritium Source Area and Plume groundwater monitoring program:

- During 2012, the monitoring wells immediately downgradient of the source area will continue to be sampled quarterly for tritium. Because sodium-22 concentrations have been consistently well below the 400 pCi/L DWS, gamma spectroscopy analyses will be reduced from semiannually to annually. The Building 912 area wells will continue to be sampled semiannually for tritium.
- During the summer of 2012, the downgradient segment of the g-2 plume located south of Brookhaven Avenue will be monitored by re-installing Transect G Geoprobe wells G2-GP-111 and G2-GP-112, and by installing additional temporary wells along newly established Geoprobe transects H and I, which will be located approximately 150 and 250 feet downgradient of Geoprobe Transect G. If tritium concentrations in these wells are found to exceed 20,000 pCi/L additional temporary wells will be installed during the 4th Quarter of 2012 to evaluate the continued attenuation of the plume.

5.27 Brookhaven Linac Isotope Producer (BLIP) Facility

As required by the ROD, BNL will continue to conduct routine inspections of the cap, and to monitor groundwater quality downgradient of the BLIP facility. The following is recommended for the BLIP groundwater monitoring program:

- Because tritium levels in groundwater have been continuously below the 20,000 pCi/L DWS since January 2006, the monitoring frequency for downgradient monitoring wells 064-47, 064-48, and 064-67 will continue to be semiannually.
- Sampling frequency for upgradient well 064-46 will continue to be annually. The routine sampling of downgradient wells 064-49 and 064-50 will be discontinued starting in 2013.

5.28 Relativistic Heavy Ion Collider (RHIC) Facility

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

5.29 Brookhaven Medical Research Reactor (BMRR) Facility

The following is recommended for the BMRR groundwater monitoring program:

- The monitoring frequency for the BMRR wells will continue to be once every two years, with the next set of samples being collected in 2012.

5.30 Sewage Treatment Plant (STP) Facility

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

5.31 Motor Pool Maintenance Area

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

5.32 On-Site Service Station

No changes to the On-Site Service Station groundwater monitoring program are warranted at this time.

5.33 Major Petroleum Facility (MPF) Area

For 2012, monitoring at the MPF will continue as required by the NYS operating permit. No changes to the MPF groundwater monitoring program are warranted at this time.

5.34 Waste Management Facility (WMF)

For 2012, monitoring will continue at the WMF as required by the RCRA Part B Permit. Following NYSDEC’s acceptance of the proposed closure of the Mixed Waste Building, modify the MWF groundwater monitoring plan to eliminate sampling of surveillance well 066-224.

5.35 Building 801

No changes to the Building 801groundwater monitoring program are warranted at this time.

5.36 National Synchrotron Light Source II (NSLS-II)

For 2012, the NSLS-II monitoring wells will be monitored annually. The emphasis of the surveillance program will be for detecting tritium in the groundwater because it is more mobile than sodium-22 and has a longer half-life (12.3 years compared to 2.6 years for sodium-22). Therefore, tritium's presence in groundwater would be a better early indicator of a failure in an operational or engineered control.

5.37 Building 452 Freon-11 Source Area and Groundwater Plume

The following is recommended for the Building 452 groundwater monitoring program:

- For 2012, the Building 452 monitoring wells will be monitored quarterly.
- The Freon-11 treatment system will be monitored in accordance with the SPDES equivalency permit.
- During 2012, soil samples will be collected near the Building 452 source area to evaluate residual Freon-11 concentrations in the vadose soils.

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Reference List

Aronson, D.A., and Seaburn, G.E. 1974. *Appraisal of the operating efficiency of recharge basins on Long Island, NY in 1969.* USGS Supply Paper 2001-D.

BNL. 2000. *Operations and Maintenance Manual for the OU III Offsite Removal Action.* Brookhaven National Laboratory, Upton, NY. February 11, 2000.

BNL. 2002a. *Operations and Maintenance Manual for the Western South Boundary Treatment System*. Brookhaven National Laboratory, Upton, NY. December 2002.

BNL. 2003a. *Operations and Maintenance Manual for the OU III Middle Road and South Boundary Groundwater Treatment Systems, Revision 1*. Brookhaven National Laboratory, Upton, NY. July 18, 2003.

BNL. 2004a. *Petition to Shutdown the OU III Carbon Tetrachloride Treatment System*. Brookhaven National Laboratory, Upton, NY. April 2004.

BNL. 2004b. *OU III Building 96 Operations and Maintenance Manual Modification*. Brookhaven National Laboratory, Upton, NY. June 2004.

BNL. 2004a. *Operations and Maintenance Manual for the Industrial Park East Offsite Groundwater Remediation System*. Brookhaven National Laboratory, Upton, NY. September 3, 2004.

BNL. 2004b. *Operations and Maintenance Manual for the North Street/North Street East Offsite Groundwater Treatment Systems*. Brookhaven National Laboratory, Upton, NY. August 24, 2004.

BNL 2004c. *Operations and Maintenance Manual for the OU IV EDB Groundwater Treatment System*. Brookhaven National Laboratory, Upton, NY. Sept. 16, 2004.

BNL 2005a. *OU III Explanation of Significant Differences*. Brookhaven National Laboratory, Upton, NY.

BNL. 2005b. *Operations and Maintenance Manual for the RA V Treatment Facility*. Brookhaven National Laboratory, Upton, NY. October 7, 2005.

BNL. 2007a. *BNL Land Use Controls Management Plan*, Revision 2. BNL, July 25, 2007.

BNL 2007b. *Record of Decision for Area of Concern 16T g-2 Tritium Source Area and Groundwater Plume, Area of Concern 16K Brookhaven Linac Isotope Producer, and Area of Concern 12 Former Underground Storage Tanks.* Brookhaven National Laboratory, Upton, NY. May 10, 2007.

BNL. 2008a. Operations and Maintenance Manual for the LIPA/Airport Groundwater Treatment System, Revision 2. Brookhaven National Laboratory, Upton, NY. November 2008.

BNL. 2008d. *Chemical/Animal Holes Strontium-90 Groundwater Treatment System Operations and Maintenance Manual*. Brookhaven National Laboratory, Upton, NY. November 2008.

BNL. 2009. *BNL Land Use Controls Management Plan*. BNL, June 10, 2009.

BNL. 2009a. *Building 96 Groundwater Source Control Treatment System Operations and Maintenance Manual*. Brookhaven National Laboratory, Upton, NY. June 2009.

BNL2009b. *Final Operable Unit III Explanation of Significant Differences for Building 96 Remediation.* Brookhaven National Laboratory, Upton, NY, July 2009.

BNL. 2009c. *Operations and Maintenance Plan for the High Flux Beam Reactor Tritium Plume Pump and Recharge System.* Brookhaven National Laboratory, Upton, NY, February 2009.

BNL 2009d. 2008 *BNL Groundwater Status Report, SER Volume II*, Brookhaven National Laboratory, Upton, NY June 2009.

BNL 2010. 2009 *BNL Groundwater Status Report, SER Volume II*, Brookhaven National Laboratory, Upton, NY June 2010.

BNL. 2011a. *BNL Spill Prevention, Control and Countermeasures Plan*. Brookhaven National Laboratory, Upton, NY. March 31, 2011.

BNL 2011b. *BNL 2011 Environmental Monitoring Plan* Brookhaven National Laboratory, Upton, NY. January, 2011.

BNL 2011c. 2010 *BNL Groundwater Status Report, SER Volume II*, Brookhaven National Laboratory, Upton, NY June 2011.

BNL. 2012a. *2011 Environmental Monitoring Report, Current and Former Landfill Areas.* Brookhaven National Laboratory, Upton, NY, March 2012.

BNL 2012b. *Operations and Maintenance Manual for the Sr-90 BGRR/WCF/PFS Groundwater Treatment System.* Brookhaven National Laboratory, Upton, NY.

BNL 2012c. *Petition to Discontinue operable Unit V Groundwater Monitoring*. Brookhaven National Laboratory, Upton, NY, March 2012.

BNL. 2012d. *2011 Groundwater Monitoring Report for the Waste Management Facility*, Brookhaven National Laboratory, Upton, NY. 2012.

deLaguna, W. 1963. *Geology of Brookhaven National Laboratory and Vicinity*, *Suffolk County, New York.*

DOE. 2011**.** *Order 458.1*, *Radiation Protection of the Public and the Environment***.** February 2011.

Franke, O.L. and McClymonds, P. 1972. *Summary of the hydrologic situation on Long Island, NY, as a guide to water management alternatives*. USGS Professional Paper 627-F.

Scorca, M.P., W.R. Dorsch, and D.E. Paquette. 1999. *Stratigraphy and Hydrologic Conditions at the Brookhaven National Laboratory and Vicinity, Suffolk County, NY, 1994-97*. U.S. Geological Survey Water Resources Investigations Report 99-4086.

U.S. Environmental Protection Agency (EPA). 1992. Interagency Agreement, Administrative Docket Number: II-CERCLA-FFA-00201, May 1992.