BROOKHAVEN NATIONAL LABORATORY

2015

Site Environmental Report

GROUNDWATER STATUS REPORT

VOLUME II

2015
SITE ENVIRONMENTAL REPORT
VOLUME II
GROUNDWATER STATUS REPORT

June 14, 2016

Environmental Protection Division
Groundwater Protection Group

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Contents

List of Appendices

List of Figures

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List of Tables

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
Ci	curies
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
D&D	decommissioning and demolition
DAR	Division of Air Resources
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
MW	monitoring well
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
TW	temporary well
USGS	United States Geological Survey
UST	underground storage tank
UVB	Unterdruck-Verdampfer-Brunnen Technology (vacuum vaporizing well)
VOC	volatile organic compound
VP	vertical profile
µg/L	micrograms per liter
WCF	Waste Concentration Facility
WLA	Waste Loading Area
WMF	Waste Management Facility

2015 BROOKHAVEN NATIONAL LABORATORY

GROUNDWATER STATUS REPORT

Executive Summary

The *2015 BNL Groundwater Status Report* is a comprehensive summary of data collected during the 2015 calendar year supplemented with investigation data collected during the first quarter 2016, and an evaluation of Groundwater Protection Program performance. This is the twentieth annual groundwater status report issued by BNL. This document examines the performance of the program on a project-by-project basis.

GROUNDWATER RESTORATION (COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION AND LIABILITY ACT - CERCLA)

Table E-1 summarizes the status and progress of groundwater cleanup at BNL under the provisions of CERCLA. During 2015, nine volatile organic compound (VOC) groundwater remediation systems were in operation, along with two strontium-90 (Sr-90) treatment systems. In 2015, 94 pounds of VOCs were removed from the aquifers by the treatment systems. To date, 7,370 pounds of VOCs have been removed from the aquifers. The Sr-90 treatment systems removed 0.99 milliCuries (mCi) of Sr-90 from the Upper Glacial aquifer in 2015, for a total of 30.89 mCi since operations began.

A significant cleanup milestone was achieved in early 2016 with regulatory approval of the petition for shutdown of the Building 452 Freon-11 Treatment System. Groundwater remediation activities for the remaining plumes will continue until the cleanup objectives for the plumes are 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 – 2015.

	1997 – 2014		2015	
VOCs Remediation (start date)	Water Treated (gallons)	VOCs Removed (pounds)(c)	Water Treated (gallons)	VOCs Removed (pounds)(c)
OU I South Boundary (Dec. 1996) (a)	4,177,473,000	369	0	0
OU III Carbon Tetrachloride (Oct. 1999) (e)	153,538,075	349	Decommissioned	0
OU III Building 96 (Feb. 2001)	418,603,416	134	32,383,000	5
OU III Building 452 Freon-11 (March 2012)	95,796,000	96	15,957,000	6
OU III Middle Road (Oct. 2001)	2,796,719,550	1,140	194,112,000	28
OU III South Boundary (June 1997)	4,650,670,850	2,989	190,013,000	22
OU III W. South Boundary (Sept. 2002)	1,376,529,000	122	106,091,000	7
OU III Industrial Park (Sept. 1999)	2,044,912,330	1,064	140,289,000	3
OU III Industrial Park East (May 2004)(f)	357,192,000	38	Decommissioned	0
OU III North Street (June 2004)	1,547,180,000	338	98,506,000	3
OU III North Street East (June 2004)	1,008,558,000	44	1,240,000	0
OU III LIPA/Airport (June 2004)	2,492,816,000	390	228,164,000	20
OU III HFBR Tritium Plume (May 1997) (a)	721,795,000	180	0	0
OU IV AS/SVE (Nov. 1997)	NA (b)	35	Decommissioned	0
OU VI EDB (August 2004)	1,587,166,000	NA(d)	177,686,300	NA (d)
Totals	23,428,949,221	**7,288**	1,184,441,300	94

	2003 – 2014		2015	
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)	55,737,826	4.78	4,052,610	0.09
OU III BGRR (June 2005)	87,832,000	25.12	19,501,000	0.9
Totals	143,569,826	29.9	23,553,610	0.99

Notes:
(a) System was placed in standby mode in 2013.
(b) Air Sparging/Soil Vapor Extraction (AS/SVE) system performance measured by pounds of volatile organic compounds (VOCs) removed. System was decommissioned in 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 decommissioned in 2010.
(f) System was decommissioned in 2014.
NA – Not applicable

The locations and extent of the primary VOC and radionuclide plumes at BNL, as of December 2015, are summarized on **Figures E-1** and **E-2**, respectively. Significant items of interest during 2015 and early 2016 include:

- 614 monitoring wells were sampled as part of the CERCLA Groundwater Monitoring Program, comprising a total of 1,328 groundwater samples. In 2015/2016, 122 temporary wells were also installed and sampled.

- 1.2 billion gallons of groundwater were treated, and 94 pounds of VOCs and 0.99 mCi of Sr-90 were removed from the aquifers (**Table E-1**).
- Two new extraction wells installed in the Industrial Park during 2014, and became operational in January 2015. These wells are capturing deeper VOCs in this area observed at the interface between the deep Upper Glacial and Magothy aquifers. One additional monitoring well was installed in conjunction with this work.
- Groundwater characterization work resulting from a *2014 Groundwater Status Report* recommendation identified a Sr-90 plume containing concentrations up to 302 pCi/L and extending approximately 800 feet downgradient of the former HWMF source area.
- As recommended in the *2014 Groundwater Status Report*, a soil vapor survey conducted to the west of the main PCE plume at Building 96 did not identify an additional source of PCE.
- The Building 452 Freon-11 Treatment System was placed in standby mode in March 2016 following the regulatory approval of a petition for shutdown.
- As recommended in the *2014 Groundwater Status Report*, two temporary wells were installed to address a data gap associated with tracking Freon-12 contamination in the Western South Boundary area. Although only trace amounts of Freon-12 were detected, DCE and TCA were detected at maximum concentrations of 96 µg/L and 79 µg/L, respectively. Additional characterization is required to define the extent of this contamination, which is present at a greater depth than these constituents have previously been observed in this area.
- North Street Treatment System, which was placed in shut down mode in 2013, had extraction wells NS-1 placed back in operation during August 2015 due to rebounding VOC concentrations above the capture goal in nearby monitoring wells. Operation will continue until concentrations decrease to levels below the capture goal.
- Ethylene dibromide (EDB) was detected at up to 0.49 µg/L in a North Street East monitoring well during 2015. EDB has a standard of 0.05 µg/L. Although EDB had not been detected in the off-site NSE plume there have been several historical detections (up to 1.5 µg/L) upgradient of this well on-site in OU I.
- The anticipated rebound of Sr-90 concentrations in the BGRR/Building 701 source area monitoring wells (as originally discussed in the *2012 Groundwater Status Report BNL 2013a*) was observed during 2013. The concentrations were both of a shorter duration and lower in value than seen in previous rebound scenarios. The rebound of Sr-90 concentrations has yet to be observed in extraction well SR-3, which is located approximately 60 feet south of the source area monitoring wells. Continued monitoring of this area for elevated Sr-90 concentrations resulting from a historic high water table elevation in late 2010 continued in 2015.
- Characterization of the soil and groundwater upgradient of Chemical Holes extraction well EW-1 did not result in any significant detections of Sr-90 either in unsaturated zone soils or in groundwater at the water table.
- During 2015, tritium continued to be detected in g-2 source area monitoring wells at concentrations above the 20,000 pCi/L drinking water standard (DWS). Monitoring results indicate that tritium concentrations in the small plume segment that was located near the National Synchrotron Light Source II (NSLS-II) facility have attenuated to less than the 20,000 pCi/L DWS.

Additional information on 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 2015, the institutional controls continued to be effective in protecting human health and the environment. In accordance with the *BNL Land Use Controls Management Plan* (BNL 2013f) 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;
- Implementing controls on the installation of new supply wells and recharge basins on BNL property;
- Continuing to offer private well testing (via SCDHS) for those homes in the previously defined hook-up area not connected to public water; and
- Maintaining 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). Monitoring conducted at the former g-2 experiment area within the Alternating Gradient Synchrotron (AGS) facility, Brookhaven Linac Isotope Producer (BLIP), and Building 452 is used to verify the effectiveness of CERCLA corrective actions. During 2015, groundwater samples were collected from 118 wells during 189 individual sampling events.

Highlights of the Facility Monitoring surveillance program are as follows:

- Monitoring conducted during 2015 at BNL's major accelerator facilities (e.g., AGS, Relativistic Heavy Ion Collider, National Synchrotron Light Source-II, and BLIP) has not identified any new impacts to groundwater quality.
- Monitoring conducted at four support facilities (Sewage Treatment Plant, Waste Management Facility, Major Petroleum Facility, and Motor Pool) has not identified any new impacts to groundwater quality.
- Monitoring at the Upton Service Station continues to detect VOCs associated with petroleum products and a degreasing solvent at concentrations that exceed NY Ambient Water Quality Standards, but at concentrations significantly lower than previous years. It is believed that the contaminants originate from historical vehicle maintenance activities and are not related to current operations.

SIGNIFICANT GROUNDWATER STATUS REPORT RECOMMENDATIONS

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

- **OU I South Boundary Treatment System** –

- Three new monitoring wells will be installed in 2016 at the locations of the highest Sr-90 concentrations from the temporary wells installed in 2015.
- One new monitoring well will be installed to monitor VOCs migrating from the Current Landfill.

- **OU III Building 96 Treatment System** – Install temporary well(s) just west of monitoring well 095-312 to evaluate the extent of VOC concentrations in Geoprobe B96-GP-01-2016.

- **North Street East Treatment System –** Due to the detection of EDB in monitoring well 000-394, the following actions will be implemented:
  - Begin sampling well 000-394 quarterly for EDB using Method 504 which has a lower detection limit than method 524 in 2016.
  - Obtain one round of samples from seven NSE monitoring wells and analyze for EDB using Method 504.
  - Continue to evaluate the monitoring data and recommend any follow up actions including the restart and temporary operation of extraction well NSE-1.
- **BGRR/WCF Sr-90 Treatment System –**
  - Place BGRR extraction wells SR-4 and SR-5 in standby mode due to consistently low concentrations of Sr-90.
  - Discontinue sampling 28 monitoring wells.
- **Chemical/Animal Holes Sr-90 Treatment System –** Due to low Sr-90 concentrations in the extraction wells and adjacent monitoring wells, Place extraction wells EW-2 and EW-3 in standby mode.
- **LIPA/Airport Treatment System –** Place extraction well RTW-5A in standby mode based upon the plume configuration and monitoring data concentrations are well below the 10 µg/L capture goal in this area.
- **Western South Boundary Treatment System -** As a follow-up to the February 2016 characterization, install additional temporary and permanent monitoring wells to define the width and extent of the higher VOCs between monitoring wells 103-15 and 119-10.

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	Pump and Treat (P&T) with Air Stripping (AS)	2013 (Actual)	Petition for system shutdown was approved by the regulators and system placed on standby in July 2013.
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	Periodic increases in Sr-90 concentrations from wells adjacent to former source area continue. Characterization of Sr-90 indicate elevated groundwater levels.
OU III					
Chemical/Animal Holes	Sr-90	Operational (EW-1, EW-3, and EW-3 pulse pumping)	P&T with ion exchange (IE)	2019	Characterization of source area indicates that peak Sr-90 concentrations continue to decline.
Carbon Tetrachloride source control	VOCs (carbon tetra-chloride)	Decommis-sioned	P&T with carbon	2009 (Actual)	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.	2018	PCE in source area monitoring wells continued declining in 2014. RTW-1 also captures leading edge of Bldg. 452 Freon-11 plume.
Building 452	VOCs (Freon-11)	Operational	P&T with AS	2016	System effectively remediated the Freon 11 plume. System placed in standby mode in March 2016.
South Boundary	VOCs	Operational (EW-6, EW-7, EW-8 and EW-12 on standby)	P&T with AS	2019	Additional extraction well EW-17 is capturing deep VOCs at site boundary.
Middle Road	VOCs	Operational (RW-4, RW-5, and RW-6 on standby)	P&T with AS	2025	Trailing edge of higher concentrations appears to be just south of Weaver Drive. No indication of a continuing source for the deep VOCs.

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	System operating as planned.
Industrial Park	VOCs	EW-8 and EW-9 Operational (UVB-1 through UVB-7 on standby)	In-well stripping and P&T with carbon	2020	Installed new deep extraction wells.
Industrial Park East	VOCs	Decommissi-oned	P&T with carbon	2009 (Actual)	Treatment system was decommissioned in 2014.
North Street	VOCs	Standby, restarted in late 2014	P&T with carbon	2013 (Actual)	System restarted due to rebound in VOCs.
North Street East	VOCs	Standby	P&T with carbon	2014 (Actual)	All VOC concentrations below capture goal. Petition for Shutdown approved in April 2014.
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	2021 (LIPA) 2021 (Airport)	System operating as planned.
HFBR Tritium	Tritium	Standby	Pump and recharge	2012 (Actual)	Source area tritium concentrations continue to decline.
BGRR/Waste Concentration Facility (WCF)	Sr-90	Operational (Pulse Sr-4, Sr-5, and Sr-6)	P&T with IE	2026	Sr-90 concentrations in BGRR/Building 701 source area monitoring wells demonstrated significant rebound during 2014 (as anticipated) in response to historic high water table levels in 2010. Characterization of downgradient portion of the WCF plume indicates a slight eastward shift.
OU IV					
OU IV AS/SVE system	VOCs	Decommis-sioned	Air sparging/ soil vapor extraction	2003 (Actual)	System decommissioned in 2003.
Building 650 sump outfall	Sr-90	Long Term Monitoring	Monitored Natural Attenuation (MNA)	NA	Sr-90 plume continues to slowly migrate south and attenuate.
OU V					
STP	VOCs, tritium	Completed	MNA	NA	VOC concentrations in all wells now below AWQS. Monitoring completed.

continued

Project	Target	Mode	Treatment Type	Expected System Shutdown	Highlights
OU VI					
Ethylene Dibromide (EDB)	EDB	Operational	P&T with carbon	2019	The EDB plume continues to attenuate. The extraction wells are capturing the plume.
g-2 and BLIP					
g-2 Tritium Plume	Tritium	Long Term Monitoring & Maintenance	MNA	NA	Tritium concentrations in source area continue to be above the DWS, but are declining over time. Small tritium plume segment located south of Brookhaven Avenue has attenuated to below DWS as expected.
BLIP Tritium Plume	Tritium	Long Term Monitoring & Maintenance	MNA	NA	Tritium concentrations less than DWS.

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 has been affected at the BNL site
- 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 2015 Groundwater Status Report* is a comprehensive summary of groundwater data collected in calendar year 2015 that provides an interpretation of information on the performance of the Groundwater Protection Program. This is the 20th 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 2015, 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 2015. 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 (CERCLA)

On December 21, 1989, BNL was included 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 2011).

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 millirems 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 2015 Environmental Monitoring Plan* (BNL 2015a). 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 2015 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 2015 Environmental Monitoring Plan (BNL 2015a)*.

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: 2040
*** - 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

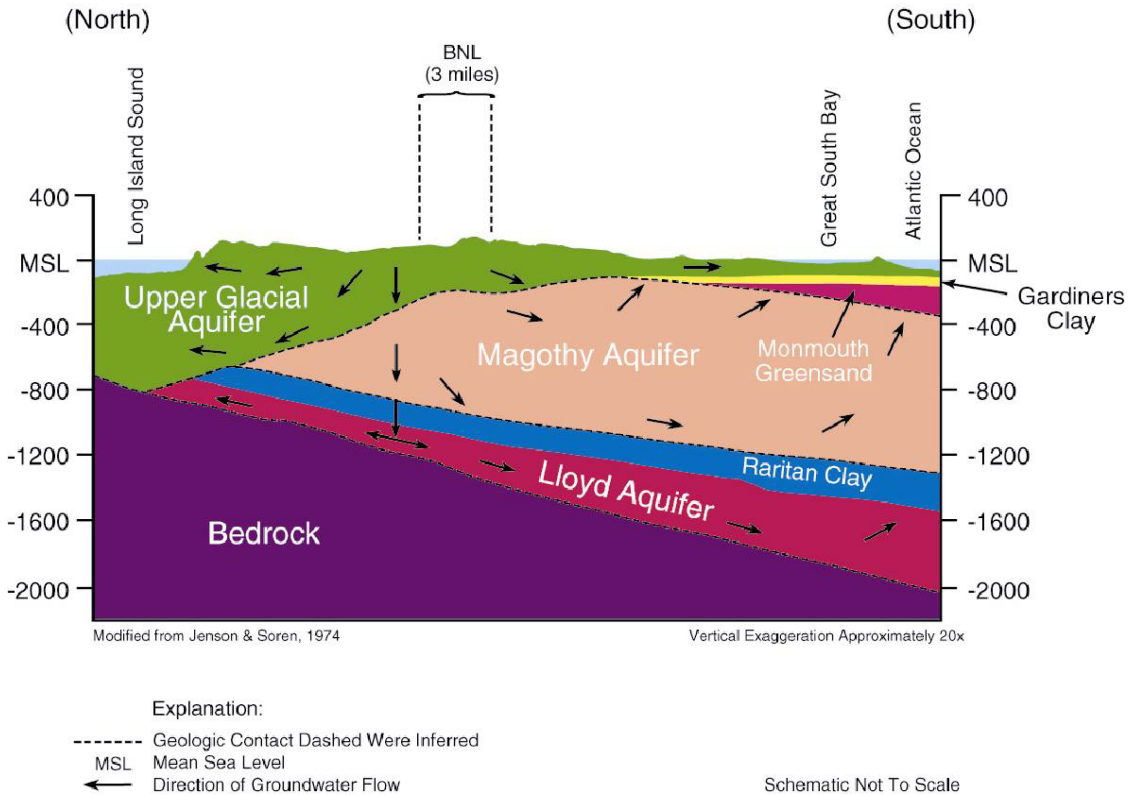
During 2015, there were seven known homeowners in the residential area overlying the plumes who continue to use their private wells for drinking water purposes. In accordance with the OU III and OU VI RODs, DOE formally offers these homeowners free testing of their private drinking water wells on an annual basis. SCDHS coordinates and performs the sampling and analysis. During 2015, one of the homeowners who were offered the free testing accepted this service.

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 2015, 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 Cretaceous aged continental deltaic 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 2015 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-site 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 flow patterns. Additional water-level data from off-site wells are obtained from the USGS.

The synoptic water-level measurement event comprising the complete network of on-site and off-site wells were conducted during December, 2015 with data collected from approximately 750 wells. A localized synoptic measurement using wells in the central part of the BNL site was conducted in September 2015, with data collected from approximately 90 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**.

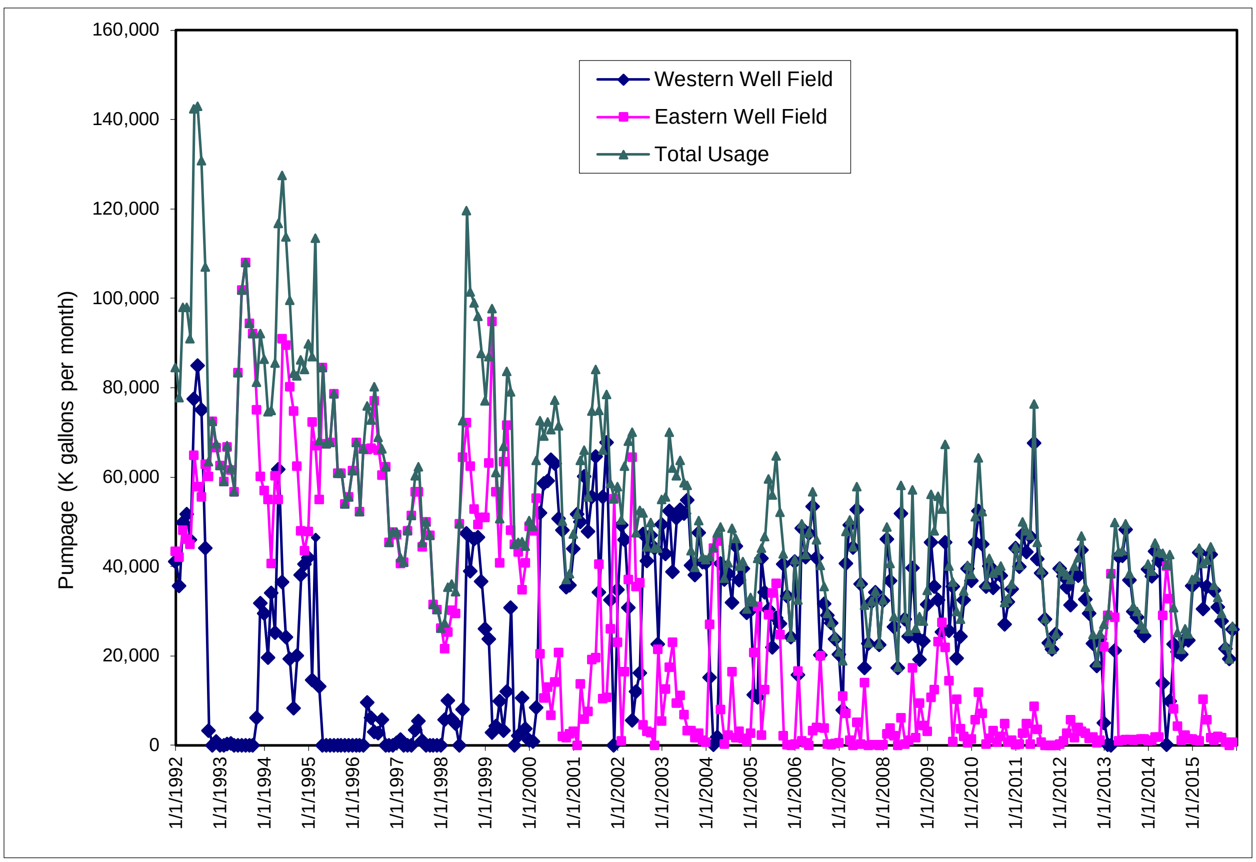
2.1.2 Pumpage of On-Site Water Supply and Remediation Wells

BNL has six water supply wells to provide potable and process cooling water, and 63 treatment wells used for the remediation of contaminated groundwater. All six water supply wells are screened entirely within the Upper Glacial aquifer. In the fourth quarter 2015, 39 of the 63 treatment wells were in active operation, while the remaining wells were in standby mode. **Figures 2-2** and **2-3** show the locations of the water supply and remediation wells. The effects that 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 2015 for the five active on-site potable supply wells (4, 6, 7, 10, and 11). It includes information on each well's screened interval and pumping capacity. 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; and the eastern field currently includes wells 10 and 11. Eastern supply well 12 has been out of service since October 2008. 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, well 10 is occasionally used for short periods of time.

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 2015.



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 2015, a total of 413 million gallons of water were withdrawn from the aquifer by BNL's potable supply wells. BNL was able to meet its goal of obtaining more than 75 percent of its total water supply from the western well field, which supplied approximately 93 percent of the water for 2015. **Table 2-2** summarizes the 2015 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

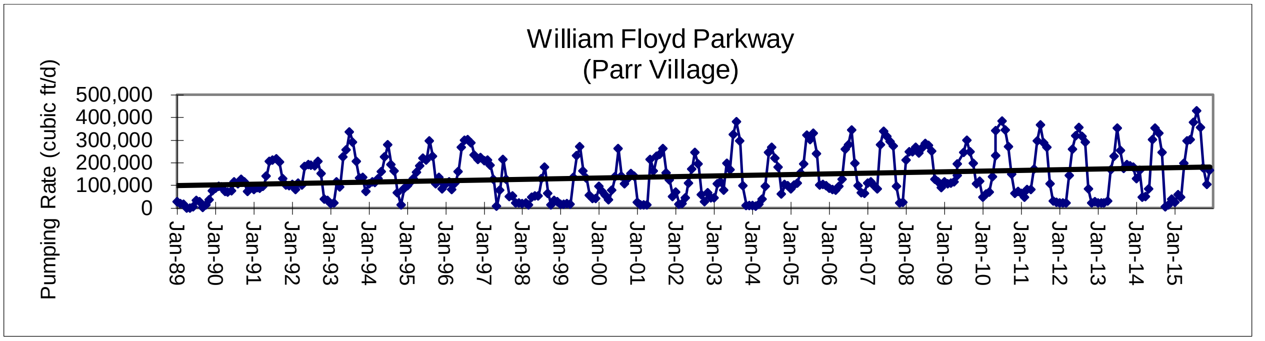
Several Suffolk County Water Authority (SCWA) well fields are located near BNL. The William Floyd Parkway Well Field is west/southwest of BNL (**Figures 2-2 and 2-3**), and consists of three water supply wells that withdraw groundwater from the mid Upper Glacial aquifer and the upper portion of the Magothy 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 2015 is provided as **Figure 2-5.** In 2015, the William Floyd Parkway (Parr Village) and Country Club Drive Well Fields produced 580 and 453 million gallons for the year, respectively. The Lambert Avenue Well Field, located south of BNL, has two wells that produced 394 million gallons for the year.

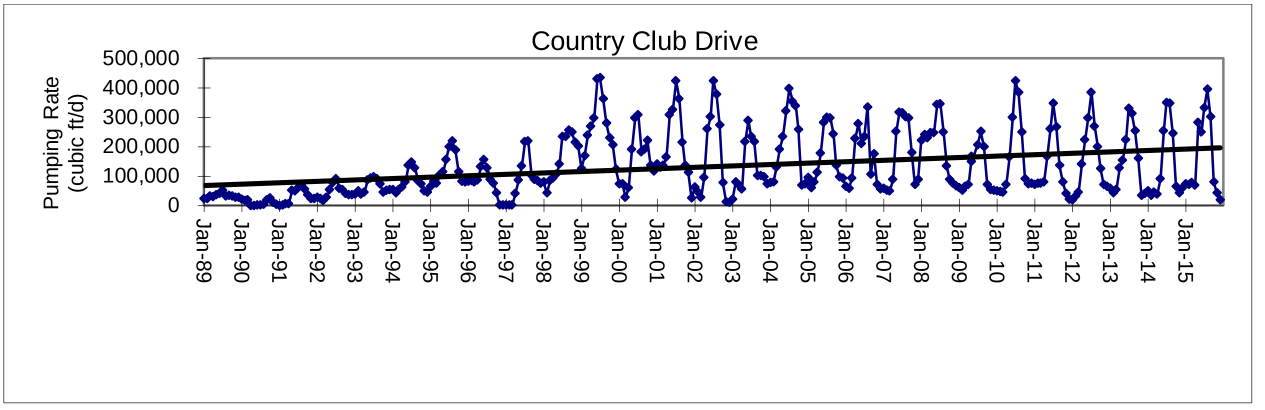
2.1.4 Summary of On-Site Recharge and Precipitation Data

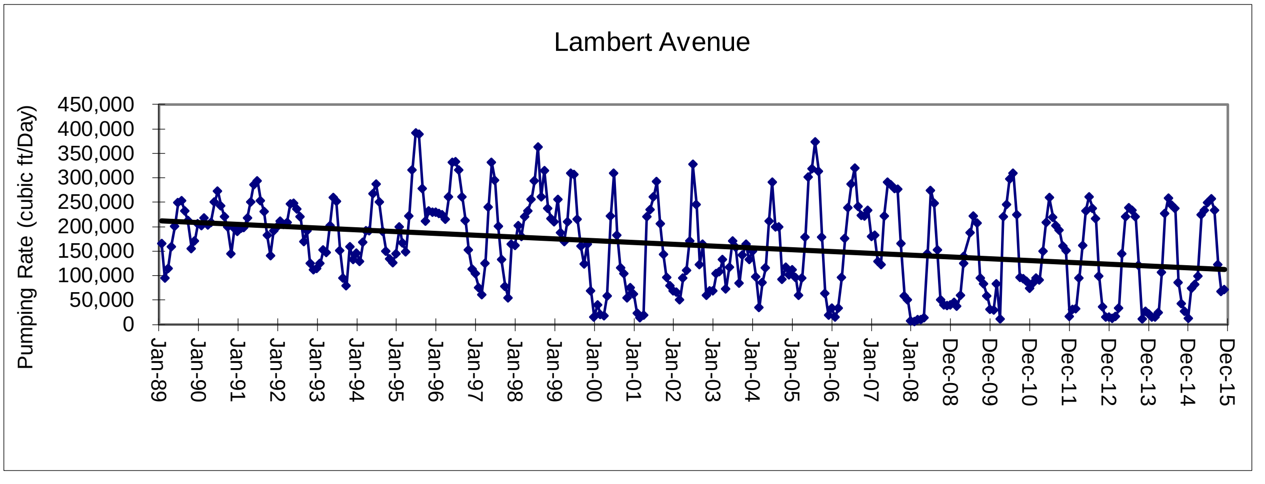
This section summarizes artificial (i.e., on-site recharge basins) and natural recharge from precipitation. **Table 2-3** summarizes the monthly and total flow of water through 10 on-site recharge basins during 2015. Their locations are shown on **Figures 2-2 and 2-3**. **Section 2.2** (Groundwater Flow) 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 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. Until 2013, water from the OU I South Boundary and the High Flux Beam Reactor (HFBR) system was discharged to the RA V basin. The HFBR and OU I treatment systems met their cleanup objectives, and their extraction wells were shut down in May and July 2013, respectively. Because reductions in water discharges to the RA V basin could have resulted in significant changes in local groundwater flow patterns, groundwater modeling was used to best divide the remaining treated water discharges toward the OU III and RA V basins in order to maintain stable groundwater flow directions (PW Grosser, 2013). Monitoring of groundwater flow patterns during 2014 and 2015 demonstrated that this effort was successful. **Table 2-3** provides estimates of flow to the recharge basins. 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 and recharge basins at the STP. Until October 2014, treated water from the STP was discharged to sand filter beds, which caused 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 seeped directly to the underlying water table beneath the filter beds tile-drain collection system, and the remaining treated effluent was discharged to the Peconic River. Most of the water released to the Peconic River recharged to the aquifer before it reached the BNL site boundary, except during times of seasonally high water levels. Starting in October 2014, the STP discharge was re-directed to newly constructed groundwater recharge basins. These discharges are causing localized mounding of the water table below the basins.

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







Precipitation provides the primary recharge of water to the aquifer system at BNL. 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 2015, it is estimated that the recharge at BNL was approximately 20 inches. **Table 2-4** summarizes monthly and annual precipitation results from 1949 to 2015 collected on site by BNL Meteorology Services. Variations in the water table generally can be correlated with seasonal precipitation patterns. As shown on **Table 2-4**, total annual precipitation in 2015 was 39.37 inches, which was below the long-term yearly average of 48.82 inches.

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 December 7-11, 2015. The contours were generated from the water-level data from shallow Upper Glacial aquifer wells. 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 2015 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**.

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 regional 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 December 1-5, 2015. 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 2015 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 1950–2015) well hydrographs were constructed from water-level data that were obtained for select USGS and BNL wells. 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.

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. The time period of 2010 through 2015 saw a ten foot variation in water table elevations at BNL. 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.

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 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 1948 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.

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 permanent and temporary monitoring wells and vertical profiles were drilled at the BNL site during 2015, 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 2015, BNL performed minor repairs to 41 monitoring wells. Two monitoring wells were abandoned during 2015.

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3.0 CERCLA GROUNDWATER MONITORING AND REMEDIATION

Chapter 3 gives an overview of groundwater monitoring and remediation efforts at BNL during 2015. 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 Trichlorofluoromethane (Freon-11) 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 and EDB plumes were contoured to their appropriate 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

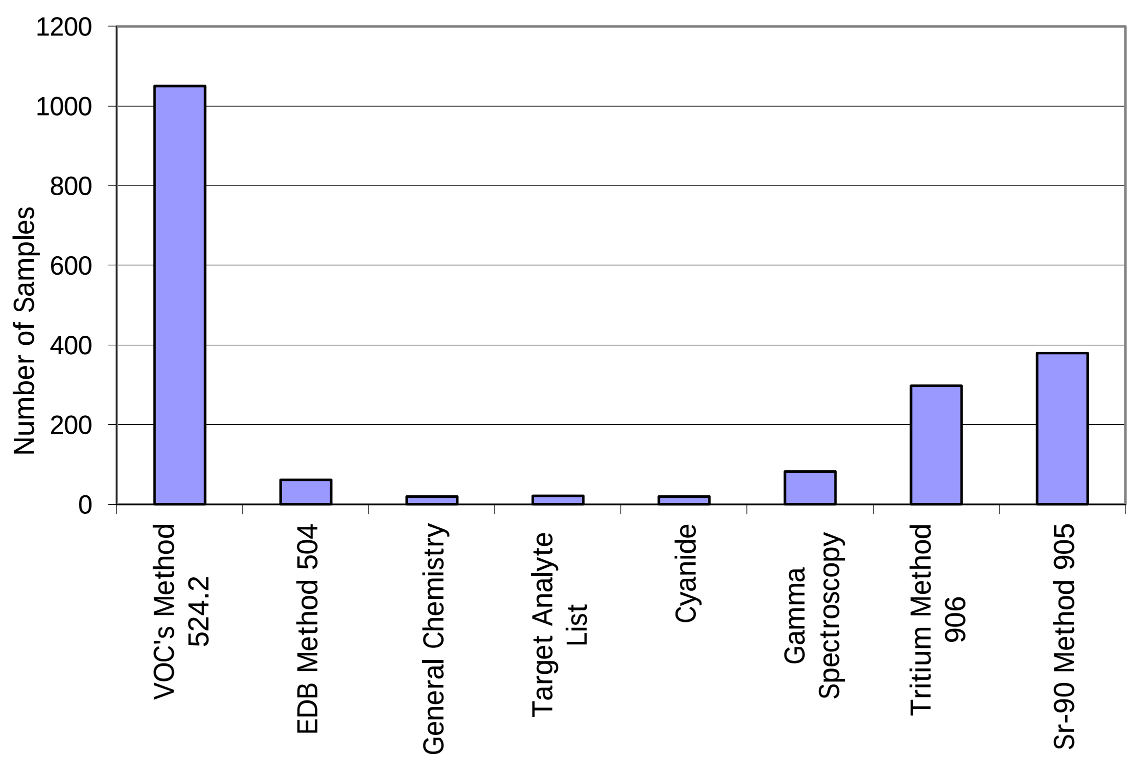
Additionally, BNL's ability to accurately depict these plumes has been enhanced over the years by the:

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

During 2015, the contaminant plumes were tracked by collecting 1,328groundwater samples obtained from 600 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 2015 data from permanent monitoring wells. Contaminant plumes associated with Building 96, Chemical/Animal Holes, Middle Road, Industrial Park, HFBR, BGRR, and g-2 Tritium Plume projects were further defined in 2015 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 2015.



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 12 groundwater remediation systems in operation. Three 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); the Carbon Tetrachloride Pump and Treat System; and the Industrial Park East Treatment 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 and numerous soil source area removals were conducted, which minimizes the potential for further 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 2015, 967 treatment system samples were obtained from 102 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. In 2008 and 2009 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. 2015 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 2015/Cumulative
Operable Unit I						
South Boundary	P&T, AS	VOC	2	Operated: 16 Standby: 2	Basin	0/369
Operable Unit III						
South Boundary	P&T, (AS)	VOC	8	18	Basin	22/3,011
HFBR Pump and Recharge	Pump and Recirculate	Tritium	4	Operate: 8.0 Standby: 10.5	Basin	0/180
Industrial Park	Recirculation/ In-Well (AS/Carbon)	VOC	7	15.5	Recirculation Well	3/1,066
****Building 96	Recirculation Well (AS/Carbon)	VOC	4	Operate: 12 Standby: 3	Recirculation Well	4.5/138.5
Middle Road	P&T (AS)	VOC	7	14	Basin	28/1173
Western South Boundary	P&T (AS)	VOC	2	13	Basin	7/130
Chemical Holes	P&T (IE)	Sr-90	3	13	Dry Well	0.09**/4.9
North Street	P&T (Carbon)	VOC	2	11	Wells	3/341
North Street East	P&T (Carbon)	VOC	2	Operate:10 Standby: 1	Wells	0/44
LIPA/Airport	P&T and Recirc. Wells (Carbon)	VOC	10	11	Wells and Recirculation Well	20/410
Industrial Park East	P&T (Carbon)	VOC	2*	Shutdown Operate: 5 Standby: 4	Wells	0/37
BGRR/WCF	P&T (IE)	Sr-90	9	10	Dry Wells	0.9**/26
Building 452 Freon-11	P&T (AS)	Freon-11	1	4	Basin	6/102*****
Operable Unit VI						
EDB	P&T (Carbon)	EDB	2	11	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
* Wells abandoned in 2014
** Sr-90 removal is expressed in mCi.
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.

*** 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.
*****Total Freon-11 mass is sum of Building 96 and Building 452 treatment systems.

3.1 OPERABLE UNIT I

The two sources of VOC 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 the former HWMF. The remnants of the VOC plume are depicted on **Figure 3.1-1**.

The on-site segment of the Current Landfill/former HWMF plume was 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 was treated for VOCs by air stripping, and 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 3.2.10**). A Petition for Shutdown of the OU I South Boundary Treatment System was approved by the regulatory agencies in July 2013 as the conditions for shutdown were satisfied as described in the *OU III ROD* (BNL, 2000a) and the *Operations and Maintenance Manual for the OU I South Boundary Treatment Facility* (BNL 2005b). The system was shut down and placed in standby mode in July 2013.

3.1.1 OU I South Boundary Treatment System

This section summarizes the operational and monitoring well data for 2015 from the OU I South Boundary Groundwater Treatment 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. A Petition for Shutdown of this system was submitted to the regulatory agencies in May 2013 and approved in July 2013.

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 OU I South Boundary 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)** to assess the groundwater treatment system and its effects on the plume**.**

Sampling Frequency and Analysis

The wells are monitored for VOCs, tritium, and/or Sr-90 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 2015. 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.

Monitoring well 088-109 is the only remaining Current Landfill source area well consistently exhibiting TVOC concentrations above 5 µg/L. In 2015, TVOC concentrations in this well fluctuated from 2 µg/L to 160 µg/L. A total of 14 temporary wells were installed in 2015/2016 to evaluate the VOCs persisting in this area. The landfill was capped in November 1995. A detailed discussion of the landfill monitoring well data is provided in the *2015 Environmental Monitoring Report, Current and Former Landfill Areas (BNL 2016a).* The downgradient portion of the OU I South Boundary plume (as defined by TVOC concentrations greater than 5 µg/L) is now limited to a small area immediately north of the extraction wells due to active pump and treat groundwater remediation and natural attenuation (**Figure 3.1-1**). The off-site portion of the plume is discussed in **Section 3.2.9**, the North Street East Treatment System.

The plume remains bounded by the current network of wells. **Figure 3.1-4** gives the historical trends in VOC concentrations for key plume core and bypass wells. **Appendix C** has a complete set of 2015 analytical results. Significant findings for 2015 include:

- Monitoring well 088-109 is located immediately east of the Current Landfill, and approximately 3,500 feet north of the BNL site boundary (**Figure 3.1-1**). This well is sampled at a quarterly frequency and typically shows TVOC concentrations below 50 µg/L; however, there have been occasional increases in TVOC concentrations (up to 160 µg/L) noted over the past several years. The increases appear to be due to continuing periodic releases of residual VOCs (primarily chloroethane) from the Current Landfill to the water table. The data does not support a correlation between VOC concentrations and either precipitation or the elevation of the water table. The groundwater travel time from the Current Landfill to the BNL site boundary is approximately 12-15 years. Updated modeling results of VOCs obtained from the 2015/2016 temporary well data set (**Table 3.1-1**)indicate that VOC concentrations from the Current Landfill will attenuate to below 5 µg/L TVOC prior to reaching the site boundary ***(Appendix H)***
- Well 107-40 has been below the capture goal of 50 µg/L since 2013. This was the last well data observed on-site above the capture goal. The fourth quarter of 2015 concentration in this well was 18 µg/L TVOC.
- Individual VOC concentrations in core wells are approaching the AWQS as of the fourth quarter 2015 (**Figure 3.1-4**).
- There were no detections of VOCs above AWQS in perimeter monitoring wells.

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**.

Tritium concentration in the sampled wells has declined significantly over the past several years with no detections observed in 2015. A plot of historical tritium results for select OU I South Boundary program wells is shown on **Figure 3.1-5**.

Forty permanent wells are monitored for Sr-90 contamination from the former HWMF **(Table 1-5)**. The highest Sr-90 detected in 2015 from a monitoring well was 36 pCi/L in well 98-30 during May (the Sr-90 DWS is 8 pCi/L). A total of 58 temporary wells were installed and sampled in four phases from April 2015 through March 2016 as recommended in the *2014 Groundwater Status Report (BNL 2015b)*, and the locations are shown on **Figure 3.1-6** (The data is included in **Table 3.1-2)**. This characterization was implemented to determine the magnitude and extent of Sr-90 concentrations exceeding the DWS that have been observed periodically in monitoring wells 088-26 and 098-30 historically. The maximum Sr-90 concentration from this characterization effort was 302 pCi/L in temporary well OUI-Sr-90-GP-32. These results confirm the presence of residual contamination in the source area that is continuing to impact groundwater. Within the plume, two small areas of Sr-90 concentrations greater than 50 pCi/L and less than 100 feet in width and up to 800 feet in length were defined extending south from the former HWMF yard (**Figure 3.1-6**).

Detectable levels of Sr-90 have been observed in sentinel monitoring wells 108-43 and 108-45 over the past several years at concentrations below the DWS. The fourth quarter 2015 results for these wells were 3 pCi/L and 3.5 pCi/L, respectively. These sentinel wells are located approximately 700 feet upgradient of the site boundary. The location of monitoring wells and the extent of Sr-90 concentrations is shown on **Figure 3.1-6**. Sr-90 concentration trends for key monitoring wells are provided on **Figure 3.1-7**. The OU I South Boundary Groundwater Treatment System does not remediate Sr-90.

3.1.6 System Operations

The extraction wells are currently sampled quarterly as the system was in standby mode for 2015. **Table 3.1-3** provides the effluent limitations for meeting the requirements of the SPDES equivalency permit. Since the system was in standby mode in 2015 no influent/effluent samples were collected.

The following is a summary of the OU I system operations for 2015:

January–December 2015

The system remained in standby mode for the year. There was no increase in VOC concentrations observed in the extraction or monitoring well network that required the extraction wells to resume pumping.

Table 3.1-3.
OU I South Boundary Treatment System
2015 SPDES Equivalency Permit Levels

Parameters	Permit Level (µg/L)	Max. Measured Value (µg/L)
pH	6.0 – 9.0 SU	NS
benzene	0.8	NS
chloroform	7.0	NS
chloroethane	5.0	NS
1,2-dichloroethane	5.0	NS
1,1-dichloroethene	5.0	NS
1,1,1-trichloroethane	5.0	NS
carbon tetrachloride	5.0	NS
1,2-dichloropropane	5.0	NS
methylene chloride	5.0	NS
trichloroethylene	5.0	NS
vinyl chloride	2.0	NS
1,2-xylene	5.0	NS
sum of 1,3- & 1,4-xylene	10.0	NS

Notes:
SU = Standard Units
NS = Not Sampled as the system was not operating

3.1.7 System Operational Data

Extraction Wells

During 2015, the extraction wells did not operate. The wells were sampled quarterly during the year (**Table 2-2**). VOC and tritium concentrations in samples from EW-1 and EW-2 are provided in **Table F-1**. Tritium was not detected in the extraction wells during 2015. VOC levels in EW-1 and EW-2 remained low with maximum TVOC concentrations of 8 µg/L and 1 µg/L respectively (**Figure 3.1-8**).

System Influent and Effluent

There were no influent or effluent samples as the system was in standby mode during 2015.

Cumulative Mass Removal

Approximately 369 pounds of VOCs were removed from the aquifer during system operation from 1996 through 2013 (**Figure 3.1-9**).

Air Discharge

There were no air emissions as the system was in standby in 2015 (**Table 3.1-4**). **Table 3.1-4** contains no data for VOC air emissions as the system was on standby during 2015.

3.1.8 System Evaluation

Although the system remains in standby, groundwater monitoring is ongoing to determine whether there is any rebound in VOC concentrations. The OU I South Boundary Treatment system performance can be evaluated based on the major decisions identified by applying the Data Quality Objectives (DQO) process.

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

Current Landfill

VOCs continue to be observed emanating from the northeast portion of the Current Landfill as observed in monitoring well 088-109 and the temporary wells installed in early 2016 to characterize the extent of these VOCs. The source area is covered by an engineered cap however, it is suspected that the water table is continuing to flush contaminants from the vadose zone and/or the bottom of the landfilled materials.

Former HWMF

2015/2016 groundwater characterization data indicates that there is an area of residual elevated Sr-90 concentrations in groundwater in the former HWMF yard up to 302 pCi/L. The area containing the highest Sr-90 concentrations is currently located from the central portion of the former HWMF yard to just south of the southeastern perimeter of the yard. The central portion of the yard was the site of waste storage areas and documented spills of radioactive liquid contamination during the period of time the facility was in operation from the 1940s until 1997. The buildings were demolished and a soil remediation of the yard was completed in 2005. A significant amount of pavement was removed from the central portion of the yard as part of the soil remediation. It is possible that some combination of disturbance from the soil remediation work and removal of the pavement (which may have acted to cap underlying soil contamination) could be responsible for the higher Sr-90 concentrations observed during the recent characterization. This is supported by the higher concentrations in groundwater being located within a ten year travel time from the central yard (which would date back to a start time of about 2005).

2. Were unexpected levels or types of contamination detected?

Former HWMF

Yes, Sr-90 concentrations up to 302 pCi/L were observed in temporary wells located in the southeast corner of the former HWMF as part of the characterization effort conducted in 2015/2016. The concentrations were significantly higher than what has been observed in monitoring over the past ten years.

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

Current Landfill

Monitoring results indicate that the OU I onsite VOC plume has been largely remediated. There is a small area from the site boundary north to well 107-40 containing individual VOC concentrations above the DWS. These VOC concentrations continue to steadily decrease. VOCs periodically released from the Current Landfill are attenuating as they migrate south.

Former HWMF
A plume of Sr-90 exceeding the 8 pCi/L DWS extends from the FHWMF yard to an area in the Long Island Solar Farm (LISF) approximately 2,400 feet to the south. This plume is migrating slowly to the south at approximately 40 to 50 feet per year. Groundwater modeling (**Appendix I**) shows the leading edge of this area above DWS arriving at the site boundary in approximately 42 years (2058) and decays to below DWS by approximately 2081.

4. Can individual extraction wells or the entire treatment system be shut down or placed in pulse pumping operation?
Yes, the system was placed in standby mode in July 2013 following regulatory approval of the Petition for Shutdown.

4a. Are TVOC/Sr-90 concentrations in plume core wells above or below 50 µg/L or 8 pCi/L, respectively?
Current Landfill
Monitoring well 088-109, located immediately southeast of the Current Landfill, has shown occasional spikes in TVOC concentrations (up to 160 µg/L) over the past several years. Based on plume core well data, TVOC concentrations throughout downgradient portion of the plume have been less than the system capture goal of 50 µg/L since January 2013 (**Figure 3.1-10**).

Former HWMF
Yes, Sr-90 is detected above 8 pCi/L. A combination of temporary and permanent wells define a plume of Sr-90 concentrations exceeding 8 pCi/L as shown in **Figure 3.1-6**.

Table 3.1-4
OU I South Boundary
2015 Air Stripper VOC Emissions Data

Parameter	Allowable ERP* (lb/hr)	Actual** ERP* (lb/hr)
carbon tetrachloride	0.016	SB
chloroform	0.0086	SB
1,1-dichloroethane	10**	SB
1,2-dichloroethane	0.011	SB
1,1-dichloroethylene	0.194	SB
chloroethane	10**	SB
1,1,1-trichloroethane	10**	SB
trichloroethylene	0.119	SB

ERP = Emissions Rate Potential, stated in pounds per hour (lb/hr).
* ERP is based on NYSDEC DAR-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.
SB= Standby

4b. Is there a significant concentration rebound in core wells and/or extraction wells following shutdown?
Current Landfill
No significant rebound of VOCs has been observed in either monitoring or extraction wells since the system was shut down in July 2013.

5. Has the groundwater cleanup goal of meeting MCLs for VOCs by 2030 been achieved?
No. MCLs have not been achieved for individual VOCs in plume core wells. Plume core wells continuing to exceed MCLs for individual VOCs include 107-40, 115-16, and 108-17. A comparison of groundwater quality conditions are shown on **Figure 3.1-2** which compares the VOC plume from 1997 to 2015.

3.1.9 Recommendations

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

- Maintain the extraction wells in standby mode. One or both extraction wells can be restarted if TVOC concentrations rebound above capture goals. Continue to analyze the extraction wells quarterly for Sr-90.

- Install permanent monitoring wells at locations GP-42, GP-40, and GP-30 at which the highest Sr-90 concentrations were observed during the 2015/2016 characterization effort. Initially sample these wells at a quarterly frequency. Monitor the downgradient migration of this high concentration area utilizing up to ten temporary wells. This supplemental monitoring will continue through 2021, followed by a comparison of monitoring data to model simulations in order to evaluate the accuracy of the simulations.
- The shutdown of the OU I South Boundary extraction wells will result in an eastward shift in groundwater flow direction back to the regional flow pattern. Install several temporary wells as necessary in the vicinity of Sr-90 sentinel monitoring wells 107-35 and 108-45 to evaluate the resulting shift in the Sr-90 migration path.
- Install a temporary well approximately 100 feet west of monitoring well 098-59 and follow up with a permanent well at that location to monitor VOCs migrating from the Current Landfill (**Appendix H**).
- Samples from 30 monitoring wells are analyzed for tritium. Tritium has not been detected in these wells above 2,000 pCi/L since 2008. It is recommended that the sampling frequency for 18 of the 30 wells currently analyzed for tritium be reduced from semi-annually to annually. The remaining wells are already being sampled annually.
- VOCs have not been detected above 5 *μg/L* since 2008 in monitoring wells 088-26, 098-33, 098-21, 107-23, 107-24, 107-25, 098-30, 099-04, 115-36, 115-03, 115-50, 115-30, and 115-15. It is recommended to discontinue sampling these wells for VOCs.

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 North Street (OU I/IV) plumes. **Figure 3.2-2** is cross-section B–B2, 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 2015. 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 18-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 OU III. The HFBR tritium plume had travelled several thousand feet south from the HFBR spent fuel pool. The downgradient, higher concentration slug was captured by EW-16. This slug has been fully remediated and the treatment system placed in stand-by mode. 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/Animal Holes area.

Sections 3.2.1 through **3.2.18** 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 Building 96 Treatment System

This section summarizes the 2015 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. For a history of the operation of these wells over the last 14 years, refer to previous Groundwater Status Reports. Starting in 2012, treatment well RTW-1 was used to treat the low level downgradient portion of the Building 452 Freon-11 plume (See **Section 3.2.2** for further discussion of the Building 452 Freon-11 plume).

3.2.1.1 System Description

For the recirculation wells RTW-2, RTW-3, and RTW-4, 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 three wells. After treatment, the clean water is recharged in wells RTW-2 through RTW-4 back to 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 air stripping and hexavalent chromium ion exchange treatment, with discharge to the nearby surface drainage culvert. Since January 2010, the resin treatment was bypassed and remains in standby mode. 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).

3.2.1.2 Source Area Remediation

In addition to the excavation of VOC contaminated soil in 2010, operation of the RTW-1 groundwater treatment system will continue until the capture goal is attained, which was 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 3.2.1-1 shows the location of the excavated soil contamination area in relation to the 2015 VOC groundwater plume. **Figure 3.2.1-3** shows a cross section of the area.

3.2.1.3 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 3.2.1-1**). The majority of the wells are sampled quarterly and analyzed for VOCs in accordance with **Table 1-5**. As recommended in the 2014 Groundwater Status Report, due to significant reduction of hexavalent chromium in the monitoring wells over the last several years, sampling was discontinued in 2015.

3.2.1.4 Monitoring Well Results

Complete VOC results are provided in **Appendix C**. The fourth quarter 2015 plume is shown on **Figure 3.2.1-1** and trends for several wells are presented on **Figure 3.2.1-2**. A summary of key monitoring well data for 2015 follows:

<u>Former Source Area to RTW-1:</u>

- The highest TVOC concentration seen in 2015 was 490 µg/L in core well 095-84 during the third quarter sampling round. This is significantly lower than the historical maximum TVOC concentration in this well of 18,000 µg/L in 1998. As noted on the trend **Figure 3.2.1-2**, since 2010, TVOC concentrations have significantly declined. This declining trend is also evident in core well 095-306. TVOC concentrations in this well declined to 55 µg/L in 2015. These levels should continue to drop off as the plume passes through this area and is captured by RTW-1. These wells are located between 70 to 200 feet downgradient of the former soil excavation area and are upgradient of RTW-1.

- Since detecting a maximum TVOC concentration of 2,435 µg/L in 2011, monitoring well 085-379 has steadily dropped to less than 250 µg/L in the third quarter of 2015. The fourth quarter 2015 TVOC concentrations are less than 100 µg/L. This well 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 any residual groundwater contamination from the former source area is identified during fluctuations in the water table.
- TVOC concentrations in core monitoring well 095-305 continue to increase every couple of years following a spike up to 3,013 µg/L in 2011. Following an increase in TVOC concentrations in January 2015 to 380 µg/L, levels dropped significantly to 70 µg/L in the fourth quarter. This well is located adjacent to well 095-306, but screened 12 feet shallower.
- Monitoring well 095-313 is located northwest of RTW-1 to monitor the western perimeter of the Building 452 Freon-11 plume. This well detected PCE up to 144 µg/L in 2012, but did not detect Freon-11. The maximum PCE detected in this well in 2015 was 32 µg/L in the first quarter. This well is screened slightly deeper than the adjacent Building 96 monitoring wells with the screen interval at 45 to 60 feet bls.
- Well 095-307, located to the west of the main plume, detected PCE at 150 µg/L in the fourth quarter of 2014. The maximum PCE concentration in 2015 was 21 µg/L. The maximum historical PCE concentration in this well was 970 µg/L in 2005. This contamination will not be captured by the Bldg. 96 treatment wells.
- As recommended in the 2014 Groundwater Status Report, in July 2015 a soil vapor survey was performed to the west of the main PCE plume upgradient of well 095-307, to identify any potential source. Thirty nine samples were collected and elevated TVOCs were identified at three locations. Follow-up soil and water table sampling was performed in August 2015. Soil samples were collected at the three elevated soil gas locations from ground surface to the top of the water table. Only trace levels of typical analytical lab contaminants were detected. A groundwater sample collected at the top of the water table (18 feet bls) at each of the three locations did not detect any VOCs. See **Figure 3.2.1-4** for the location of the soil gas points and the soil/groundwater borings, and Table 3.2.1-4 for the data.

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

- Elevated TVOC concentrations continue to be detected in two monitoring wells downgradient of RTW-1. Maximum TVOC concentrations of 140 µg/L and 53 µg/L were detected in the second quarter 2015 in plume core wells 095-159 and 095-172, respectively. VOCs in these wells have been slowly declining over the last several years. This contamination will be captured by RTW-2 and RTW-3. These recovery wells will be restarted when this contamination reaches them.
- As recommended in the 2014 Groundwater Status Report, in March 2016, an additional temporary well (Geoprobe B96-GP-01-2016) was installed between wells 095-159 and 095-162 to further delineate the extent of PCE contamination identified in Geoprobe B452-GP-49 (installed in 2014). Samples were obtained up to the water table. The maximum PCE concentration was 320 µg/L at 42 feet bls. This is consistent with the 2014 Geoprobe results that detected PCE up to 298 µg/L at 40 feet bls. **Figure 3.2.1-1** identifies the location of the 2016 Geoprobe and **Table 3.2.1-5** presents the data.

Wells Downgradient of RTW-2 through RTW-4:

- The bypass monitoring wells immediately downgradient of extraction wells RTW-2, RTW-3, and RTW-4 showed reduced TVOC concentrations since 2007.VOCs in the bypass wells have been below standards since 2010.
- Sentinel monitoring well 095-318, located along Weaver Drive, identified TVOC concentrations up to 17 µg/L in the second quarter of 2015. The primary VOC was PCE at 16 µg/L. TVOC concentrations in this well have declined since the well was installed in 2010 and detected 143 µg/L. This contamination will be addressed by the Middle Road treatment system.

Hexavalent Chromium Monitoring:

- As noted in **Section 3.2.1.3**, sampling for hexavalent chromium was discontinued in 2015.

Freon-11:

- As further described in **Section 3.2.2**, Building 96 extraction well RTW-1 is also being used to address the low level downgradient portion of the Freon-11 plume. The maximum Freon-11 concentration detected in RTW-1 in 2015 was 15 µg/L in the second quarter.
- Freon-11 continues to be detected in several of the Building 96 monitoring wells at low levels. Freon-11 barely exceeded the AWQS in one well in 2015. The maximum Freon-11 concentration detected in 2015 was 5.1 µg/L in plume core well 095-172.

3.2.1.5 System Operations

Operating Parameters

Treatment well RTW-1 operated full time during 2015. Treatment wells RTW-2 and RTW-3 were placed in stand-by mode in January 2016 due to low VOC concentrations. RTW-4 has been in stand-by mode since October 2012.

January – September 2015

The system was turned off from January 22nd until February 4th due to a snow storm. In March, RTW-1 was off the majority of the month to replace the blower motor. In April, the system was turned off for a week to install an adapter to remove water from the air lines. During May, the wells were off at various intervals to clean the air stripper trays. From July through September, wells RTW-1 and RTW-2 were off intermittently due to electrical issues. During this period the system treated approximately 24 million gallons of water.

October – December 2015

Well RTW-1 was off for one week in October and November due to electrical issues. In December, RTW-1 and RTW-2 were off for 10 days for repairs. During this period, the system treated approximately 9 million gallons of water.

During 2015 the system treated approximately 32 million gallons of water (**Table F-7**).

3.2.1.6 System Operational Data

Recirculation/Treatment Well Influent and Effluent

Table F-5 lists the monthly influent and effluent VOC concentrations for the two active recirculation wells, and treatment well RTW-1. The highest TVOC concentration from the influent of these wells was 280 µg/L in RTW-1 in the third quarter of 2015. The maximum TVOC concentration in the influent of the downgradient wells was 1.4 µg/L in RTW-3, in the second quarter. **Figure 3.2.1-5** shows the TVOC concentrations in the treatment wells over time. **Table 3.2.1-1** 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 2015.

The maximum hexavalent chromium level detected in the effluent in RTW-1 in 2015 was 6.5 µg/L in September. Since January 2010, the resin treatment was bypassed and remains in standby mode.

Table 3.2.1-1

OU III Building 96 RTW-1 Treatment Well, 2015 SPDES Equivalency Permit Levels

Parameter	Permit Level (µg/L)	Max. Measured Value (µg/L)
pH range	5.0–8.5 SU	6.0–7.9 SU
chromium (hexavalent)	100	6.5
tetrachloroethylene	5.0	4.6
1,1,1-trichloroethane	5.0	<0.5
thallium	Monitor	0.88
trichlorofluoromethane	5.0	<0.5
methyl bromide	5.0	<0.5
methyl chloride	5.0	<0.5
methylene chloride	5.0	<0.5

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

SU = Standard Units

Air Discharge

In 2015, 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-6**, and the VOC emission rates are summarized on **Table 3.2.1-2.** 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 Division of Air Resources (DAR)-1 Air Toxics Assessment limits for the worst-case potential impacts to the public.

Cumulative Mass Removal

Table 3.2.1-3 shows the monthly extraction well pumping rates. The annual average pumping rate for the system was 62 gpm. The pumping and mass removal data are summarized on **Table F-7**. In 2015, approximately 5 pounds of VOCs were removed. Since February 2001, the system has removed approximately 139 pounds of VOCs.

3.2.1.7 System Evaluation

The 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 3.2.1.2** above, the previously identified high PCE concentrations in soil were excavated in the summer of 2010. Over the last four years, TVOC concentrations in well 085-379 (located in the former source area) have slowly declined from 2,435 µg/L in 2011 to 82 µg/L in December 2015. 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.

As discussed in **Section 3.2.1.4**, follow-up characterization near well 095-307 to the west of the original soil excavation did not identify a source for this contamination.

2. Were unexpected levels or types of contamination detected?

Elevated VOCs were detected in temporary wells installed between wells 095-159 and 095-162 in December 2014 and March 2016. This location is approximately 50 feet downgradient of RTW-1. This area of contamination most likely migrated beyond the extraction well while it was off for repairs.

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. A small area of PCE located near well 095-159 will be captured by downgradient extraction well RTW-2. This well will be restarted when the contamination reaches here. 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 PCE migrating from the source area.

As noted in response to DQO Decision 1 above, the VOC contamination periodically detected in well 095-307, located to the west of the main plume, will not be captured by the Building 96 extraction wells. This contamination may be addressed by the Middle Road Treatment System and natural attenuation.

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 was projected to operate until approximately 2016. However, based on current data RTW-1 is projected to run through 2018.

Table 3.2.1-2
Building 96 Area
2015 Average VOC Emission Rates

Parameter	Allowable ERP* (lb/hr)	Actual** ER (lb/hr)
dichlorodifluoromethane	0.0000187	0.00000180
acetone	0.000674	ND
methylene chloride	0.000749	ND
2-butanone	0.000187	ND
benzene	0.000112	0.0000125
tetrachloroethylene	0.000165	0.0000792
m,p-xylene	0.0000116	ND
isopropylbenzene	0.000243	ND
n-propylbenzene	0.0000599	ND
1,3,5-trimethylbenzene	0.000375	ND
1,2,4-trimethylbenzene	0.000225	0.0000039
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

Influent TVOC concentrations in downgradient recirculation wells RTW-2 through RTW-4 have been below 50 µg/L since 2008. VOCs have not been detected above standards for 2014 and 2015 in RTW-2 and RTW-3, and nearby up-gradient monitoring wells have only detected TVOCs concentrations slightly above the system capture goal once in the past two years at a value of 53 µg/L (in April 2015). Due to these consistently low levels, extraction wells RTW-2 and RTW-3 were shut down and placed in standby mode in January 2016. Extraction well RTW-4 remains in standby mode.

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

TVOC concentrations in 13 of 21 core wells were above 50 µg/L in 2015.

4b. Is there a significant concentration rebound in core wells and/or extraction wells following shutdown?
The system remained in operation in 2015 with the exception of RTW-4. There has been no rebound of VOCs in RTW-4 or adjacent monitoring wells since it was placed in standby mode in 2012.

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, MCLs are expected to be achieved by 2030.

3.2.1.8 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. Maintain a monthly sampling frequency of the influent and effluent.
- Maintain treatment wells RTW-2, RTW-3, and RTW-4 in standby mode, and maintain a monthly sampling frequency of the influent. Restart the wells if extraction or monitoring well data indicate that TVOC concentrations exceed 50 µg/L.
- Continue to maintain the RTW-1 resin treatment in standby mode, and if concentrations of hexavalent chromium in the effluent increase to over 50 µg/L (an administrative limit established that is half of the SPDES limit of 100 µg/L), treatment would resume. The maximum hexavalent chromium detected in the effluent in 2015 was 6.5 µg/L.
- Install temporary well(s) just west of monitoring well 095-312 to evaluate the extent of VOC concentrations in Geoprobe B96-GP-01-2016.

3.2.2 Building 452 Freon-11 Treatment System

This section summarizes the 2015 operational data from the Building 452 Freon-11 Treatment System, which consists of one pumping well with air stripping treatment. It also presents conclusions and recommendations for future operation of the system.

In April 2011, BNL detected the refrigerant Freon-11 (Trichlorofluoromethane) in Building 96 area groundwater monitoring well 085-378. From April through early August, 2011, temporary groundwater monitoring wells were installed to characterize the vertical and horizontal extent of Freon-11 in the groundwater. 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 3.2.2-1**). Twelve new monitoring wells were installed for long-term surveillance of the source area and plume. The maximum Freon-11 concentration detected during 2011 was 38,800 µg/L in well 085-382, located approximately 100 feet downgradient of Building 452.

Following the characterization of the plume, the Building 452 Freon-11 Source Area and Groundwater Plume were designated Area of Concern 32. Remedial actions for the plume were documented as an Explanation of Significant Differences (ESD) under the OU III ROD (BNL 2012a).

3.2.2.1 System Description

Due to the high levels of Freon-11 detected in groundwater and the extent of the plume, it was determined that active remediation of the plume was required to ensure that the OU III ROD cleanup objectives are met. To achieve the cleanup objectives, operation of new extraction well EW-18 and the use of existing Building 96 Groundwater Treatment System extraction well RTW-1 are being used to remediate the main portion of the Freon-11 plume. The Building 452 treatment system began full-time operation in March 2012. Groundwater from extraction well EW-18 is treated using an air stripper tray system located in a treatment building located adjacent to the treatment building for RTW-1 (**Figure 3.2.2-1**). Groundwater from extraction well RTW-1 is also treated using tray air stripper system (see **Section 3.2.1**). The treated water from extraction wells EW-18 and RTW-1 is discharged to a nearby stormwater culvert which leads to BNL Recharge Basin HS. The discharges are regulated under two NYSDEC SPDES equivalency permits. Review of the potential atmospheric emissions following the New York State air emissions modeling (DAR-1) process showed that the release of Freon-11 from this system will not pose short-term or long-term impacts. A complete description of the system is included in the *Operations and Maintenance Manual Building 452 Groundwater Treatment System* (BNL 2012b).

3.2.2.2 Source Area

The groundwater monitoring wells located immediately downgradient of the source area are used to verify expected reductions in Freon-11 concentrations over time.

3.2.2.3 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 3.2.2-1**).

Sampling Frequency and Analysis

During 2015, the Building 452 monitoring wells were sampled quarterly, and the samples were analyzed for VOCs (**Table 1-6**).

3.2.2.4 Monitoring Well Results

Complete VOC results are provided in **Appendix C**. The fourth quarter 2015 plume is shown on **Figure 3.2.2-1**. The cross-section view of the plume is shown on **Figure 3.2.2-2**. Freon-11 concentration trends in key monitoring wells are presented on **Figure 3.2.2-3**. A summary of key monitoring results for 2015 follows:

Building 452 Source Area:

- Freon-11 concentrations in all source area monitoring wells have been less than the 50 µg/L capture goal since the third quarter of 2014. Compared to 2011 when Freon-11 concentrations in source area wells reached 38,800 µg/L, monitoring results for the fourth quarter 2015 indicate significant reductions in Freon-11 concentrations, with a maximum concentration of 23.7 µg/L detected in well 085-382 (**Figure 3.2.2-3**).

Plume Core Wells:

- Plume core wells 085-385 and 085-386 are located within the capture zone of EW-18. Freon-11 concentrations in these wells have been less than the 50 µg/L capture goal since May 2014. During the fourth quarter 2015, the maximum concentration was 9.1 µg/L.
- Freon-11 concentrations in core well 085-387 were below the 50 µg/L capture goal during the entire year, with Freon-11 decreasing to 3.4 µg/L by the fourth quarter. Well 085-387 is located downgradient of EW-18 and upgradient of RTW-1.
- During 2015, the maximum influent Freon-11 concentrations in extraction wells EW-18 and RTW-1 were 40.6 µg/L and 15 µg/L, respectively.

Bypass Wells:

- During the fourth quarter 2015, Freon-11 was not detected in bypass wells 095-313, 095-314 and 095-315. A trace level (0.5 µg/L) of Freon-11 was detected in Building 96 well 095-162. The monitoring results indicate that extraction well RTW-1 is effectively remediating the downgradient portion of the plume not captured by EW-18.
- Low levels of Freon-11 (<3 µg/L) were detected in Building 96 treatment wells RTW-2 and RTW-3 during the first three quarters of 2014. Freon-11 dropped to non-detectable levels during the fourth quarter of 2014, and was not detected in any samples collected during 2015.

3.2.2.5 System Operations

Operating Parameters

Starting in February 2015, extraction well EW-18 operated in a pulsed pumping mode of one month on, one month off. Operating conditions for Building 96 extraction well RTW-1are presented in **Section 3.2.1**.

During 2015, the Building 452 Freon-11 groundwater treatment system treated approximately 16 million gallons of groundwater (**Table 2-2**).

January – September 2015

The system was turned off January 23rd in preparation for a snow storm and then remained off until March 12th. The system was off all of February for pulsed pumping. The system ran intermittently in

July due to electrical problems. The system operated normally the remainder of the time. During this period the system treated approximately 13 million gallons of groundwater.

October – December 2015

The system operated normally for this period and treated approximately 3 million gallons of groundwater.

3.2.2.6 System Operational Data

Treatment Well Influent and Effluent

Table F-8 lists the monthly influent and **Table F-9** lists the monthly effluent VOC concentrations for extraction well EW-18. The highest Freon-11 influent concentration was 40.6 µg/L. **Figure 3.2.2-4** shows the Freon-11 concentrations in the treatment well over time. **Table 3.2.2-1** shows the maximum measured effluent contaminant concentrations compared to the SPDES equivalency permit for the treatment system. The treated effluent met all SPDES equivalency permit parameters during 2015.

During 2015, the maximum Freon-11 influent concentration in extraction well RTW-1 was 15 µg/L. Freon-11 was not detected in the other Building 96 treatment wells RTW-2 or RTW-3 (**Section 3.2.1**). The treated effluent from the RTW-1 treatment system met all SPDES equivalency permit parameters during 2015.

Table 3.2.2-1
Building 452 EW-18 Treatment Well
2015 SPDES Equivalency Permit Levels

Parameter	Permit Level (µg/L)	Max. Measured Value (µg/L)
pH range	5.0–8.5 SU	6.2–7.8 SU
benzene	1.0	<0.5
bromodichloromethane	50.0	<0.5
carbon tetrachloride	5.0	<0.5
chloroform	7.0	<0.5
dichlorodifluoromethane	5.0	<0.5
1,1-dichloroethylene	5.0	<0.5
4-isopropyltoluene	5.0	<0.5
methyl chloride	5.0	<0.5
methylene chloride	5.0	<0.5
tetrachloroethylene	5.0	<0.5
toluene	5.0	<0.5
1,2,3-trichlorobenzene	5.0	<0.5
1,1,1-trichloroethane	5.0	<0.5
trichlorofluoromethane	5.0	<0.5
1,2,4-trimethylbenzene	5.0	<0.5
xylenes (m+p)	5.0	<0.5

SU: Standard Units

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

Cumulative Mass Removal

Table 3.2.2-2 shows the monthly extraction well pumping rates. The annual average pumping rate for EW-18 was 61 gpm. The pumping and mass removal data for the Building 452 Treatment System are summarized on **Table F-10**. During 2015, approximately six pounds of Freon-11 were removed from the aquifer by the Building 452 treatment system. Since the start of treatment operations in March 2012, approximately 97 pounds of Freon-11 have been removed. The system has also remediated low levels of several other low concentration VOCs (e.g., chloroform, TCE and TCA) for a total removal of approximately 99 pounds of VOCs. Freon-11 has been continuously detected in Building 96 treatment well RTW-1 since December 2010, and approximately 5 pounds of Freon-11 has been removed by this treatment system. Combined, the two treatment systems have removed approximately 102 pounds of Freon-11 from the aquifer (BNL 2016b).

3.2.2.7 System Evaluation

The Building 452 Freon-11 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?
Yes there is a continuing source. However, there has been a significant reduction in Freon-11 concentrations in source area monitoring wells, from a maximum of 38,800 µg/L in 2011 to less than 24 µg/L during the fourth quarter of 2015. Although Freon-11 is still entering the groundwater from the vadose zone at concentrations above the NYS AWQS of 5 µg/L, the observed concentrations are below the 50 µg/L TVOC cleanup goal. **Figure 3.2.2-5** shows a comparison of the plume in 2011 and 2015.

2. Were unexpected levels or types of contamination detected?
No unexpected levels of Freon-11 were detected during 2015. Freon-11 concentrations in all areas of the plume have declined to levels below the 50 µg/L TVOC cleanup goal.

3. Has the downgradient migration of the plume been controlled?
Yes, the downgradient migration of the remaining portion of the Freon-11 plume is being controlled by Building 96 extraction well RTW-1.

4. Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?
The system has met all shutdown requirements. Based upon the observed reduction in Freon-11 concentrations to below the 50 µg/L TVOC cleanup goal in all source area monitoring wells, and all but one downgradient monitoring well by the end of 2014, extraction well EW-18 was placed into a pulsed-pumping mode (one month on, one month off) starting in February 2015. Monitoring conducted during 2015 demonstrated that there was no rebound in Freon-11 concentrations while the treatment system was in pulsed pumping mode, and all Freon-11 concentrations were below the 50 µg/L TVOC cleanup goal. A Petition for Shutdown was submitted to the regulatory agencies in January 2016 (BNL 2016b). Following agency approval of the petition, the system was placed in standby mode in March 2016. Building 96 extraction well RTW-1 will continue in full time operation for several more years, and will control the downgradient migration of the remaining Freon-11 plume.

4a. Are Freon-11 concentrations in plume core wells above or below 50 ug/L?
During 2015, Freon-11 concentrations in all plume core wells were below the 50 µg/L TVOC cleanup goal.

4b. Is there a significant concentration rebound in core wells and/or extraction wells following shutdown?
Following system shutdown in March 2016, the monitoring wells and extraction well EW-18 will be monitored to verify that significant rebound does not occur.

5. Has the groundwater cleanup goal of meeting MCLs been achieved?
Meeting the 5 µg/L MCL for Freon-11 has not been achieved. Following the start of system shutdown in March 2016, a period of monitored natural attenuation and continued operation of RTW-1 will be required to reduce the Freon-11 concentrations to less than the MCL.

3.2.2.8 Recommendations

The following are recommendations for the Building 452 Freon-11 remediation system and monitoring program:

- As defined in the approved Petition for Shutdown for the Building 452 Freon-11 Treatment System, maintain the Building 452 Treatment System in standby mode. Maintain Building 96 treatment well RTW-1 in full-time operation.

- Reduce the sampling frequency for the groundwater monitoring wells and EW-18 from quarterly to semiannually for the remainder for the shutdown period.

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3.2.3 Middle Road Treatment System

The Middle Road Treatment System began operating in October 2001. This section summarizes the operational data from the Middle Road system for 2015, 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 Treatment system has seven extraction wells and air-stripping treatment 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. A new extraction well (RW-7) was installed and began operations in November 2013. The system is currently operating utilizing wells RW-1, RW-2, RW-3, and RW-7 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 2* (BNL 2014a).

3.2.3.2 Groundwater Monitoring

The Middle Road Monitoring Program consists of a network of 39 monitoring wells located between the Princeton Avenue firebreak road and the OU III South Boundary Pump and Treat System (**Figure 1-2**). The locations of these wells are shown on **Figure 3.2.3-1**. The 39 Middle Road wells are sampled and analyzed for VOCs (**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-7 and RW-3 (**Figure 3.2.3-1**). TVOC concentrations in monitoring wells east of RW-3 are well below the 50 µg/L capture goal for this system. The highest TVOC concentration in Middle Road monitoring wells during 2015 was 615 µg/L in well 105-68 during the January sampling. This monitoring well is located approximately 500 feet north of extraction well RW-7.

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-7 through RW-3) extends to the deep Upper Glacial aquifer/Magothy aquifer interface. **Figure 3.2.3-3** shows plots of the VOC concentrations versus time for key monitoring wells associated with the Middle Road Treatment system.

Results for key monitoring wells are as follows:

- Plume core well 104-37 (screened in the deep Upper Glacial aquifer) is approximately 2,000 feet upgradient of RW-7, just south of Princeton Avenue. The TVOC concentration in October 2015 for this well was 124 µg/L. TVOC concentrations have generally been between 100 µg/L and 400 µg/L since the well was installed in 2008.
- Well 105-68 was installed approximately 500 feet north of the extraction well RW-7 in May 2013. This well showed elevated TVOC concentrations with the highest concentration of 615 µg/L in January 2015. The data from this location along with data from monitoring well 104-37 and 121-49 indicate that there is a zone of VOC contamination, primarily PCE and carbon tetrachloride, in the deep Upper Glacial aquifer extending from Princeton Avenue to the South Boundary (**Figure 3.2.3-2** and **Figure 3.2.3-4**).
- Plume core monitoring wells 105-66 and 105-67 continued to show elevated TVOC concentrations of 249 µg/L and 197 µg/L respectively, reported during the fourth quarter of 2015.

- TVOC concentrations in monitoring wells in the vicinity of extraction wells RW-4, RW-5, and RW-6 were below the system capture goal of 50 µg/L in 2015.
- Wells 095-322 and 095-323 were installed along Weaver Drive in 2014 (**Figure 3.2.3-1**). These wells were installed to monitor the northern edge of the Middle Road VOC plume. Well 095-323 had a TVOC concentration of 28 µg/L in November 2015 and well 095-322 had a TVOC concentration of 41 µg/L in November 2015.

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 194 million gallons of water were treated in 2015 by the Middle Road Treatment System.

The following is a summary of the Middle Road System operations for 2015.

January – September 2015

The system was down for four days in February for maintenance of the RW-1 flow meter. In March the system was down for two weeks for electrical repairs. In May, June and July well RW-2 was off for repairs to the well screen, pump and well piping. In August well RW-3 was off for 3 days for a flow meter replacement. Approximately146 million gallons of water were treated.

Table 3.2.3-1.
Middle Road Air Stripping Tower
2015 SPDES Equivalency Permit Levels

Parameters	Permit Limit (µg/L)	Max. Observed Value (µg/L)
pH range (SU)	6.5–8.5	6.9 – 7.6
carbon tetrachloride	5	<0.5
chloroform	7	<0.5
dichlorodifluoromethane	5	<0.5
1,1-dichloroethane	5	<0.5
1,1-dichloroethylene	5	<0.5
methyl chloride	5	<0.5
tetrachloroethylene	5	<0.5
toluene	5	<0.5
1,1,1-trichloroethane	5	<0.5
1,1,2-trichloroethane	5	<0.5
trichloroethylene	10	<0.5

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

October – December 2015

The system operated normally for the Fourth quarter of 2015. During the fourth quarter the system pumped and treated approximately 48 million gallons of water. Well RW-1 was shutdown as per recommendation in the 2014 Groundwater Status Report in November 2015.

3.2.3.5 System Operational Data

System Influent and Effluent

Figure 3.2.3-6 plots the TVOC concentrations in the extraction wells versus time. Results of the extraction well samples are found on **Table F-11.** The influent VOC concentrations showed a slight increase over the reporting period. The average TVOC concentration in the influent during 2015 was 19.5 µg/L. The results of the influent and effluent sampling are summarized on **Tables F-12** and **F-13**, 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 374 gpm during 2015 (**Table 3.2.3-3**, and **Table F-14)**, and approximately 28 pounds of VOCs were removed. Approximately 1,173 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 3.2.3-5**.

Air Discharge

Table 3.2.3-2 shows the air emissions data from the system for the OU III Middle Road air stripper tower during 2015, and compares the values to levels stipulated in NYSDEC DAR-1 regulations. Emission rates are obtained through mass-balance calculations for the water treated during that time (**Table F-13**). The concentration of each constituent was averaged for 2015, and those values were used in determining the emissions rate. The air emissions for the Middle Road system were below permitted limits.

Extraction Wells

The system is currently operating utilizing wells RW-1, RW-2, RW-3, and RW-7. 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. TVOC concentrations in wells RW-1, RW-4, RW-5 and RW-6 are all well below the capture goal of 50 µg/L in 2015 with a maximum concentration of 19 µg/L in well RW-5 in April. The maximum concentration observed in the operating wells in 2015 was in Well RW-7 with a peak concentration of 68 µg/L in August. See **Figure 3.2.3-5** for a plot of the TVOC concentrations for the seven extraction wells. **Table 3.2.3-3** shows the monthly extraction well pumping rates.

Table 3.2.3-2.
Middle Road Air Stripper
2015 Average VOC Emission Rates

Parameter	Allowable ERP* (lb/hr)	Actual** (lb/hr)
carbon tetrachloride	0.022	0.0002
chloroform	0.0031	0.0000
1,1-dichloroethane	10***	0.0000
1,2-dichloroethane	0.008	0
1,1-dichloroethylene	0.034	0.0001
cis-1,2-dichloroethylene	10***	0
trans-1,2-dichloroethylene	10***	0
tetrachloroethylene	0.387	0.0027
1,1,1-trichloroethane	10***	0.0006
trichloroethylene	0.143	0.0001

Notes:
ERP = Emission Rate Potential. Reported in lb/hr.
*ERP based on NYSDEC DAR-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.

3.2.3.6 System Evaluation

The Middle Road Treatment 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?
The known source areas for contamination at the Middle Road are the Building 96 area and the former carbon tetrachloride plume and they have been remediated or controlled.

2. Has the downgradient migration of the plume been controlled?
Yes, the western edge of the plume in the deep Upper Glacial aquifer is now being captured by newly extraction wells RW-2 and RW-7.

3. Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?
Extraction wells RW-1, RW-4, RW-5 and RW-6 will remain in standby even though low VOC concentrations below the 50 µg/L capture goal continued to be observed in the vicinity of these wells. Extraction wells RW-2, RW-3 and RW-7 will continue operations.

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

3b. Is there a significant concentration rebound in core wells and/or extraction wells following shutdown?
There has been no rebound in the extraction wells that are shut down and no rebound in the monitoring wells in this area.

4. Has the groundwater cleanup goal of meeting MCLs been achieved?
No, the cleanup goal has not been met but is expected to be met by 2030.

3.2.3.7 Recommendations

The following recommendations are made for the Middle Road Treatment System and groundwater monitoring program:

- Maintain extraction wells RW-1, RW-4, RW-5 and RW-6 in standby mode. Restart the well(s) if extraction or monitoring well data indicate that TVOC concentrations exceed the 50 µg/L capture goal.
- Continue operation of RW-2, RW-3 and RW-7.
- Discontinue sampling of monitoring well 113-06 as this well has not shown VOCs above AWQS since 1997.

3.2.4 OU III South Boundary Treatment System

This section summarizes the operational data from the South Boundary Treatment System for 2015, and gives conclusions and recommendations for future operation. Also included within this section is an evaluation of the extraction and monitoring well 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 eight extraction wells. The system is currently operating at a pumping rate of approximately 500 gpm, utilizing four 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. Extraction well EW-17 was added to the system during 2012. Wells EW-3 and EW-5 were placed in standby in October 2015. The system is currently operating with just wells EW-4 and EW-17. 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 2* (BNL 2014a).

3.2.4.2 Groundwater Monitoring

The monitoring well network consists of 45 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 3.2.15**.

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. VOCs were detected in the deep Upper Glacial aquifer in the vicinity of the site boundary, as depicted on **Figure 3.2-2, Figure 3.2.3-4, Figure 3.2.4-1,** and **Figure 3.2.4-2. Appendix C** has the complete groundwater monitoring results for 2015.

The plume core wells continued to show the same trend of decreasing VOC concentrations that were observed following the start-up of the treatment system in 1997, except for several key wells located in the deep Upper Glacial aquifer in the vicinity of wells EW-4 and EW-17. The bulk of the VOC contamination in this area is currently located immediately upgradient of wells EW-4 and EW-17, as can be seen on **Figure 3.2.4-2,** which is a cross section (G–G') 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:

- Western perimeter well 121-08 had a TVOC concentration of 15 µg/L in November and eastern perimeter well 114-07 had a concentration of 1 µg/L in November. Individual VOC concentrations in the remaining plume perimeter wells were less than 5 µg/L in November 2015. This is well below the capture goal of the system of 50 µg/L for TVOC concentrations.
- Bypass detection well 121-43 located several hundred feet south of extraction wells EW-4 and EW-17 had shown elevated levels of VOCs. In April 2011 the level was 338 µg/L and has steadily declined to 4 µg/L in November 2015. Extraction well EW-17 was installed to address the high VOC concentrations observed in well 121-43 (**Figure 3.2.4-1**) and began operations in July 2012.
- Three monitoring wells were installed to monitor the performance of extraction well EW-17. They are 121-47 a western perimeter well, 121-48 an eastern perimeter well and 121-49 located upgradient of this well. The upgradient monitoring well 121-49 showed high TVOC concentrations in 2015 with the highest concentration in November of 703µg/L.

- Monitoring well 121-45 was installed 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. TVOC concentrations were at 23 µg/L in November. This continues a downward trend in TVOC concentrations in this monitoring well.
- Well 121-54 was installed to monitor VOC concentrations upgradient of extraction well RW-17. This well had TVOC concentrations of up to 222 µg/L in 2015.
- Plume core well 121-11 is upgradient of EW-3. TVOC concentrations were 17 µg/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 a concentration of 9 µg/L in November 2015.

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. Tritium from these samples continues to be non-detect. Effluent VOC concentrations from the treatment system during this period of operation were below equivalency permit requirements.

Table 3.2.4-1.
OU III South Boundary Air Stripping Tower
2015 SPDES Equivalency Permit Levels

Parameters	Permit Limit* (µg/L)	Max. Observed Value (µg/L)
pH range (SU)	6.5 – 8.5	6.8–7.9
carbon tetrachloride	5	<0.5
chloroform	7	<0.5
dichlorodifluoromethane	5	<0.5
1,1-dichloroethane	5	<0.5
1,1-dichloroethylene	5	<0.5
methyl chloride	5	<0.5
tetrachloroethylene	5	<0.5
toluene	5	<0.5
1,1,1-trichloroethane	5	<0.5
1,1,2-trichloroethane	5	<0.5
trichloroethylene	10	<0.5

Notes:
*Maximum allowed by requirements equivalent to a SPDES permit. Required sampling frequency is monthly for VOCs and pH.
SU – Standard units.

System Operations

In 2015, approximately 190 million gallons of water were treated by the South Boundary System. Well EW-12 has not been sampled since April 2012. This is because the installation of well EW-17 utilized some of the equipment from this well. In the unlikely event this well is needed, a modification could be made to make this well operational. This determination will be made based on the monitoring well data in the vicinity of EW-12.

January – September 2015

Approximately 156 million gallons of water were pumped and treated. The system was down for a week in February and March for maintenance. In April well EW-4 was off for the entire month with an electrical problem. In May well EW-17 was off for replacement of the flow meter. In July, well EW-3 was off one week for maintenance.

October – December 2015

The OU III South Boundary System pumped and treated approximately 34 million gallons of water. EW-3 and EW-5 were put into standby mode in October because VOC concentrations have been below AWQS during 2014 and the first three quarters of 2015. EW-17 sampling was reduced from monthly to quarterly.

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-16** and **F-17**, 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 removal (**Table F-18**). The cumulative total of VOCs removed by the treatment system versus time is plotted on **Figure 3.2.4-4**. The 2015 total was approximately 22 pounds. Cumulatively, the system has removed approximately 3,014 pounds since it was started in June 1997.

Table 3.2.4-2.
OU III South Boundary Air Stripper
2015 Average VOC Emission Rates

Parameter	Allowable ERP*	Actual** ER
carbon tetrachloride	0.022	0.0003
chloroform	0.0031	0.0001
1,1-dichloroethane	10***	0
1,2-dichloroethane	0.008	0
1,1-dichloroethylene	0.034	0.0001
cis-1,2-dichloroethylene	10***	0.0003
trans-1,2-dichloroethylene	10***	0
tetrachloroethylene	0.387	0.0018
1,1,1-trichloroethane	10***	0.0001
trichloroethylene	0.143	0.0007

Notes:
ERP = Emissions Rate Potential, stated in lb/hr.
* ERP is based on NYSDEC DAR-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.

Air Discharge

Table 3.2.4-2 shows the air emissions data from the OU III South Boundary system for 2015, and compares the values to levels stipulated in NYSDEC DAR-1 regulations. Emission rates are obtained through mass-balance calculations for water treated during that time (**Table F-16**). 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.

Extraction Wells

There are two extraction wells that are currently operating. Well EW-4 continued to show slowly decreasing TVOC concentrations in 2015 (19 µg/L in July to 15 µg/L in October). EW-17 showed TVOC concentrations ranging from 30 µg/L in February to 23 µg/L in September. EW-17 sample frequency was changed from monthly to quarterly starting in October. This well is located slightly downgradient and deeper than well EW-4. Wells EW-3 and EW-5 had VOC concentrations below the AWQS in 2015, and were placed into standby mode in the fourth quarter (**Figure 3.2.4-3**). **Table F-15** summarizes the data for the extraction wells. **Table 3.2.4-3** shows the monthly extraction well pumping rates. The system averaged 367 gpm in 2015.

3.2.4.6 System Evaluation

The OU III South Boundary Treatment 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.

2. Has the downgradient migration of the plume been controlled?
Yes, extraction well EW-17 is capturing the higher concentrations that were migrating beneath well EW-4. This is evident by the reduced VOC concentrations present in the bypass well 121-43.

3. Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?
Six of the eight extraction wells have been shut down as they have achieved the capture goals for this system. The two wells will continue to operate to capture VOCs 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 along the eastern segment of this system have not shown a concentration rebound in the monitoring or extraction wells. Two of the westernmost wells are still operating.

6. Has the groundwater cleanup goal of meeting MCLs been achieved?
No, MCLs have not been achieved, although they are expected to be achieved by 2030.

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

- Maintain wells EW-3, EW-5, 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.
- Continue to operate wells EW-4 and EW-17 on a full time basis.
- Maintain the routine O&M monitoring frequency implemented last year.
- Stop sampling shallow monitoring wells 121-09, 121-22, 121-13. Well 121-09 has never exceeded the MCL since its installation in 1997. VOCs in well 121-13 have been below MCL's since 2006 and well 121-22 has been below MCLs since 1998. These wells are shallower than the depth of this plume and are no longer providing useful information.

3.2.5 Western South Boundary Treatment System

The Western South Boundary Treatment System was designed to capture VOCs in the Upper Glacial aquifer along portions of the BNL western south boundary. The capture goal for the system is TVOC concentrations exceeding 20 µg/L. 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 pulsed 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 2014. Extraction well WSB-2 remains in a pulsed 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 18 wells is used to monitor this plume. 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, DCE, and chloroform. VOC contamination is located in the mid to deep Upper Glacial aquifer. **Figure 3.2.5-1** presents fourth quarter 2015 monitoring well concentrations. **Figure 3.2.5-2** provides a north-south cross section (H to H') of the plume. **Figure 3.2.5-3** provides trend graphs for key monitoring wells. A summary of key monitoring well data for 2015 follows:

- The 2015 maximum TVOC concentration detected in the plume was 49 µg/L in plume core well 103-15 in the first and fourth quarters. This well is screened in the deep Upper Glacial aquifer between Middle Road and East Princeton Avenue. It is located approximately 4,000 feet upgradient of WSB-1. VOCs exceeding the 5 µg/L AWQS were Freon-12 and TCE, with maximum concentrations of 35 µg/L and 6 µg/L, respectively. VOCs in this well have been slowly declining since it was installed in 2009. Core monitoring well 119-10, located at Middle Road to monitor VOCs migrating past 103-15, identified TVOC concentrations up to 15 µg/L in 2015. Freon-12 was detected up to 8 µg/L.
- As recommended in the *2014 Groundwater Status Report*, two temporary wells were installed 100 feet apart in February 2016 to monitor the VOCs (particularly Freon-12) between monitoring wells 103-15 and 119-10. The maximum TVOC concentration in the temporary wells was 182 µg/L in WSBVP-01-2016 at 180 feet bls **(Table 3.2.5-4).** The maximum VOCs detected were DCE and TCA at 96 µg/L and 79 µg/L, respectively. These are the same compounds present in the downgradient and slightly shallower portion of the plume. Freon-12 was not detected in any of the temporary well samples above the AWQS.
- Core monitoring well 119-06, screened at 130 feet bls had TVOC concentrations up to 170 µg/L in December 2008, with TCA (100 µg/L) as the primary compound. Since 2010, this well has remained below AWQS. Temporary well WSBVP-02-2016, located approximately 1,000 feet upgradient of 119-06 also identified TVOCs up to 30 µg/L at 140 feet bls This indicates that these shallower VOCs are continuing to move through this area.
- The maximum TVOC concentration in core well 126-17 was 31 µg/L during the first quarter of 2015. This well is screened at 140 feet bls and located approximately 700 feet north of WSB-1 to provide a data point between this extraction well and well 119-06. The primary compounds detected were TCA and DCE at 15 µg/L and 14 µg/L, respectively. This well has shown a steady

decline in TVOC concentrations from a high of 388 µg/L when it was installed in February 2011 to 18 µg/L in the fourth quarter 2015.

- 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 AWQS since 2005. VOC concentrations in core wells 126-11 and 126-13 remained below the AWQS since 2011.
- Well 130-03, located west of extraction well WSB-1, had a maximum TVOC concentration of 15 µg/L in 2015. TVOC concentrations in this well have been below the 20 µg/L capture goal since 2012. The capture zone of the Western South Boundary extraction well WSB-1 was not intended to include this area.

Table 3.2.5-1
Western South Boundary Treatment System
2015 SPDES Equivalency Permit Levels

Parameter	Permit Level (µg/L)	Max. Measured Value (µg/L)
pH range	6.5–8.5 SU	6.4–7.9 SU
carbon tetrachloride	5	<0.5
chloroform	7	<0.5
dichlorodifluoromethane	5	<0.5
1,1-dichloroethane	5	<0.5
1,1-dichloroethylene	5	<0.5
methyl chloride	5	<0.5
tetrachloroethylene	5	<0.5
toluene	5	<0.5
1,1,1-trichloroethane	5	<0.5
1,1,2-trichloroethane	5	<0.5
trichloroethylene	10	<0.5

Note:
Required effluent sampling frequency is 2x/month for VOCs and monthly for pH.
SU = Standard units

3.2.5.4 System Operations

During 2015, the extraction wells were sampled quarterly and the influent and effluent of the air stripping tower were sampled twice per month. Extraction well WSB-1 continued full-time operation through 2015 due to elevated TVOC concentrations greater than the capture goal of 20 µg/L in upgradient core wells. Extraction well WSB-2 continued to operate in pulsed pumping mode. 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 2015, except for one minor pH excursion. The system operations are summarized below.

January – September 2015

The WSB-2 extraction well operating schedule was one month on and two months off. The system was off for three weeks in February due to freezing issues and maintenance. During the first three quarters, the system treated approximately 77 million gallons of water.

October – December 2015

The system operated normally for the fourth quarter. The system treated approximately 29 million gallons of water.

3.2.5.5 System Operational Data

Extraction Wells

During 2015, the Western South Boundary System treated approximately 106 million gallons of water, with an average flow rate of approximately 205 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 concentrations for extraction wells WSB-1 and WSB-2 are provided in **Table F-19**. TVOC concentrations for extraction wells WSB-1 and WSB-2 have remained below the capture goal of 20 µg/L since 2006. Individual VOC compounds in extraction well WSB-02 were below AWQS in 2015. VOCs in extraction well WSB-01 were either below or slightly above AWQS in 2015. VOC levels in both wells have remained relatively constant since system start-up in 2002. **Figure 3.2.5-4** provides a graph of extraction well trends over time.

System Influent and Effluent

Influent TVOC concentrations continued to remain below 20 µg/L. Individual VOC concentrations slightly exceeded the AWQS during the year, with a maximum TCA value of 7 µg/L in April 2015, and maximum DCE value of 7 µg/L in June (**Table F-20**). These levels are consistent with the historical influent concentrations.

The air stripping 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-21)**.There were no detections of tritium in the effluent in 2015.

Table 3.2.5-3
Western South Boundary
2015 Air Stripper VOC Emissions Data

Parameter	Allowable ERP* (lb/hr)	Actual ERP (lb/hr)
carbon tetrachloride	0.016	0
chloroform	0.0086	0.0001
1,1-dichloroethane	10**	0.00002
1,2-dichloroethane	0.011	0.00001
1,1-dichloroethene	0.194	0
chloroethane	10**	0
1,1,1-trichloroethane	10**	0.0004
trichloroethylene	0.119	0.0001

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

Cumulative Mass Removal

Average flow rates for each monthly monitoring period were used, in combination with the TVOC concentration in the influent, to calculate the pounds of VOCs removed per month (**Table F-22**). The cumulative mass of VOCs removed by the treatment system is provided on **Figure 3.2.5-5**. During 2015, seven pounds of VOCs were removed. A total of 130 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 2015 and compares the values to levels stipulated in NYSDEC DAR-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 Treatment System performance can be evaluated based on decisions identified for this system from the groundwater DQO process.

1. Were unexpected levels or types of contamination detected?
Yes, temporary wells WSBVP-01-2016 and WSBVP-02-2016 identified elevated TVOC concentrations up to 182 µg/L (consisting of DCE and TCA) between 160 and 180 feet bls. These detections are deeper than the TCA and DCE previously observed in the Middle Road location for this plume. The intent of the temporary wells was to further characterize the extent of Freon-12 in this area, which has been detected up to 55 µg/L historically. As a result of the characterization, plumes of TCA and DCE were defined at two different depths (**Figure 3.2.5-2**).

2. Has the downgradient migration of the plume been controlled?
The system is effectively capturing the higher concentration segments of the plume. VOC concentrations in the plume perimeter wells remained below the AWQS during 2015, indicating that

the plume is being controlled by the extraction wells. VOC concentrations in well 130-03 have decreased since late 2004. The capture zone of WSB-1 was not intended to include this area. The capture zone for the treatment system is depicted on **Figure 3.0-1**. The downgradient extent of the deeper VOCs has not yet been defined.

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 for WSB-1 of reducing contamination to less than the 20 µg/L capture goal. Core monitoring wells upgradient of WSB-1 still exceed the capture goal. Pulsed pumping continued for WSB-2 (one month on and two months off).

3a. Are TVOC concentrations in plume core wells above or below 20 µg/L?
Three of the eleven core wells exceed the 20 µg/L capture goal. One of these wells (103-15) is approximately 4,000 feet upgradient of WSB-1 (about a 13 year travel time to WSB-1). It is expected that the VOCs in this well will attenuate to less than AWQS before they reach the site boundary. TVOC concentrations in the other two core wells have been declining in the last few years to just above the capture goal. The February 2016 temporary wells installed downgradient of well 103-15 also identified TVOC concentrations above the capture goal. Core monitoring wells upgradient of WSB-2 are less than the 20 µg/L capture goal.

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

4. Has the groundwater cleanup goal of meeting MCLs been achieved?
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.
- Based on the low TVOC concentrations below the capture goal of 20 µg/L, shut down extraction well WSB-2. If TVOC concentrations greater than 20 µg/L are observed in WSB-2 or the adjacent core monitoring wells, extraction well WSB-2 may be put into full time operation.
- As a follow-up to the February 2016 characterization, install additional temporary and permanent monitoring wells to define the width and extent of the higher VOCs between monitoring wells 103-15 and 119-10.
- Following the characterization, perform an update to the groundwater model to determine the downgradient migration and attenuation of the VOCs to the AWQS.
- Maintain the routine O&M monitoring frequency for the monitoring wells.

3.2.6 Industrial Park Groundwater Treatment System

This section summarizes the operational data from the Industrial Park Groundwater Treatment System for 2015 and presents conclusions and recommendations for its future operation. The system began operation in September 1999. A Petition for Shutdown was submitted to the regulators in February 2013 (BNL, 2013a). After receiving approval from the regulators the system was shutdown on May 1, 2013. In March 2014 wells UVB-3 through UVB-6 were returned to full time operation due to a rebound of VOC concentrations. The 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 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 original 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 2000b).

During 2014 two new groundwater extraction wells were installed in the Industrial Park. They are shown on **Figure 3.2.6-1** as IP-EW-8 and IP-EW-9. These wells became operational in January 2015. The wells are screened deeper than the adjacent UVB wells to capture deeper VOC contamination identified just upgradient of this area (**Figure 3.2.6-2**). These wells are utilizing liquid phase carbon to treat the water rather than in-well air stripping. A complete description of the Industrial Park Modification is included in the *Operations and Maintenance Manual for the OU III Modification to the Industrial Park Groundwater Treatment System* (BNL 2015c).

3.2.6.2 Groundwater Monitoring

Well Network

The monitoring well network consists of 53 wells and is designed to monitor the VOCs in the vicinity of the industrial park south of the site, and the effectiveness of the groundwater treatment system.

Sampling Frequency and Analysis

Wells are sampled for VOCs as per the schedule in **Table 1-5**.

During 2015 one new monitoring well (IP-MW01-2015) and two temporary vertical profile wells (IP-VP-01-2015 and IP-VP-02-2015) were added to supplement the monitoring for the above referenced Industrial Park modification.

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 2015. Based on these data, the plume is effectively bounded by the current well network. **Figure 3.2.6-1** shows the plume distribution based on fourth quarter 2015 data. The vertical extent of contamination is shown on **Figure 3.2.6-2**. The location of this cross section (I–I') is illustrated on **3.2.6-1**.

Table 3.2.6-2 has the results of both vertical profile borings. A summary of the temporary well analytical results are as follows (**Figure 3.2.6-3**):

- Elevated TVOC concentrations above 50 µg/L were observed in both vertical profile wells in the deep Upper Glacial aquifer/Magothy aquifer interface at a peak concentration of 97 µg/L in VP-01 and 58 µg/L in VP-02. The depths of the higher VOC concentrations are consistent with the screened interval of the newly installed extraction wells. One new monitoring well was installed at the location of VP-01 (IP-MW01-2015).

  The 2015 results for key monitoring wells are:

Plume Core Wells

- The most recent data from the wells are posted on **Figure 3.2.6-1**. The data from these wells shows that the higher VOC concentrations are still located to the north of the two new extraction wells. The highest concentration was 235 µg/L located in well 000-528 in May 2015. This is approximately 1000 feet upgradient of the new extraction 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 low VOC concentrations over the past several years. In 2015 well 000-253 had a maximum TVOC concentration of 3µg/L and well 000-256 had a high TVOC concentration of 5 µg/L.
- A steady decline in TVOC concentrations has been observed in well 000-112 (immediately upgradient of UVB-1 and UVB-2) since 1999, when concentrations were approximately 2,000 µg/L. TVOC concentrations were 1 µg/L in December 2015.
- Well 000-259 is located between UVB-2 and UVB-3. In 2015 this well was sampled quarterly, and had TVOC concentrations ranging from 34 µg/L in May to 10 µg/L in August.
- Well 000-262 is located between UVB-4 and UVB-5. In 2015 the TVOC concentrations ranged from a low of 11 µg/L in August to 37 µg/L in March.
- Monitoring wells 000-528 and 000-529, are to track VOC concentrations in the Industrial Park south of well 121-43 (located just south of the Long Island Expressway). Well 000-528 contained a maximum TVOC concentration of 235 µg/L in August and well 000-529 had a maximum TVOC concentration of 42 µg/L in May.
- Well 000-530 is located between extraction wells UVB-3 and UVB-4 and well 000-531 is located between wells UVB-5 and UVB-6. The 2015 sampling results for well 000-530 showed a maximum TVOC concentration of 64 µg/L in January.. The sampling for well 000-531 showed a maximum TVOC concentration of 68 µg/L in February. These wells are above the sytem capture goal for the Industrial park system of 50 µg/L, so based upon this data these UVB wells are operating.
- One new monitoring well (IP-MW01-2015) was installed in 2015 to enhance the monitoring network upgradient of the two new extraction wells. This well is screened from 230 to 240 feet

below grade. This was the area were the highest TVOC concentrations (97 µg/L) were identified in the vertical profile done at this location (IP-VP-01-2015).

- Well 000-544 is a bypass well on Carleton Drive. It detected TVOC concentrations up to 42 µg/L in November. This well was installed as a bypass well and this contamination was past the new extraction wells before they were installed.

Plume Bypass Wells

- TVOC concentrations in the wells located near Carleton Drive were stable or decreasing during 2015. Wells 000-431 and 000-432 serve as bypass monitoring points downgradient of UVB-2. VOC concentrations in 000-431 and 000-432 were below AWQS during 2015. VOC concentrations in bypass wells 000-275, 000-276, and 000-277 were below AWQS during 2015, indicating that the system has been effective in capturing the plume. Well 000-278 is directly downgradient of well UVB-4 and in 2015 had VOC concentrations below AWQS.
- Well 000-274 had a maximum TVOC concentration of 3 µg/L in May. These wells are located immediately downgradient of well UVB-1, which was shut down in 2005. These concentrations are well below AWQS.

Perimeter Wells

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

3.2.6.4 System Operations

In 2015, approximately 52 million gallons of groundwater were treated by the Industrial Park In-Well Air Stripping System and 95 million gallons by new extraction wells IP-EW-8 and IP-EW-9 . The system was in standby until March when wells UVB-3 through UVB-6 were put back into full time operation due to detections of TVOCs above the capture goal. 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**. New extraction wells IP-EW-8 and IP-EW-9 operate under a SPDES Equivalency Permit (**Table 3.2.6-3).** The system is sampled on a monthly basis for VOCs and weekly for pH. Effluent VOC concentrations from the treatment system during this period of operation were below equivalency permit requirements. The following summarizes the system operations for 2015.

January – September 2015

Wells UVB-3 through UVB-6 were off from the beginning of January to the beginning of July to repair malfunctioning float switches and damage done to the system due to a lightning strike. Wells EW-8 and EW- 9 were off from May 7th to May 26th due to a problem with the high level float switches in the diffusion wells. In August well UVB-5 was off the majority of the month due to electrical repairs. In September well UVB-6 was off most of the month to replace the packer. Wells UVB-1, UVB-2 and UVB-7 remained in standby. The system pumped and treated a total of approximately 93 million gallons of water during this period.

October – December 2015

Wells UVB-3 through UVB-6 where off in October for several days to repair a fault in the blower motor. During the period of October through December well UVB-3 ran intermittently due to electrical issues. Wells UVB-1, UVB-2 and UVB-7 remained in standby. The system pumped and treated a total of approximately 54 million gallons of water during this period.

Table 3.2.6.3 OU III Industrial Park Treatment System
2015 SPDES Equivalency Permit Levels

Parameters	Permit Limit (µg/L)	Max. Measured Value (µg/L)
pH (range)	5.0 – 8.5 SU	5.4 – 7.4 SU
carbon Tetrachloride	5.0	<0.50
chloroform	7.0	0.8
1,1-dichloroethylene	5.0	<0.50
1,2-dichloroethane	5.0	<0.50
tetrachloroethylene	5.0	<0.50
1,1,1-trichloroethane	5.0	<0.50
Trichloroethane	5.0	1.7

Notes:

Required sampling frequency is monthly for VOCs and weekly for pH.

SU = Standard Units

3.2.6.5 System Operational Data

Recirculation Well Influent and Effluent

During 2015, influent TVOC concentrations in the treatment system wells were 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 2015. The removal efficiencies for the air strippers in the extraction wells for 2015 are shown in **Table F-23**.

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-24** summarizes these data. During 2015, flow averaged approximately 50 gpm per well for the four air stripping wells while they were operating and 91 gpm for the two new extraction wells. **Figure 3.2.6-6** plots the total pounds of VOCs removed by the treatment system vs. time. During 2015, approximately three pounds of VOCs were removed from the aquifer, with a total of 1,067 pounds of VOCs removed since 1999.

Air Treatment System

Air samples were collected quarterly from the GAC vessels when the system was operating 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 checked to optimize the efficiency of individual recirculation wells.

Airflow rates are measured for each in-well air-stripping unit inside the treatment building (**Table F-25**). Although these rates were checked during the year and were within normal operating ranges. However, no flow rates were recorded in 2015 due to a data collection issue.

3.2.6.6 System Evaluation

The Industrial Park Treatment 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 2015.

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 2015. The capture zone for the OU III Industrial Park System is depicted on **Figure 3.0-1**. A comparison of the plume from 1997 to 2015 is provided on **Figure 3.2.6-7**

3. Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?
Approval of the *Petition for Shutdown OU III Industrial Park Groundwater Treatment System* (BNL, 2013b) was received from the regulators in April 2013 and the system was shut down in May 2013. However the system was restarted in March 2014 with wells UVB-3, UVB-4, UVB-5 and UVB-6 due to an increase in TVOC concentrations in several core monitoring wells above the capture goal of 50 µg/L. In addition two new extraction wells were added in 2014 (EW-8 and EW-9) to capture newly identified deeper upgradient VOCs.

4. Are TVOC concentrations in plume core wells above or below 50 ug/L?
There are several plume core wells above the 50 µg/L TVOC capture goal in 2015.

5. Is there a significant concentration rebound in core wells and/or extraction wells following shutdown?
The average TVOC concentration for core monitoring wells is shown on **Figure 3.2.6-8.** Wells UVB-3 through UVB-6 where restarted in March 2014 due to a rebound in concentrations above the 50 µg/L capture goal.

6. Has the groundwater cleanup goal of meeting MCLs been achieved?
No, MCLs have not yet been achieved, but are expected to be by 2030.

3.2.6.7 Recommendations

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

- Continue operation of the two new extraction wells IP-EW8 and IP-EW9.
- Continue to operate pumping wells UVB-3,UVB-4, UVB-5 and UVB-6. If TVOC concentrations drop below the capture goal in the adjacent monitoring wells these wells may be shut down.
- Wells UVB-1, UVB-2 and UVB-7 should remain in standby.
- Discontinue sampling of monitoring wells 000-260, 000-257, 000-263, 000-266, 000-269, as these wells have all had concentrations below AWQS for over ten years and are screened shallower then the plume that is associated with this project.

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3.2.7 Industrial Park East Monitoring Program

This section summarizes the 2015 monitoring well data for the Industrial Park East (IPE) plume, and presents conclusions and recommendations for future monitoring. As noted in the *2013 Groundwater Status Report* and the *Petition for Closure, Industrial Park East Groundwater Treatment System* (BNL 2013b), the system has met the criteria established in the *Operations and Maintenance Manual for the Industrial Park East Offsite Groundwater Remediation System* (BNL 2004a) for system closure and was decommissioned. The two extraction wells and four of 16 monitoring wells were decommissioned in October 2013. Any remaining contaminants in the downgradient portion of the plume will attenuate to below drinking water standards in the Upper Glacial and Magothy aquifers before the required 2030 and 2065 cleanup timeframes, respectively.

The building, including the carbon units and controls, and the recharge wells are now being used to support the remediation of the deep VOC plume in the Industrial Park. Remediation of the deep VOC plume is further discussed in **Section 3.2.6** Industrial Park.

3.2.7.1 Groundwater Monitoring

The post closure monitoring network consists of 11 wells (**Figure 1-2**) where eight wells are sampled annually and three sampled semi-annually for VOCs (**Table 1-5**). The data from the 11wells are also evaluated as part of the North Street and Magothy monitoring programs.

3.2.7.2 Monitoring Well Results

The primary VOCs associated with this portion of the OU III plume are TCA, TCE, carbon tetrachloride, and DCE. Fourth-quarter 2015 TVOC well data are posted on **Figure 3.2.7-1**. Although the TVOC concentrations continue to be greater than 5 µg/L as shown of the figure, individual VOCs are below AWQS for all wells in 2015. **Figure 3.2.7-2** presents the 2015 individual VOC data compared to the AWQS. The complete analytical results are in **Appendix C.** Results for key monitoring wells are as follows:

- All wells have shown a declining trend in VOC concentrations for the last several years. Plume core monitoring wells, 122-24 (Magothy) and 122-25 (Magothy) have remained below AWQS since 2007. Although plume core well 000-429 (Magothy) detected a maximum concentration up to 5.0 µg/L of carbon tetrachloride in the fourth quarter of 2014, it did not detect VOCs above AWQS in 2015. The declining VOC concentration trends for wells 122-24 and 122-25 shown on **Figure 3.2.7-4** indicates that the trailing edge of the plume migrated south of these wells in 2005/2006. These wells are also downgradient of the OU III South Boundary treatment system extraction well EW-8, which was designed to capture contamination in the shallow portion of the Magothy aquifer at the south boundary.
- Well 000-427, which is screened near the interface of the Upper Glacial and Magothy aquifers, did not detect VOCs above AWQS in 2015. This well has remained near the AWQS of 5 µg/L for several years, as shown on **Figure 3.2.7-4**. **Figure 3.2.7-3** shows a north-south cross section view of the contaminant plume.
- Magothy monitoring well 000-526 was installed in September 2011 to monitor downgradient contamination that had been observed in well 000-494 in 2008. There have been no detections of VOCs in this well since it was installed.

3.2.7.3 Groundwater Monitoring Program Evaluation

This system was 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. As noted in the Petition for Closure, the system addressed the highest VOC concentration portion of the plume (above 50 µg/L TVOC).

The Industrial Park East Groundwater Monitoring Program can be evaluated in the context of basic decisions established for the program using 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 associated with the Industrial Park East Plume during 2015.

2. Is the plume naturally attenuating as expected?.
Yes.

3. Has the downgradient migration of the plume been controlled?
VOC concentrations in the plume segment in the Upper Glacial aquifer have been reduced to less than AWQS.

4. Has the groundwater cleanup goal of meeting MCLs been achieved?
Yes, individual VOC concentrations in the core monitoring wells (upgradient of and in the vicinity of the former extraction wells) have been below MCLs since 2014

3.2.7.4 Recommendations

The following is recommended for the Industrial Park East Groundwater Monitoring Program.

- Continue monitoring wells 000-494, 000-526, 000427, and 000-429 for VOCs in accordance with the post closure monitoring requirements.
- In accordance with the 2013 Petition for Closure of the Industrial Park East Groundwater Treatment System, the following changes to the groundwater monitoring program are recommended since the wells have been below the AWQS for a minimum of four consecutive sampling events:

Table 3.2.7-1 Industrial Park East Groundwater Monitoring Program Changes

Well ID	**Aquifer**	**Recommended Disposition**	**Rationale**
000-211	Deep Glacial	Discontinue VOCs, maintain for water levels	Below AWQS since 2009. No upgradient contamination.
000-426	Magothy	Discontinue VOCs, maintain for water levels	Below AWQS since 2004. No upgradient contamination.
000-490	Magothy	Discontinue VOCs and decommission	Below AWQS since 2004. No upgradient contamination.
000-492	Magothy	Discontinue VOCs and decommission	Below AWQS since 2004. No upgradient contamination.
000-495	Magothy	Discontinue VOCs and decommission	Below AWQS since 2009. No upgradient contamination.
122-24	Magothy	Discontinue VOCs and decommission	Below AWQS since 2007. No upgradient contamination.
122-25	Magothy	Discontinue VOCs and decommission	Below AWQS since 2004. No upgradient contamination.

3.2.8 North Street Treatment System

The North Street Treatment 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 Flower Hill Drive (**Figure 3.2.8-1**). The groundwater treatment system began operating in May 2004. In June 2013 a *Petition for Shutdown OU III North Street Groundwater Treatment System* (BNL 2013c) was submitted to the regulators for review and approval. The system was shut down in August 2013 after receiving approval from the regulators. The system was restarted in June 2014 due to a rebound in VOC concentrations in several monitoring wells above the 50 µg/L TVOC concentration capture goal. The system was again shutdown in July 2015 due to a reduction in VOC concentrations. In August 2015, well NS-1 was restarted due to elevated VOC concentrations in a monitoring well located immediately up-gradient of this well.

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 operate at a rate of up to 200 gpm each. 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**). The monitoring program also had addressed 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 the North Street VOC plume.

Sampling Frequency and Analysis

Sampling of the 20 monitoring wells is performed as per the schedule on **Table 1-5**. All wells, except for 000-343, were also sampled and analyzed annually for tritium. Tritium sampling was stopped in 2014 except for the extraction wells which continue to be analyzed for tritium, as per a recommendation in the 2013 Groundwater Status Report.

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. The complete groundwater monitoring well data for 2015 are included in **Appendix C**. A north–south hydrogeologic cross section (K–K') of the plume is provided on **Figure 3.2.8-2.** The location for the cross section is shown on **Figure 3.2-1**. **Figure 3.2.8-3** shows plots of the VOC concentrations for key monitoring wells. A summary of key monitoring well data for 2015 follows:

- Plume core well 000-465 is located 100 feet upgradient of extraction well NS-1. 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. In 2015 the highest, TVOC concentration in the plume was 77 µg/L in well 000-465 during August. The primary VOC detected in this well in 2015 was carbon tetrachloride at 64 µg/L.

- TVOC concentrations in core well 000-474, located approximately 500 feet upgradient of extraction well NS-2, have been steady at about 17 µg/L in 2015.

- TVOC concentrations in plume core well 000-463, located approximately 200 feet north of NS-1, have shown a significant decline in 2015 with a high of 41 µg/L in March and below AWQS for VOCs the remainder of 2015.

- 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 and VOC concentrations have been below AWQS throughout 2015. The trailing edge of the higher concentration segment of this plume has migrated south of this location.

- Airport monitoring wells 800-90 and 800-101, located south of the North Street extraction wells have displayed increasing VOC concentrations over the past several years. The leading edge of the higher concentration segment, which had migrated beyond the North Street extraction well locations prior to that systems start-up, has now reached this location. This deeper contamination will be captured by the Airport System's Magothy treatment well RTW-4A.

- The plume continues to be bounded as indicated on **Figure 3.2.8-1** by the perimeter wells

- **Figure 3.2.8-6** compares the TVOC plume from 1997 to 2015. The southern 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.

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 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.

January – September 2015

The system treated approximately 73 million gallons of water during the first three quarters. NS-1 and NS-2 were off for three weeks in February due to a storm that damaged several electrical components. NS-1 remained off until the last week of March. In April the wells were off several times due to electrical issues. In June NS-1 was off for 2 weeks for an electrical fault. In July NS-1 and NS-2 extraction wells were placed in standby mode. In August extraction well NS-1 was turned on due to the elevated levels of VOCs in the up gradient monitoring well 000-465. NS-2 remained in standby mode.

October – December 2015

The system treated approximately 26 million gallons of water during the fourth quarter 2015. Well NS-2 remained in standby.

3.2.8.5 System Operational Data

The system was operational from January to July with the system in standby mode from July until August 25th. NS-1 extraction well was started on August 25th and extraction well NS-2 remained in standby mode. The system was down for scheduled carbon change outs and repairs as required.

Table 3.2.8-1
North Street Treatment System
2015 SPDES Equivalency Permit Levels

Parameters	Permit Limit (µg/L)	Max. Observed Value (µg/L)
pH (range)	5.5 – 8.5 SU	5.8 – 6.4 SU
carbon tetrachloride	5	<0.5
chloroform	5	1.6
1,1-dichloroethane	5	<0.5
1,2-dichloroethane	5	<0.5
1,1-dichloroethylene	5	<0.5
tetrachloroethylene	5	<0.5
toluene	5	<0.5
1,1,1-trichloroethane	5	<0.5
trichloroethylene	10	<0.5

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

Extraction Wells

Table F-27 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 during system operations were 115 gpm and 75 gpm, respectively. Well NS-1 was in standby mode from July 1st to August 25th. Well NS-2 was also put into standby mode in July and continued for the rest of 2015. **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-28**. TVOC values in well NS-1 have steadily dropped from a high of 599 µg/L in 2004 to approximately 2 µg/L in 2015. Well NS-2 has remained below 7 µg/L in 2015. There was no tritium detected in the extraction wells in 2015.

System Influent and Effluent

The 2015 VOC concentrations for the North Street carbon influent and effluent are summarized on **Tables F-29** and **F-30**. The combined influent TVOC concentration declined from 260 µg/L in 2004 to 3 µg/L in December 2015. There was no tritium detected in the effluent in 2015.

The carbon vessels for the system effectively removed the contaminants from the influent groundwater. All 2015 effluent data for this system were below the SPDES Equivalency permit limits.

Cumulative Mass Removal

The mass of VOCs removed from the aquifer by the North Street Treatment 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 2015, approximately 99 million gallons of groundwater were pumped and treated by the North Street system, and approximately three pounds of VOCs were removed. Since May 2004, the system has removed 341 pounds of VOCs. The mass removal data are summarized on **Table F-27**.

The down gradient 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**.

3.2.8.6 System Evaluation

The North Street Treatment System 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 2015. However a rebound in a monitoring well located near extraction well NS-1 in 2015 was slightly above the capture goal of 50 µg/L TVOC concentrations and resulted in the restart of this extraction well in August.

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 2015; therefore the plume continues to be controlled. A segment of the plume passing through well 800-90 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.

3. Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?
Well NS-1was restarted during 2015 due to increased VOC concentrations in monitoring well 000-465 directly up-gradient of extraction well NS-1.

3a. Are TVOC concentrations in plume core wells above or below 50 ug/L?
One of the 11 plume core wells of the North Street system showed TVOC concentrations greater than 50 µg/L during 2015. Well 000-465 had a concentration of 77 µg/L TVOC in August 2015.

3b. Is there a significant concentration rebound in core wells and/or extraction wells following shutdown?
In 2015 there was a rebound in one well as noted above, so the system was restarted with only extraction well NS-1 only operating.

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 2015 six of 11 core wells had VOCs above the MCL. 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 Treatment System and groundwater monitoring program:

- Based upon the continued analysis showing well 000-465 below the capture goal of 50 µg/L in November 2015 and February 2016 shutdown well NS-1. If concentrations in any core monitoring wells increase to over the 50 µg/L capture goal, the extraction well(s) may be restarted.
- Continue the current groundwater monitoring well schedule for the North Street system.

3.2.9 North Street East Treatment System

This section summarizes the 2015 operational and monitoring well data for the OU III North Street East (NSE) Treatment 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 Treatment 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. The North Street and NSE carbon treatment units and control systems are located in the same building along North Street. The extraction well pump for NSE-1 and NSE-2 are designed to operate at approximately 200 gpm and 100 gpm, respectively. Extraction well NSE-2 has been shut down and in standby mode since 2010. Following approval from the regulators on the *Petition for Shutdown for the OU III North Street East Groundwater Treatment System*, the system was shut down in June 2014 and placed in stand-by mode. 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 16 wells (**Figure 1-2**). The monitoring program was designed to monitor the VOC plume off site, south of the OU I South Boundary Treatment System, as well as the efficiency of the NSE groundwater remediation system. Through the third quarter of 2015, the wells were sampled quarterly at the shutdown monitoring frequency that began in 2009. As recommended in the 2014 Groundwater Status Report, the frequency was reduced to standby monitoring (semi-annual for core and bypass wells and annual for perimeter wells). Because there have been no detections of tritium above 1,000 pCi/L in any of the NSE wells since 2005, sampling for tritium was eliminated in 2014. 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 remnant of the plume is approximately 1,000 feet south of the LIPA right-of-way and extends to extraction well NSE-1.

Figure 3.1-3 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 3.1-4** gives the historical trends in VOC concentrations for key core and bypass wells along the NSE plume. **Appendix C** contains a complete set of 2015 analytical results for the 16 NSE program wells. A summary of key monitoring well data for 2015 follows:

- In the August and September 2015 samples from perimeter well 000-394, located just south of the LIPA right-of-way, ethylene dibromide (EDB) was detected at 0.38 µg/L and 0.49 µg/L, respectively. The values were estimated since the detection limit for the analytical method performed (Method 524.2) was 0.5 µg/L. The DWS for EDB is 0.05 µg/L. Although EDB had not been detected historically in the off-site NSE plume there have been several detections (up to 1.5 µg/L) upgradient of this well on-site in OU I from 1997 to 2005. To confirm theses detections, a split sample was obtained from this well in April 2016 and sent to two different analytical laboratories for EDB analyses by Method 524.2 and Method 504. The one sample using Method 524.2 detected EDB at 0.54 µg/L, and the other sample using Method 504 (with lower analytical detection limits) identified EDB at 0.679 µg/L. These results confirmed the 2015 detections of EDB.

- Since 2011, individual VOCs (except for EDB) continue to remain below AWQS in all monitoring wells. The maximum VOC detected in 2015 was 2.6 µg/L of TCA in core well 000-477.

3.2.9.4 System Operations

The extraction wells were sampled quarterly throughout the year for VOCs and tritium. **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 shut down and placed in standby mode in June 2014.

Table 3.2.9-1.
OU III North Street East Treatment System
2015 SPDES Equivalency Permit Levels

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

Notes:
ND = Not Detected above method detection limit of 0.50 µg/L.
Required effluent sampling freq. is monthly for VOCs and pH.
NS = Not Sampled as the system was not operating

January through September 2015

The system remained shut down and in standby mode.

October through December 2015

The system remained shut down and in standby mode.

Extraction Wells

During 2015, the extraction wells did not operate. The wells were sampled quarterly during the year. **Table 2-2** shows no monthly pumping data for the two extraction wells as they were on standby for the year. **Table 3.2.9-2** shows the monthly extraction well pumping rates. NSE-1 and NSE-2 remained in standby mode. **Figure 3.2.9-2** plots the TVOC concentrations in the extraction wells. VOC concentrations for NSE-1 and NSE-2 are provided in **Table F-31**. Steady TVOC concentration trends are noted for both wells during 2015, with concentrations below 9 µg/L in NSE-1 and below 2 µg/L in NSE-2 during the entire year. All individual VOCs were below their AWQS. Tritium was not detected in the extraction wells in 2015.

System Influent and Effluent

No VOC concentrations for 2015 for influent and effluent are noted on **Tables F-32** and **F-33** as the system was in standby mode.

Cumulative Mass Removal

The cumulative mass of VOCs removed by the treatment system versus time is noted on **Figure 3.2.9-3** and on **Table F-34**. A cumulative total of 44 pounds of VOCs were removed from the aquifer during system operation.

3.2.9.6 System Evaluation

The system began operation in 2004 and was predicted to run for approximately 10 years. The system operated as designed and was shut down and placed in standby mode in June 2014. No operating difficulties were experienced beyond normal maintenance.

The NSE Treatment System performance can be evaluated based on decisions identified for this system from the groundwater DQO process.

1. Were unexpected levels or types of contamination detected?
Yes, as noted in **Section 3.2.9-3** above, EDB was detected in plume perimeter well 000-394 twice in 2015 above the DWS. In accordance with the BNL Groundwater Contingency Plan, BNL collected additional samples from well 000-394 to verify the monitoring results. Resampling of this well in April 2016 confirmed the presence of EDB.

2. Has the downgradient migration of the plume been controlled?
Yes. The system operated for ten years, and an analysis of the plume perimeter and bypass wells shows that there have been no significant increases in VOC concentrations in 2015, 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. **Figure 3.2.9-4** shows the overall plume size reduction over time.

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

As noted in **Section 3.2.9.1**, the system has met all of the criteria established in the operation and maintenance manual for system shutdown. As discussed in more detail in the *Petition for Shutdown for the OU III North Street East Groundwater Treatment System* (BNL 2014c), the shutdown criteria of reaching less than 50 μg/L TVOCs for at least four consecutive sampling rounds has been met in all plume monitoring and extraction wells. In addition, VOC mass removal over the past several years has been very low. As a result, following regulatory approval, the system has remained shut down since June 2014 and is in standby mode.

3a. Are TVOC concentrations in plume core wells above or below 50 ug/L?
TVOC concentrations in all monitoring wells are below 50 μg/L. The maximum TVOC concentration detected in 2015 was in monitoring well 000-477 at 6 μg/L.

3b. Is there a significant concentration rebound in core wells and/or extraction wells following shutdown?
Significant rebounding of the VOCs in the monitoring or extraction wells was not evident as a result of the shutdown of NSE-2 in late 2010 or as a result of the entire system shutdown in June 2014.

4. Has the groundwater cleanup goal of meeting MCLs been achieved?
MCLs have been achieved for individual VOCs in all 16 plume monitoring wells from 2011 through 2015, except for well 000-394, which detected EDB above the DWS in 2015.

3.2.9.7 Recommendations

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

- Maintain the treatment system in standby mode. The extraction wells will continue to be sampled on a quarterly basis. One or both extraction wells can be restarted if TVOC concentrations in the core monitoring wells or extraction wells rebound to concentrations above the capture goal of 50 μg/L.
- The following actions will be implemented in response to the EDB detection in well 000-394:
    - Continue to implement the Groundwater Contingency Plan.

- Begin sampling well 000-394 quarterly for EDB using Method 504 in 2016.
- Continue sampling well 000-394 annually for VOCs using Method 524.2
- Obtain one round of samples from NSE monitoring wells 000-138, 000-477, 000-478, 000-479, 000-480, 000-481, 000-484 and analyze for EDB using Method 504.
- Continue to evaluate the monitoring data and recommend any follow up actions including the restart and temporary operation of extraction well NSE-1.

3.2.10 LIPA/Airport Treatment System

This section summarizes the 2015 operational and monitoring well data for the LIPA/Airport 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 and Magothy aquifers 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. Groundwater for this area is discussed in **Section 3.2.11** as “South of Carlton Drive.”
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 of 50 µg/L TVOC has been met and these wells are in standby mode.
3. The six extraction wells in the Airport System were installed to address the leading edge of the plumes which have migrated past the LIPA extraction wells and the North Street extraction wells prior to their installation. The sixth well (RW-6A) was added in 2007 to address VOCs observed to the west of extraction well RTW-1A. The Airport system wells have a capture goal of 10 µg/L TVOC. RTW-4A also addresses Magothy aquifer contamination, as this well is screened in the Magothy aquifer. Extraction wells RTW-1A, RTW-4A and RW-6A are in full time operation. Extraction well RTW-2A, RTW-3A, and RTW-5A are in pulsed pumping operation.

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 49 wells. The Magothy extraction well on Stratler Drive has six monitoring wells associated with its operation. There are 12 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 has 31 monitoring wells, which monitor the portions of the plume south of the LIPA and the North Street systems. All of these wells are used to evaluate the effectiveness and progress of the cleanup associated with these three components of the system. **Figures 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 DCE. Groundwater monitoring for these systems was initiated in 2004. Fourth-quarter 2015 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:

LIPA Monitoring

- During 2015 TVOC concentrations for the Magothy extraction well EW-4L on Stratler Drive were between 3 µg/L and 12 µg/L.
- The Magothy monitoring wells located in the vicinity of extraction well EW-4L all detected concentrations below 50 µg/L TVOC during 2015. The highest TVOC concentration observed during 2015 was in well 000-460 during August 2015 at 16 µg/L.
- Two of the three Upper Glacial LIPA extraction wells, EW-1L and EW-3L, were shut down in October 2007. Well EW-2L was shut down in 2010. All three of the extraction wells remained below 16 µg/L in 2015. This is consistent with monitoring well data associated with the LIPA system. **Figure 3.2.10-3** plots the TVOC influent trends for the LIPA extraction wells.

Airport Monitoring

- Upgradient monitoring wells 800-94 and 800-95, approximately 1,500 feet north of wells RTW-1A, RTW-2A, and RW-6A. In 2015 the levels showed a slight increase in well 800-94 at 96 µg/L in August. Well 800-95 was at 31 µg/L in December which was a slight decrease (**Figure 3.2.10-6**).
- **Figure 3.2.10-4** plots the TVOC influent trends for the Airport extraction wells. Five of the six airport extraction wells had TVOC concentrations below the capture goal of 10 µg/L in 2015. Extraction well RW-6A showed TVOC concentrations up to 14 µg/L in 2015, and carbon tetrachloride exceeded the 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 2004. No detections of carbon tetrachloride were found in this well until December 2005, when it was detected at 1.6 µg/L. In August 2006 the concentration increased to over 100 µg/L. During 2007 a new extraction well RW-6A was installed to capture the contaminants in the vicinity of well 800-96 (**Figure 3.2.10-1**). Well 800-96 detected carbon tetrachloride concentrations ranging up to 78 µg/L in 2015 (**Figure 3.2.10-6**).
- None of the bypass wells installed downgradient of this area detected VOCs above AWQS.
- Well 800-92, located upgradient of extraction wells RTW-3A and RTW-4A had TVOC concentrations above capture goals for the past several years **(Figure 3.2.10-6)**. In 2015, the TVOC concentration ranged from 32 µg/L to 37 µg/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 800-90 co-located near well 800-92 but screened at 250-260 feet below grade detected TVOC concentrations up to 122 µg/L in August 2015.

- 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 19 µg/L to 27 µg/L in 2015. This is above the capture goal of 10 µg/L for the Airport extraction wells and warrants the continued operation of well RTW-4A.
- Monitoring well 800-138 was installed adjacent to well 800-59 in 2013, and screened about 40 feet deeper than this well from 245 feet to 255 feet bls. This will be used to monitor higher concentrations of VOCs identified in upgradient well 800-92. VOC concentrations in this well reached a high of 8 µg/L TVOC concentrations in December 2015.

3.2.10.4 System Operations

In 2015, 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. Several of the Airport extraction wells are on a pulsed pumping schedule (RTW-2A, RTW-3A, RTW-5A), being pumped one week per month. Wells RTW-1A, RTW-4A and RW-6A are pumped on a full-time basis. For the LIPA extraction wells only LIPA Magothy extraction well EW-4L is operating full time. The other three LIPA wells are currently shutdown as they have achieved the cleanup goals.

The following is a summary of the Airport/LIPA Treatment System operations for 2015.

January – September 2015

The Airport/LIPA System was operational in the first three quarters with RTW-1A, RTW-4A, EW-6A and EW-4L operating on a full-time basis. The remainder of the extraction wells at the Airport System, were run one week per month on a pulsed pumping schedule. In the first quarter the system was off for seven days in February due to a snow storm and several days in March for a carbon change out. EW-4L (LIPA) was down for three weeks in May due to a communication issue and Well RTW1A, RTW-4A and RW6A was off for one week for the repair of a flowmeter. Well EW-4L was frequently shutdown this year due to construction activities related to a major upgrade to the BNL Meteorological tower which caused the communication system for this well to be shutdown. This well cannot operate without the communication system. The Airport system was down for three days in June and September for scheduled carbon change outs.

October – December 2015

The Airport/LIPA system had some down time in the fourth quarter due to BNL Meteorological tower construction for well EW-4L and one carbon change-out in December.

Extraction Wells Operational Data

During 2015, approximately 228 million gallons of groundwater were pumped and treated by the Airport/LIPA system, with an average flow rate of 471 gpm for Airport and 81 gpm for LIPA (**Table 3.2.10-2)**. **Table F-35** summarizes the system's mass removal. VOC concentrations for the Airport and LIPA extractions wells is provided in **Table F-36**

Table 3.2.10-1
OU III LIPA/Airport Treatment System
2015 SPDES Equivalency Permit Levels

Parameters	Permit Level (µg/L)	Max. Measured Value (µg/L)
pH	5.5–7.5 SU	5.7-7.3 SU
carbon tetrachloride	5	<0.5
chloroform	7	.63
1,1-dichloroethane	5	<0.5
1,1-dichloroethylene	5	<0.5
methylene chloride	5	<0.5
1,1,1-trichloroethane	5	<0.5
trichloroethylene	10	<0.5

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

3.2.10.5 System Operational Data

System Influent and Effluent

VOC concentrations for the carbon influent and effluent in 2015 are summarized on **Tables F-37** and **F-38,** respectively.

The carbon vessels for the system effectively removed the contaminants from the influent groundwater. System effluent data were below the regulatory limit specified in the SPDES equivalency permit **(Table 3.2.10-1)**.

Cumulative Mass Removal

The mass of VOCs removed from the aquifer by the Airport/LIPA Treatment System was calculated using the average flow rates for each monitoring period (**Table F-35**) in combination with the TVOC concentration in the carbon unit's influent, to calculate the pounds per month removed. The plot of cumulative mass of VOCs removed vs. time (**Figure 3.2.10-5**) shows that 20 pounds of VOCs were removed during 2015, with a total of 410 pounds removed since system start-up.

3.2.10.6 System Evaluation

The 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 for the LIPA/Airport Treatment System during 2015.

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

Yes, based on the historical analytical data collected from the monitoring wells the plumes are being controlled. The capture zones and the monitoring data 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 this data, 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 shut down as they have reached their cleanup goals. Three of the six Airport extraction wells are being pulsed pumped. Based upon monitoring data and plume configuration shutdown well RTW-5A.

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. Several Airport core wells are above 10 µg/L. Well 800-96 located in the vicinity of well RW-6A continues to show elevated levels of TVOC concentrations up to 78 µg/L in December. Upgradient wells 800-94 and 800-95 showed maximum TVOC concentrations of 96 µg/L and 31 µg/L respectively. Well 800-90 showed a peak TVOC concentration of 122 µg/L in 2015.

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 shut down.

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 Treatment System and groundwater monitoring program:

- Continue the Airport extraction wells pulsed 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 TVOC 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.
- 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. Continue operation of Magothy well EW-4L, if no rebound in concentrations for well EW-4L are observed in 2016 shut down this extraction well in 2017.
- Stop pulse pumping and shutdown Well RTW-5A in August 2016 as based upon the plume configuration and monitoring data concentrations are well below the 10 µg/L capture goal in this area.

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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 49 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 2015).

	Max. TVOC (in µg/L)			
Location	2015	Historical	Primary VOCs	Results
Western South Boundary	<0.5	<5.0	None	Magothy not impacted. Two monitoring wells serve as outpost/sentinel wells for Suffolk County Water Authority William Floyd Well Field.
Middle Road to South Boundary	103	340	PCE, CCl_4	VOCs identified in upper 20 to 40 feet of Magothy at Middle Road area where Magothy brown clay is absent. Well 113-09 had 103 µg/L TVOC in April 2015, and well 113-19 had 59 µg/L in January 2015. VOCs not detected at South Boundary beneath the clay.
Industrial Park	267	268	PCE TCA	VOCs identified in the Upper Magothy south of the south boundary system. Two new Magothy extraction wells installed in the Industrial Park in 2014 to capture and treat this contamination. Maximum TVOC concentrations were detected in well 127-09 at 267 µg/L at 230 feet bls.
North Street	122	123	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. Well 800-90 had a TVOC concentration of 122 µg/L in August 2015. The leading edge of this contamination is at the eastern portion of the Airport system, with 27 µg/L TVOC in well 800-101 in December 2015, which is adjacent to Airport extraction well RTW-4A.
North Street East	12	30	DCA, DCE	Low VOC concentrations have been detected from the BNL South Boundary to North Street below the Magothy brown clay, at approximately 40 to 150 feet into the upper Magothy. 12 µg/L TVOC was detected in well 000-343 in May 2015.
Industrial Park East South Boundary	11	570	TCA, CCl_4	TVOC concentrations were less than 20 µg/L at the south boundary and off site in the Industrial Park East, where the brown clay is absent. Magothy and Upper Glacial contamination is continuous in the Industrial Park. A TVOC concentration of 11 µg/L was detected in well 122-05 located at the South Boundary in April 2015. This is the highest TVOC concentration identified in this area. The monitoring well located on the corner of Boxwood and Stratler Drives (000-526) has had no levels of VOCs above MCLs.
South of Carleton Drive	16	7,200	CCl_4	Historically high VOC concentrations just south of Carleton Drive where the brown clay is absent. Contamination is contiguous between Magothy and Upper Glacial aquifers. Well 000-130 showed a maximum TVOC concentration of 4 µg/L in May 2015. Well 000-460 located on Stratler Drive showed a TVOC concentration of 16 µg/L in August.

The Magothy remedy identified in the *OU III Explanation of Significant Differences* (ESD) (BNL, 2005a) document calls for the following:

1. Reaching MCLs in the Magothy aquifer by 2065 by active groundwater treatment and natural attenuation.

2. Continued operation of the five extraction wells until cleanup objectives are met as part of the treatment systems that provide capture of Magothy VOC contamination (Middle Road, South Boundary [Magothy well currently in standby], Airport, Industrial Park East [Decommissioned], and LIPA)
3. 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 selected Magothy aquifer remedy.
4. Institutional controls and five-year reviews.

Table 3.2.11-2. Magothy Remedy.

Area Investigated	Status of Selected Remedy
Western South Boundary	Continue monitoring and evaluate data.
Middle Road to South Boundary	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. Continue to operate the Middle Road well RW-7 and South Boundary well EW-17.
North Street	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 were past the extraction wells prior to system operation. Continue monitoring and evaluate data.
North Street East	Continue monitoring and evaluate data.
South Boundary to Industrial Park East	Continue monitoring and evaluate data.
South of Carlton Drive	Continue operation of the LIPA Magothy extraction well on Stratler Drive until cleanup goals are achieved.
Industrial Park	Continue operation of the two new industrial park extraction wells. Continue monitoring and data evaluation.

3.2.11.1 Monitoring Well Results

There are 49 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. Data for all Magothy monitoring wells are presented in **Appendix C.** 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). The higher concentrations historically detected in this well of carbon tetrachloride were captured by the LIPA extraction well on Stratler Drive. The maximum TVOC concentration in this well in 2015 was 4 µg/L .A more detailed discussion is available in **Section 3.2.10**.

Wells 000-249 and 000-250: These wells are in the Industrial Park near well UVB-1. Well 000-249 had TVOC concentrations ranging up to 8 µg/L in 2015. Well 000-250 had no VOC concentrations above AWQS in 2015.

Wells 000-425 and 000-460: These wells are adjacent to the LIPA Stratler Drive Magothy extraction well. Well 000-425 had TVOC concentrations up to 5 µg/L during 2015. Well 000-460, located east of the extraction well but within the capture zone, had TVOC concentrations up to 16 µg/L in 2015.

Well 122-05: This well, located at the eastern edge of the OU III South Boundary System, showed TVOC concentrations up to 11 µg/L in 2015.

Well 113-09: This well is located at the Middle Road, west of extraction well RW-1. It is screened near the Upper Glacial/Magothy interface. During 2015, TVOC concentrations of up to 103 µg/L were detected. Concentrations have been stable for the past few years in this well. These contaminants will be captured by new extraction well RW-7.

Well 000-343: Located south of the site boundary and between the North Street and North Street East systems. This well had maximum TVOC concentrations of 12µg/L in 2015.

Wells 000-427 and 000-429: These wells are located just south of the former Industrial Park East System on Carleton Drive. In 2015, well 000-427 had TVOC concentrations up to 5 µg/L and well 000-429 had concentrations less than 1 µg/L

Well 800-90: This well is located near Moriches-Middle Island Road upgradient of Airport extraction wells RTW-3A and RTW-4A. The maximum TVOC concentration in 2015 was 122 µg/L. 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 VOC concentration in 800-101 has resulted in the full time operation of the Airport extraction well RTW-4A (**Section 3.2.10**).

Well 800-138: This monitoring well and was installed (in 2013) adjacent to well 800-59 and screened about 40 feet deeper than this well (245 feet to 255feet bls). This well will be used to monitor higher concentrations of VOCs identified in upgradient well 800-92. TVOC concentrations in this well had increased to 8 µg/L by December 2015.

Well 127-08 and 127-09: These wells were installed to monitor higher concentrations of VOCs identified upgradient of extraction wells IPM-8 and IPM-9. They had peak TVOC concentrations of 171 µg/L and *266* µg/L respectively in 2015.

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 Middle Road, LIPA/Airport and new IP wells. The North Street, North Street East and South Boundary Magothy extraction wells are currently in standby as they have reached the OU III cleanup goals identified for shutdown of these wells. The IPE extraction well was abandoned as it had reached its cleanup goal.
- Discontinue sampling of wells identified in S**ection 3.2.8** associated with the Industrial Park East groundwater monitoring program.

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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 nine wells (**Figure 3.2.12-1**). The well locations aid in monitoring 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. Wells 109-03 and 109-04 are analyzed quarterly for VOCs, gamma spectroscopy, tritium, and Sr-90 (**Table 1-5**) and split samples are analyzed by the Suffolk County Department of Health Services.

3.2.12.2 Monitoring Well Results

No VOCs were detected above AWQS. The highest VOC detected was 2.3 µg/L of TCA in well 065-02. Radionuclides were not detected in any of the samples collected from wells 109-03 and 109-04 during 2015.

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 residual contaminants in the central area of the site are 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?

Yes. 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 2015, no VOCs or radionuclides were detected at concentrations exceeding the MCLs. No VOCs have been detected above the AWQS since December 2012. The only exception is benzene which is believed to be a sampling contaminant from a gasoline powered compressor in the sample from well 109-04 during March 2013. Therefore, the OU III ROD objective of meeting MCLs by 2030 has been met for this area.

3.2.12.4 Recommendation

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

- Since the MCLs have been achieved, discontinue sampling for VOCs in all wells except for wells 109-03 and 109-04. Wells 109-03 and 109-04 serve as SCWA William Floyd Parkway Well Field sentinel wells and monitoring of these wells will continue.

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3.2.13 Off-Site Monitoring

The OU III Off-Site Groundwater Monitoring Program incorporates off-site wells that monitor groundwater quality south of the southwestern site boundary to the vicinity of the Carmans River.

3.2.13.1 Groundwater Monitoring

Well Network

The network consists of 11 wells that were installed during the OU III Remedial Investigation for various purposes (**Figure 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**). Due to a scheduling conflict, sample collection was delayed until the second week of January 2016.

3.2.13.2 Monitoring Well Results

The complete results for the monitoring wells in this program can be found in **Appendix C**. Data from these wells are posted on **Figure 3.2.13-1**.

The monitoring wells in the OU III Off-Site Monitoring Program are perimeter and sentinel wells. No wells in the OU III Off-Site Monitoring Program had levels of VOCs that exceeded the AWQS in 2015. With the exception of wells 000-99 in 2005 and 800-52 in 2011, the OU III Off-Site Monitoring Program wells have not detected concentrations of VOCs detected above the AWQS since the wells were installed.

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?
VOCs were not detected above the AWQS in 2015.

3.2.13.4 Recommendation

The following changes are recommended for the OU III Off-Site Monitoring Program:

- Since MCLs have been achieved for four consecutive sampling rounds, discontinue sampling for VOCs in all wells.

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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 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**. There were no confirmed detections of radionuclides in the OU III South Boundary Radionuclide Monitoring Program wells in 2015.

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 2015.

3.2.14.4 Recommendations

The following changes are recommended to the South Boundary Radionuclide Groundwater Monitoring Program:

- Since there have never been any confirmed detections of tritium in wells 099-11, 100-12, and 100-13 since they were installed in 1997, it is recommended that monitoring for tritium be discontinued in these wells.

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3.2.15 BGRR/WCF Strontium-90 Treatment System

The Brookhaven Graphite Research Reactor (BGRR)/ Waste Concentration Facility (WCF) Treatment System addresses the Sr-90 plumes in groundwater downgradient of these facilities. The BGRR/ WCF remedy consists of:

1. Operation of nine extraction wells using ion exchange to remove Sr-90, with discharge of the treated 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 in groundwater: one extending south from the WCF area, one extending south of the BGRR (Building 701)/ Below Ground Ducts (BGD) and former Canal House, and another that is south of the former Pile Fan Sump (PFS)/Building 801 Area (**Figure 3.2.15-1**).

The WCF (Building 811) was demolished and radiologically contaminated soils were removed during 2015. This was done to help remove potential radiological sources that could impact groundwater.

3.2.15.1 System Description

Operation of 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. SR-4 and SR-5 have been in a pulsed pumping mode since 2011. Four extraction wells (SR-6, SR-7, SR-8, and SR-9) were installed in 2010 to address higher Sr-90 concentrations located in the downgradient portion of the WCF plume (in the vicinity of the HFBR) and began operation in 2011.

Groundwater from the extraction wells is piped 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/Building 801 Area Groundwater Treatment System* (BNL 2012c).

3.2.15.2 Groundwater Monitoring

Well Network

A network of 95 monitoring wells is used to monitor the Sr-90 plumes associated with the BGRR, WCF, and PFS/Building 801 Areas. Twelve temporary wells (see **Figure 3.2.15-1** for locations) were installed in 2015 to augment the permanent well network and fill in plume data gaps.

Sampling Frequency and Analysis

The well samples are analyzed for Sr-90. As noted in **Table 1-5**, several of the wells also serve dual purposes for other programs. Monitoring well results are tabulated in **Appendix C**. In 2015, the sampling frequency for all three of the Sr-90 plume segments (BGRR, PFS/Building 801 area and WCF), was in the O&M phase (annual) for most wells. The monthly sampling frequency for source area monitoring wells 075-664 and 075-701 continued in order to monitor for Sr-90 releases from underneath Building 701/BGDs.

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/Building 801 areas is depicted based on groundwater data obtained from the fourth-quarter 2015 sampling round supplemented with data from the temporary wells which were sampled during the second and third quarters of 2015. **Table 3.2.15-2** contains the temporary well data for 2015. The following cross-sectional views are also provided:

- **Figure 3.2.15-2** (M–MI') for the BGRR (Building 701 Area) plume – A north–south cross section from the BGRR south to Brookhaven Avenue
- **Figure 3.2.15-3** (N–N') for the PFS/and PFS/Building 801 Area plume – A north–south cross section from Building 801 south to Cornell Avenue
- **Figure 3.2.15-4** (O–O') 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 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 northwest of the WCF (Building 811). This area within the WCF is upgradient of the current location of extraction wells SR-1 and SR-2. The highest historical Sr-90 concentration in the former PFS/Building 801 Area (566 pCi/L) occurred in 1997 in a temporary well installed downgradient of this area.

A comparison of the plume from 2004 through 2015 is provided on **Figure 3.2.15-10.** The following is a summary of the 2015 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.

- Monitoring well 065-175 has contained the highest Sr-90 concentrations immediately downgradient of the source area in the WCF. Following a general slow decline in concentrations since 2000 the Sr-90 concentration in this well increased to 355 pCi/L in April 2014. The Sr-90 concentration in this well has subsequently decreased steadily and was 14 pCi/L during the fourth quarter of 2015 **(Figure 3.2.15-5)**. It is anticipated that concentrations will rebound once again based on the expected migration of higher Sr-90 concentrations observed upgradient in temporary wells at the former “D” Waste storage tank area in early 2015 (BNL 2015b). Extraction wells SR-1 and SR-2 are located immediately south of the CF source area. Extraction well SR-1 has displayed a slow and steady decline in concentrations since the pump and treat system began in 2005 (**Figure 3.2.15-9**). SR-2 has also showed an overall decline in concentrations with periodic concentration spikes over the past two years.
- The WCF Sr-90 plume from Rutherford Drive south to Brookhaven Avenue has shifted slightly to the east since 2012. This determination is based on groundwater flow direction information derived from the water table contour map (see **Figure 2-2**) in combination with observations of changing concentrations in permanent and temporary wells in this area over the previous two years (**Figure 3.2.15-1**). Efforts have been made to balance the flow to the RA V and OU III Basins (**Figure 2-2**) following the shutdown of both the OU I South Boundary and the HFBR treatment systems by diverting additional water from the OU III Middle Road Treatment System from the OU III Recharge Basin to the RA V basin. Groundwater flow directions in this portion of the BNL site are sensitive to recharge to these basins along with the HO Recharge Basin in combination with supply water pumping across the site. The Groundwater Protection Group

works in coordination with BNL Water and Sanitary Planning Committee to balance pumping and recharge and maintain groundwater flow directions across the site.

BGRR (Building 701 area) Plume

Refer to **Figure 3.2.15-2** for a cross-sectional view of the BGRR (Building 701 Area) plume.

- Source area monitoring wells 075-664 and 075-701 were sampled on a monthly basis in 2015 in an effort to gain an understanding of the relationship between high water table events and resultant increases in Sr-90 concentration in these wells. Sr-90 that continues to emanate from under the Building 701/BGDs area is 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.
- Plotting water table elevation data against Sr-90 concentrations in SR-3 over the previous 15 years appears to show a correlation between high water table periods and increased Sr-90 concentrations in the source area monitoring wells and SR-3 as shown in **Figure 3.2.15-6**. Approximately four years after a high water table period has been observed there is a resulting increase in Sr-90 concentrations in these source area wells. A maximum concentration of 257 pCi/L was observed in source area monitoring well 075-701 in October 2015 following the high water table event in 2010. There was an observable increase in Sr-90 concentrations in extraction well SR-3 during the middle of 2014 followed by a continuous decline to low levels during the first quarter of 2016 (4.5 pCi/L in March 2016). The maximum concentration of Sr-90 detected in SR-3 during 2014 was 43 pCi/L (April). This is an order of magnitude lower than some of the previous increases seen in this well following high water table events.

  2015 marked the fifth year of monitoring the BGRR cap wells. Sr-90 concentrations in monitoring well 075-700 have steadily declined to 0.8 pCi/L in October 2015 following a high concentration of 40 pCi/L in April 2012. Sr-90 concentrations in monitoring well 075-699 decreased to 0.8 pCi/L in 2015 following a peak concentration of 104 pCi/L in April 2013. This well is located approximately 200 feet south of the former BGRR canal house.
- Sr-90 concentrations in monitoring wells located in the downgradient segments of the BGRR/Building 701 and PFS/Building 801 plumes remained stable during 2015. The plumes continue to migrate slowly south and are bounded by the monitoring well network.
- Two temporary wells (BGRR-GP-127 and GP-128) were installed in 2015 to augment the monitoring well cluster 075-670 and 075-671 located just north of Brookhaven Avenue and east of Building 725, to assess any eastward shift of the plume in this area. Sr-90 concentrations were less than the MDA in both temporary wells, indicating that either the plume shift in this area is not significant or that the Sr-90 migrating through this area from the north is discontinuous in nature.
- A permanent monitoring well (BGRR-MW01-2015) was installed during 2015 downgradient of the leading edge of the Building 701 Sr-90 plume. This is a sentinel well for this plume and the Sr-90 concentration of 3 pCi/L observed during the fourth quarter monitoring round indicates that Sr-90 is migrating towards this area.

Former Pile Fan Sump/Building 801 Plume

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

- The small area containing the highest Sr-90 concentrations now appears to have migrated south of monitoring well 065-37 and is located in the vicinity of BGRR-GP-125 where a maximum concentration of 75 pCi/L was observed (see **Figure 3.2.15-1**). Sr-90 concentrations just downgradient of Building 801 have been between 24 pCi/L and 36 pCi/L over the past two years indicating that there is still a residual source of Sr-90 in or just outside of Building 801 (**Figure**

3.2.15-5). Additional downgradient characterization of this plume north of Brookhaven Avenue is not possible due to the presence of facilities, structures and utilities.

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 2015 while the system was operating, samples from the influent, effluent, and midpoint locations of the treatment system were collected twice a month. All system samples were analyzed for Sr-90 and VOCs. The influent was also analyzed for tritium. Sr-90 concentrations in the extraction wells in 2015 are summarized on **Table F-39**. System influent and effluent concentrations are summarized on **Tables F-40** and **F-41**. **Table F-42** contains the monthly Sr-90 removal totals for the system.

During 2015, wells SR-4, SR-5 and SR-6 operated in a one month on, one month off pulsed pumping mode. Operating details are given in the O&M manual for this system (BNL 2012c). Below is a summary of the system operations for 2015.

January – September 2015

The system was off from January 23rd to February 4th due to a snowstorm. In June, the system was turned off on the 23rd for a resin vessel change out and restarted on July 7th. The system was off from September 16th to September 23rd for a bag filter change out. During this period wells SR-4 to SR-6 ran in a one month on, one month off pulsed pumping schedule. The system treated approximately 15.5 million gallons of water during this period.

October – December 2015

The system was off from October 8th to October 15th due to a broken pipe that needed to be replaced. In November the system was off from the 12th to the 23rd for a carbon vessel change out. The system was off from December 7th to December 11th to repair an extraction well. The system operated normally for the remainder of the year. The system treated approximately 5 million gallons of water during this period.

Extraction Well Operational Data

During 2015, approximately 20.5 million gallons of water were treated by the remediation system, with an average flow rate of 38 gpm. **Table 3.2.15-3** shows the monthly extraction well pumping rates while **Table F-39** shows Sr-90 concentrations.

Table 3.2.15-1
BGRR Sr-90 Treatment System
2015 SPDES Equivalency Permit Levels

Parameter	Permit Level	Max. Measured Value
pH range	5.5–8.5 SU	6.2–7.4 SU
Sr-90	8.0 pCi/L	2.8
Chloroform	7.0 µg/L	0.83
1,1-Dichloroethane	5.0 µg/L	<0.5
Ethylbenzene	5.0 µg/L	<0.5
Methyl Chloride	5.0 µg/L	<0.5
Methylene Chloride	5.0 µg/L	2.71
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	0.99
1,2,4-Trimethylbenzene	5.0 µg/L	<0.5
Xylene, total	10.0 µg/L	<0.5

Notes:
.
SU = Standard Units
Required sampling frequency is monthly for Sr-90 and VOCs, and weekly for pH.

3.2.15.5 System Operational Data

During 2015, influent concentrations of Sr-90 ranged from 10 pCi/L to 30 pCi/L, with the highest concentration observed in extraction well SR-2 at a concentration of 60 pCi/L during September. The highest influent tritium concentration during 2015 was 586 pCi/L in February (**Table F-40**). During 2015, Sr-90 was detected in the effluent at a maximum concentration of 2.8 pCi/L. There were no VOCs or Sr-90 detected above the SPDES Equivalency Permit discharge limits in the 2015 effluent samples (**Table 3.2.15-1**).

Extraction Wells

Maximum Sr-90 concentrations in each of the extraction wells during 2015 were as follows:

- SR-1 20 pCi/L in September
- SR-2 60 pCi/L in September
- SR-3 34 pCi/L in June
- SR-4 2 pCi/L in March
- SR-5 4 pCi/L in May
- SR-6 10 pCi/L in January
- SR-7 14 pCi/L in June
- SR-8 13 pCi/L in February
- SR-9 19 pCi/L in February

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 2015, the flow averaged 42 gpm. Approximately 0.9 mCi of Sr-90 was removed during 2015, for a total of 26 mCi removed since system start-up in 2005 (**Table F-42**). Cumulative mass removal of Sr-90 is shown on **Figure 3.2.15-7**. **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 BGRR/ WCF Strontium-90 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: 2015 data from temporary wells in the WCF yard (up to 103 pCi/L Sr-90) indicate the presence of residual source area contamination in the vadose zone. Buildings 810 and 811, located in the eastern portion of the WCF Yard, were demolished in 2015. Contaminated piping and soils located underneath and adjacent to the building were also removed and sent to an approved disposal facility following the building demolition. These areas could not be accessed while the facilities were still in operation. Although a sharp decline in Sr-90 concentrations was observed in monitoring well 065-175 during 2015, it is anticipated that an area of higher concentrations observed at upgradient temporary well locations in the center of the yard will migrate towards this well in 2016. The removal of the buildings, infrastructure, and soils from the yard should reduce the volume of residual source area material. Groundwater monitoring will continue. Sr-90 emanating from this area is captured and treated by SR-2.

BGRR Plume: The source area is capped by Building 701 and an engineered cap that was completed in 2011. The source area is being monitored to determine whether there is a continuing release of Sr-90 from beneath the building. The correlation between water table elevation and releases of residual Sr-90 inventory located below portion(s) of Building 701 is discussed in **Section 3.2.15-3**. Based on an analysis of nine years of data from source area extraction well SR-3, it appears likely that significant increases in water table elevation are releasing Sr-90 remaining in the deep vadose zone below Building 701. The peak Sr-90 concentrations in both the source area monitoring wells and SR-3 following the historical high water table elevation in 2010 do not appear to have been as high as in prior instances. This may be an indication of a diminishing inventory of contaminated soils beneath the building available to be mobilized by the water table. Monitoring will continue in this area in 2016.

PFS/Building 801 Area Plume: Elevated Sr-90 concentrations in source area monitoring wells persisted in 2015 although the concentrations were lower than previous years. Sr-90 concentrations in this plume are expected to meet the ROD cleanup goal.

2. Were unexpected levels or types of contamination detected?

WCF Plume: There were no unexpected levels of Sr-90.
BGRR Plume: There were no unexpected levels of Sr-90.
PFS/Building 801 Area Plume: There were no unexpected levels of Sr-90.

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

WCF Plume: The downgradient migration of the plume has been controlled. The eastward shift in the downgradient segment of this plume has resulted in a partial bypassing of the capture zone of SR-9 to the east. These Sr-90 concentrations in this area are well below the system capture goal of 175 pCi/L and are expected to meet the ROD cleanup goals.

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

PFS/Building 801 Area Plume: This plume is not being actively remediated. Based on the groundwater characterization work performed in 2014 and 2015 the plume is expected to attenuate and meet the ROD cleanup goals.

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

WCF Plume: The cleanup goal has not yet been met. The extraction wells are capturing source area Sr-90 contamination immediately downgradient from the WCF source. Extraction well SR-6 is in a pulsed pumping mode due to low Sr-90 concentrations.
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 although they have been in a pulsed pumping mode to aid in stimulating Sr-90 removal from the aquifer. It is recommended that both of these wells be placed in standby as SR-3 has effectively cut off the migration of SR-90 from the source area.

PFS/Building 801 Area 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?
This system is still operational. No significant Sr-90 concentration rebound has been observed in Building 701/BGD extraction wells SR-4, SR-5, and SR-6 or the core monitoring wells. These are the only extraction wells in pulsed pumping mode.

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:

- Continue to monitor source area Sr-90 concentrations on a monthly basis immediately downgradient of the BGRR.
- Maintain the sampling frequency for BGRR cap monitoring wells 075-699 and 075-700 at semi-annual due to elevated Sr-90 concentrations from 2012-2014.
- Characterize the Sr-90 concentrations along Temple Avenue immediately south of the HFBR Building using several temporary wells.
- Install temporary wells as needed to fill in data gaps and characterize the BGRR Sr-90 plume segment south of Cornell Avenue and just to the north of Building 725.
- Continue operating wells SR-1, SR-2, SR-3, SR-7, SR-8, and SR-9 in full time mode.
- Due to low Sr-90 concentrations in BGRR extraction well SR-6, continue this well in a pulsed pumping mode (one month on and one month off).
- Place BGRR extraction wells SR-4 and SR-5 in standby due to low concentrations and the cutting off of the plume to the north by SR-3.
- Discontinue sampling monitoring wells 065-173, 065-18, 065-19, 065-20, 065-165, 065-166, 065-167, 065-171, 065-40, 065-172, 075-188, 075-667, 075-668, 075-680, 075-663, 075-09, 075-10, 075-190, 075-191, 075-192, 075-202, 075-203, 075-195, 075-196, 075-197, 075-198, 075-199, and 075-200. There have been no detections greater than 3 pCi/L in any of these wells since 2009. The eastward shift of the plume since these wells were installed has resulted in their locations not being optimal to monitor segments of the Sr-90 plumes. Utilize temporary wells as needed.
- Install temporary wells as needed to evaluate whether the BGRR cap monitoring wells have been impacted by a shift in groundwater flow direction.
- Maintain well 065-175 semi-annual sampling frequency to monitor for Sr-90 migrating south from the WCF yard.

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3.2.16 Chemical/Animal Holes Strontium-90 Treatment System

This section summarizes the operational data from the Chemical/Animal Holes Strontium-90 Treatment System for 2015, 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 (8 pCi/L) 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 36 wells. **Figures 1-2** and **3.2.16-1** show the monitoring well locations. As recommended in the 2014 Groundwater Status Report, in May 2015, three permanent shallow wells were installed to monitor the residual Sr-90 upgradient of EW-1. To enhance the monitoring well network in the downgradient western portion of the plume, a monitoring was installed in June 2015.

Sampling Frequency and Analysis

To help support a decision for shutdown, the sampling frequency for the monitoring wells is semi-annual (shutdown phase).

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 2015 monitoring well data for all wells except for the three newly installed wells upgradient of EW-1 (which use the fourth quarter data). The plume depiction is also supplemented with temporary well data from late 2015.

The area of highest concentration (approximately 50 pCi/L) is currently located immediately upgradient of EW-1. Lower concentrations are identified south of the Princeton Avenue firebreak. Overall, the plume concentrations have significantly decreased over the last several years. To date, the highest Sr-90 concentration observed in groundwater in this area was 4,720 pCi/L at well 106-99 in 2005. Sr-90 concentrations in the plume have been below 250 pCi/L since February 2011. As shown on **Figure 3.2.16-6**, the plume is now discontinuous as a result of the progress of the treatment system. See **Figure 3.2.16-2** for trends for key monitoring wells.

A summary of key monitoring well data for 2015 and temporary well data from late 2015 follows:

- The highest Sr-90 concentration observed in 2015 was 178 pCi/L in plume core well 106-95 during the first quarter sampling. This monitoring well is located approximately 40 feet north of

EW-1. This well has typically ranged between 60 pCi/L to 300 pCi/L since it was installed in 2002. However, following an historical high detection of 1,280 pCi/L in 2005, Sr-90 concentrations have been dropping off in this well. The third quarter 2015 sample detected 58 pCi/L of Sr-90.

- Sr-90 concentrations in core well 106-94, located upgradient of EW-1 has been declining since a maximum Sr-90 concentration of 680 pCi/L in 2005. Sr-90 was detected during the third quarter 2015 at 44 pCi/L. Sr-90 concentration trends in plume core wells 106-16 and 106-99 have significantly declined over time with the maximum value of 47 pCi/L in 2015.
- The maximum Sr-90 concentration detected in the three new monitoring wells installed approximately 150 feet upgradient of EW-1 in was 96 pCi/L in CAH-MW-02-2015 in May. Sr-90 concentrations dropped off to less than the DWS in the fourth quarter.
- Characterization of the soil and groundwater upgradient of EW-1 was performed in November and December 2015 to determine if there is a continuing source of Sr-90 from the former Chemical/Animal Holes area. Soil samples were collected at 23 locations continuously from 12 feet below grade to just above the water table. A groundwater sample was collected at the water table at 24 locations. See **Figure 3.2.16-1** for the locations of the temporary wells and **Table 3.2.16-3** for the analytical data. The maximum Sr-90 concentration in the soil samples was 7 pCi/g in temporary well SB-A12. The maximum Sr-90 concentration detected in groundwater was 10 pCi/L in SB-I08, which is located adjacent to monitoring well MW-02-2015.
- Perimeter monitoring well 106-135 remained less than the DWS for 2014 and 2015. The temporary well installed at this location in 2010 identified Sr-90 at 85 pCi/L. Monitoring well MW-04-2015, installed in June 2015 south of Princeton Avenue further defines the plume segment downgradient of well 106-135. Sr-90 was not detected above the DWS in this well..
- Plume core well 106-125, located upgradient of EW-2, detected 498 pCi/L of Sr-90 in 2007, and has remained below 30 pCi/L since 2011. Sr-90 was detected in this well in 2015 up to 12 pCi/L. Plume core well 106-119, located upgradient of the southern-most extraction well EW-3 has remained below the DWS since 2012.
- Sr-90 was only detected once in bypass wells 106-120, 106-121, and 106-122 since 2012. Well 106-121 detected 2 pCi/L in 2015. These wells are approximately 100 feet downgradient of EW-3.

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

3.2.16.4 System Operations

In October 2014, the Chemical/Animal Holes Strontium-90 Treatment System began to run in a one month on, two month off pulsed pumping status. Due to elevated Sr-90 concentrations upgradient, in October 2015 well EW-1 was turned back in full time operation while wells EW-2 and EW-3 continued in a pulsed pumping mode (one month on, two months off). The influent, midpoint, and effluent locations were sampled twice per month when the system was operating. During the time the system was off, no samples were collected. The samples were analyzed for Sr-90 and the effluent samples were analyzed for pH (**Table 3.2.16-1**). All extraction wells were sampled quarterly (**Table F-43)**. The maximum Sr-90 concentration in the extraction wells was 21 pCi/L in EW-1.

Sr-90 concentrations for the system influent and effluent in 2015 are presented in **Tables F-44** and **F-45**. The maximum Sr-90 influent concentration in 2015 was 9 pCi/L. There were no detections of Sr-90 in the system effluent in 2015. **Table F-46** contains a summary of the monthly Sr-90 mass removal for the system.

Summarized below are the system operations data for 2015.

Table 3.2.16-1.
Chemical Holes Sr-90 Treatment System
2015 SPDES Equivalency Permit Levels

Parameter	Permit Level	Max. Measured Value
pH range (SU)	5.0–8.5	5.4–6.6
Sr-90 (pCi/L)	8.0	<MDA

Notes:
pCi/L = pico Curies per liter
SU = Standard Units
MDA = Minimal detectable activity
Required sampling frequencies are monthly for Sr-90 and pH.

January – September 2015

The system was in pulsed pumping mode (one month on and two months off). In September, the system was off from the 16th to the end of the month to replace the pump and motor in EW-1. The system treated approximately 3 million gallons of water from January through September.

October – December 2015

In October, the system pulsed pumping frequency was changed to well EW-1 running full time and EW-2 and EW-3 remained in a one month on, two months off schedule. Well EW-1 was off for approximately one week in October to install a new flow meter. The system operated normally the remainder of the time. Approximately 2 million gallons of water was treated during this period.

3.2.16.5 System Operational Data

In October 2015, EW-1 was placed back into full time operation to ensure capture of any upgradient Sr-90 contamination. Concentrations of Sr-90 in EW-1 have steadily dropped-off since 2009 and averaged 14 pCi/L in 2015. This is consistent with the reduced Sr-90 levels detected in monitoring wells upgradient of EW-1 since 2012. Sr-90 concentrations in EW-2 have decreased as expected since this well became operational in November 2007. Upon start-up, up to 139 pCi/L of Sr-90 was detected in EW-2 and the concentration has steadily dropped to less than the DWS since 2012. When EW-3 became operational, concentrations were already low at 13 pCi/L. They remained low through late 2011 and then started increasing slightly. Sr-90 concentrations in EW-2 and EW-3 averaged 3 pCi/L and 4 pCi/L in 2015 respectively. **Figure 3.2.16-4** presents the extraction well data over time. The 2015 analytical data show that influent Sr-90 concentrations ranged from 2.5 pCi/L to 8.8 pCi/L (**Table F-44**). The effluent samples did not detect any Sr-90. Approximately 4.2 million gallons of groundwater were treated during 2015.

Cumulative Mass Removal

Average flow rates for each monitoring period were used, in combination with the Sr-90 influent concentration, to calculate the mCi removed. System flow averaged 19 gpm during 2015. **Table 3.2.16-2** shows the monthly extraction well pumping rates. The cumulative total mass of Sr-90 removed was approximately 0.09 mCi during 2015, with a total of approximately 4.9 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 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?

The former Chemical/Animal Holes, located upgradient of extraction well EW-1 were excavated in 1997. Although Sr-90 has been detected up to 96 pCi/L in monitoring well MW-02-2015 in 2015 in the upgradient portion of the plume, concentrations have decreased from the 2008 and 2012 temporary wells installed at this location. As discussed in **Section 3.2.16.3** above, the temporary well soil and groundwater samples obtained in this area in late 2015 did not identify a continuing source of Sr-90. As seen by the trends in **Figure 3.2.16-2**, Sr-90 concentrations in monitoring wells immediately upgradient of EW-1 have been significantly reduced over the last seven to eight years. This is indicative of the progress of the active remediation and the significant reduction of any residual contamination remaining in the vadose zone.

2. Were unexpected levels or types of contamination detected?
There were no unexpected levels or types of contamination detected in the plume in 2015.

3. Has the downgradient migration of the plume been controlled?
The monitoring data from plume perimeter wells to the west and east as well as the system bypass wells indicate that the main portion of the plume is controlled by extraction well EW-1. Although the lower concentration portion of the plume to the west of EW-2 will likely not be captured by the extraction wells, the Sr-90 concentrations are low and are expected to attenuate to the DWS before 2040.

4. *Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?*
The original groundwater modeling performed for this plume projected that EW-1 would operate for approximately 10 years (by 2014) in order to reduce the Sr-90 concentrations in the plume to meet the overall cleanup objective of DWS by 2040. Although Sr-90 levels upgradient of extraction well EW-1 have declined in recent years, this well needs to continue operating full time. Extraction wells EW-2 and EW-3 will be proposed for shut down.

4a. Are Sr-90 concentrations in plume core wells above or below 8 pCi/L?
Sr-90 concentrations in 10 of 17 core wells were above 8 pCi/L in 2015.

4b. Is there a significant concentration rebound in core wells and/or extraction wells following shutdown?
Since the system was placed in a pulsed pumping mode (one month on and two months off) in October 2014, no significant rebound was evident.

5. *Has the groundwater cleanup goal of meeting drinking water standards been achieved?*
No. The DWS has not been achieved for Sr-90 in all plume core wells. However, based on current upgradient Sr-90 concentrations, the DWS is expected to be achieved by 2040. Comparison of the current plume with the 2002 plume is provided in **Figure 3.2.16-6.**

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 well EW-1 in full time mode.
- Due to low Sr-90 concentrations in the extraction wells and adjacent monitoring wells, shut down EW-2 and EW-3 and place in standby mode. If significant rebound is identified, these extraction wells may be restarted.

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 prevent off site migration of the plume. 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 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, 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.

The *Petition For Shutdown, High Flux Beam Reactor, Tritium Plume Pump and Recharge System* (BNL 2013e) was submitted to the regulatory agencies in March 2013 based on satisfaction of the criteria established in the *2008 Groundwater Status Report* (BNL, 2009b) and documented in the *Operations and Maintenance Plan for the High Flux Beam Reactor Tritium Plume Pump and Recharge System (*BNL, 2009c). The petition was approved by the regulatory agencies in May 2013 and the extraction wells were placed in standby mode.

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 included 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, EW-11, and EW-16 are sampled at a quarterly frequency.

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 36 wells is used to monitor the source area and verify the predicted attenuation of the plume (**Figure 1-2**).

Sampling Frequency and Analysis

Sampling details for the well network are provided on **Table 1-5**. Select wells are also analyzed for VOCs.

3.2.17.3 Monitoring Well Results

Figure 3.2.17-1 displays postings of fourth quarter 2015 data for each of the wells in the monitoring network. In 2015 the plume monitoring was scaled back to the area immediately downgradient of the HFBR source due to the attenuation of the downgradient portion of the plume.

There were no tritium detections observed during 2015 monitoring that exceeded the 20,000 pCi/L DWS. The highest concentration was 19,500 pCi/L in monitoring well 075-44 during the third quarter. This well is located immediately south of the HFBR building. **Appendix C** contains the complete set of monitoring well data. The following is a summary of groundwater monitoring well results:

Samples are collected from a network of two monitoring wells north of the HFBR. Trace levels of tritium were detected in these wells during 2015. The wells serve as early detection points in the event that groundwater flow shifts to a more northerly direction and toward supply wells 10 and 11. Groundwater flow during 2015 was consistently to the south. Maintenance of the southerly flow in this area of the site is accomplished through the BNL Water and Sanitary Planning Committee which meets regularly to discuss on-site pumping and recharge of groundwater.

Elevated tritium concentrations directly downgradient of the HFBR have been observed to correlate with high water-table elevation events. This results in water-table flushing of the unsaturated zone beneath the HFBR. The correlation is evident when comparing water table elevations immediately downgradient of the HFBR with peak tritium concentrations in the monitoring wells located in this area as shown in **Figure 3.2.17-2**. The figure also demonstrates how the magnitude and frequency of these events has decreased over the 18 years of monitoring. The highest tritium concentration observed in this area during 2015 was 19,500 pCi/L in monitoring well 075-44. There have been a total of 25 tritium detections since 2011 exceeding the 20,000 pCi/L DWS all of which were in monitoring wells located between Brookhaven Avenue and the HFBR. The highest concentration during this period was 142,000 pCi/L in well 075-225 from July 2011. **Figure 3.2.17-2** plots the highest tritium concentrations in monitoring wells located immediately downgradient of the HFBR for each sampling round over time. Based on the decreasing concentration trend it appears that the inventory of tritium beneath the HFBR that is affected by the water-table flushing has significantly decreased over the years.

3.2.17.4 System Operations

Table F-50 shows VOC and tritium concentrations in the extraction wells. Extraction wells EW-9, EW-10, EW-11, and EW-16 were sampled quarterly and analyzed for tritium and VOCs in 2015. The treatment system was in standby mode throughout 2015.

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, however the inventory of tritium that remains in the unsaturated zone beneath the HFBR building appears to be decreasing. The water table elevation is currently low compared to historical values. The low elevation of the water table could be minimizing any flushing affect regarding the remaining inventory beneath the HFBR. The highest concentration observed in the source area during 2015 was 19,500 pCi/L in monitoring well 075-44. The steadily declining peak tritium concentrations in wells immediately downgradient of the HFBR and the water table elevation are shown in **Figure 3.2.17-2**.

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 2015.

3. Is the plume attenuating as expected?
Yes. The downgradient segment of the plume south of Brookhaven Avenue has attenuated to concentrations below the DWS and monitoring has been suspended in this area. **Figure 3.2.17-2** demonstrates the decline in source area concentrations over the years.

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?
The regulatory agencies approved the Petition for Shutdown of this system in May 2013, and the system was placed in standby mode at that time.

5a. Are tritium concentrations in extraction wells above or below the 20,000 pCi/L DWS?
Monitoring of the downgradient segment of the plume concluded in 2014.

5b. Is there a significant concentration rebound in extraction wells following shutdown?
There has not been any indication of tritium concentration rebound in either the monitoring or extraction wells since they were placed in standby mode.

6. Has the groundwater cleanup goal of meeting MCLs been achieved?
The downgradient portion of the former plume south of Brookhaven Avenue has met cleanup goals. Monitoring of the source area will continue until tritium concentrations consistently remain below the DWS.

3.2.17.6 Recommendations

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

- The extraction wells remain in standby mode. One or more extraction wells can be restarted if tritium concentrations in the extraction wells rebound to concentrations above 20,000 pCi/L.

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3.3 OPERABLE UNIT IV

This section summarizes the data from the Building 650 and Sump Outfall Strontium-90 Monitoring Program that 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 (sump outfall) 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. Building 650 is included on the BNL Environmental Liabilities list of buildings that have contamination associated with them and will be addressed as funding is made available.

3.3.1.1 Groundwater Monitoring

Well Network

The network consists of 20 wells used to monitor the Sr-90 concentrations originating from the former Building 650 sump outfall area. The network was supplemented with three temporary wells installed just north of the NSLS II Facility in May 2015 (**Figure 1-2 and 3.3.1-1**).

Sampling Frequency and Analysis

During 2015, 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 south and away from the former Building 650 sump outfall area. 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 between Brookhaven Avenue and the NSLS II Facility, based on the results from monitoring wells 076-181 and 076-182 and the three temporary wells (see **Table 3.3.1-1**).

Sr-90 concentrations in the source area continue to decrease as evidenced by data from wells 076-13 and 076-169 over the previous 17 years (**Figure 3.3.1-2**). The highest concentration observed in the plume during 2015 was in monitoring well 076-07 (37 pCi/L in July).

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 yet there are still persistent detections of Sr-90 in source area monitoring well 076-13 at levels just above the DWS. 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. The persistence of Sr-90 in this source area is consistent with Sr-90 sources areas at the former Chemical Holes, WCF and the former HWMF.

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

All Sr-90 detections in 2015 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. The groundwater 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.

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 2015 (076-07, 076-13, 076-415, and 076-182) 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,** including quarterly monitoring for well 076-13.

3.4 OPERABLE UNIT V

3.4.1 OU V Monitoring Program

The Sewage Treatment Plant (STP) processes sanitary wastewater from BNL's research and support facilities. Treated effluent from the STP was discharged to the Peconic River under a NYSDEC SPDES permit until September 2014. Since October 2014, BNLs STP effluent has been released to groundwater recharge basins. 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 monitored 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 4.4** of this document. On March 10, 2012, BNL issued a *Petition to Discontinue Operable Unit V Groundwater Monitoring* to the regulators for their review (BNL 2012d). Based on the recommendations and the regulatory comments, the groundwater monitoring program was reduced to one monitoring well, 000-122 in 2012. The last round of data from this well in 2013 indicated that all VOC concentrations were below AWQS. Based on the recommendation in the *2013 Groundwater Status Report*, sampling of well 000-122 was discontinued. This completed the groundwater sampling requirements for OU V.

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3.5 OPERABLE UNIT VI EDB TREATMENT SYSTEM

The OU VI EDB Treatment System addresses an ethylene dibromide (EDB) plume in groundwater extending from south of North Street for approximately 3,000 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 26 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**). However, wells 000-178, 000-508, 000-519, 000-520, 000-524, and 000-527 were sampled at a quarterly 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. Three 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 2015 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 as depicted on cross section Q–Q' (**Figure 3.5-2)**. See **Figure 3.5-3** for historical EDB trends for key monitoring wells. A summary of key monitoring well data for 2015 follows:

- EDB concentrations in all core wells upgradient of well 000-178 have declined significantly over the past several years. EDB in well 000-178 has increased from late 2006 through 2012, indicating movement of the higher concentration portion of the plume south. A 2012 sample detected 4.8 µg/L of EDB, which is an historical high for this well since it was installed in 1998. Since 2012, concentrations have been dropping off to a maximum of 1.2 µg/L in the second quarter 2015. This was also the maximum EDB detection in the plume in 2015. This well is upgradient of EW-2E. The federal DWS for EDB is 0.05 µg/L.
- Core well 000-507 has detected gradually increasing levels of EDB above the DWS since it was installed in 2005. In 2012, EDB concentrations reached an historical high for this well of 1.67 µg/L. Since 2013, concentrations have dropped with a maximum EDB value of 0.34 µg/L in the second quarter 2015. This well is immediately upgradient of extraction well EW-1E.
- Monitoring well 000-520 was installed in March 2011 to monitor the eastern extent of the plume (**Figure 3.5-1**). This well is located next to the treatment system building. EDB concentrations in

this well ranged from 2.73 µg/L in 2011 to 0.04 µg/L in the third quarter of 2015. This contamination will be captured by the extraction wells. As shown on the cross section **(Figure 3.5-2)**, this well is screened just above the Gardiners Clay (between 135 and 145 feet bls).

- EDB in the eastern perimeter monitoring well 000-524, installed in September 2012, remained below the DWS of 0.05 µg/L since 2013. This indicates that the lateral extent of the plume continues to be captured.
- Bypass monitoring well 000-527 was installed in September 2013 south of extraction well EW-2E to verify capture of the deeper contamination identified in monitoring well 000-178. This well is screened 10 feet deeper than adjacent bypass well 000-519. EDB was not detected in well 000-527 in 2013 or 2014. EDB was detected at an estimated value of 0.008 µg/L in the first quarter 2015. However, EDB was not detected in subsequent sampling events. Remaining 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**. The core of the plume is located between the extraction wells and well 000-178. Comparing the plume's distribution from 1999 to 2015 (**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. EDB was detected in well 000-173, located south of North Street in 2015, but below the DWS. This indicates that the trailing edge of the plume is moving south. Overall, peak EDB concentrations declined from 7.6 µg/L in 2001 (in well 000-283) to 1.2 µg/L in 2015 (in monitoring well 000-178).

EDB was the only VOC detected above the standard in any OU VI well in 2015 (**Appendix C**).

3.5.4 System Operational Data

The sampling frequency of the extraction wells is quarterly. 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 Treatment System
2015 SPDES Equivalency Permit Levels

Parameters	Permit Limit (µg/L)	Max. Measured Value (µg/L)
pH (range)	5.0 – 8.5 SU	5.4 – 7.4 SU
ethylene dibromide	0.03	<0.02
chloroform	7.0	0.8
1,1-dichloroethene	5.0	<0.50
1,1,1-trichloroethane	5.0	<0.50
methyl chloride	5.0	<0.50
methylene chloride	5.0	1.7

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

January – September 2015

The system was down from January 23 to February 4 due to a snowstorm. The system was off two days in June for a carbon change-out. In July, the system was off six days for electrical repairs. The system treated approximately 128 million gallons of water during this period.

October – December 2015

The system operated normally for this period. The system treated approximately 48 million gallons of water.

Extraction Wells

During 2015, the system treated approximately 178 million gallons of water, with an average flow rate of approximately 343 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-47**. In 2015, the extraction wells had a maximum EDB detection of 0.042 µg/L in EW-2E in July, which is below the DWS. No other VOCs were detected in the extraction wells above the AWQS.

Figure 3.5-5 shows the EDB concentrations in the extraction wells over time. EDB levels in EW-1E have remained relatively stable from 2008 through 2013, hovering around the DWS. Since then, concentrations began to decline to a low of 0.02 µg/L in 2015. EDB in EW-2E has remained steady since 2011, with detections typically just below the DWS.

System Influent and Effluent

EDB was detected in all of the monthly sampling events of the combined influent throughout 2015, with a maximum concentration of 0.04 µg/L. During 2015, the system effluent was below the regulatory limits specified in the SPDES equivalency permit (See **Table 3.5-1**). Influent and effluent results are reported on **Tables F-48** and **F-49,** respectively.

Cumulative Mass Removal

No cumulative mass removal calculations were performed because of the typically low detections of EDB historically below the DWS in the system influent. EDB was detected in all four quarterly samples in both extractions wells; however, EDB was not detected above the standard in 2015. 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

Start-up of the system began in August 2004. 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 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. There is no continuing source.

2. Were unexpected levels or types of contamination detected?

No.

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

Yes. The hydraulic capture of the system is operating as designed as evidenced by the EDB concentrations in the extraction wells. Based on the low detections of EDB in perimeter well 000-524, the eastern extent of the plume is defined. Bypass monitoring well 000-527 ensures that the deeper portion of the plume is being captured by the extraction wells. EDB was identified just above detectable levels in this well at an estimated value of 0.008 µg/L in the first quarter 2015. EDB was not detected in the remaining three bypass wells since 2005.

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 of meeting DWS in the core monitoring wells and extraction wells. Although EDB concentrations in EW-2E are just below the DWS, the higher concentration portion of the plume are still evident near well 000-178 (see **Figure 3.5-3**).

The plume has moved slower than originally simulated in the 2000 groundwater model. It was originally envisioned that the system would need to operate between eight to ten years. Due to the current location of the plume compared to the extraction wells, the system is operating longer than expected. In June 2015, the groundwater model was updated using current data to better refine the remaining time required to remediate the EDB plume to below the DWS. The model projects a duration of approximately five additional years of pumping to meet the DWS (2019-2020).

4a. Are EDB concentrations in plume core wells above or below 0.05 µg/L?
In 2015, five of ten plume core wells had concentrations greater than the 0.05 µg/L 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 pulsed pumped or shut down.

5. Has the groundwater cleanup goal of meeting MCLs been achieved?
No. The DWS has not been achieved for EDB in all plume core wells. However, it is expected to be achieved by 2030, as required by the OU VI ROD. The system will continue to operate through 2019/2020.

3.5.6 Recommendations

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

- Maintain operation of the treatment system.
- Since there have been no detections of EDB or other compounds above the DWS or AWQS since 2003, it is recommended that sampling of upgradient monitoring wells 099-11, 100-12, and 100-13 for VOCs be discontinued.

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 2015 program included 10 wells in the northwestern portion of the BNL property (**Figure 1-2**) hydraulically upgradient of lab operations.

Sampling Frequency and Analysis

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

3.6.2 Monitoring Well Results

The complete groundwater analytical data for 2015 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 0.32 µg/L of chloroform in well 017-03 (AWQS of 5 µg/L).

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 2015. 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 2015 Environmental Monitoring Report, Current and Former Landfill Areas* (BNL 2016a). 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 2015, the landfill had been capped for 20 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 2015:

- Benzene was detected in downgradient wells 087-11and 088-109 at concentrations slightly above the AWQS with a maximum concentration of 1.7 µg/L. The other VOCs detected above the groundwater standard were chloroethane and 1,1-DCA which were only detected in one downgradient monitoring well (088-109). The maximum concentration of 1,1-DCA during 2015 was 35 µg/L. Chloroethane concentrations ranged up to 124 µg/L, indicating that VOCs continue to emanate from the landfill. An analysis of the trends of VOCs indicated the concentrations are stable to decreasing. These concentrations are naturally attenuating and are not detected at the site boundary above the AWQS.

- Concentrations of landfill water chemistry parameters and metals such as ammonia and iron in several downgradient wells were above the upgradient values. This suggests that leachate continues to emanate from the landfill into groundwater, but at low levels.
- Tritium continued to be detected in well 087-27 downgradient of the Current Landfill, but at concentrations well below DWS. This is consistent with historical observations. There have been no detections of radionuclides above the DWS since 1998.
- 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

Due to the consistent elevated levels of chloroethane in monitoring well 088-109, temporary wells were drilled in early 2016, north and south of this location to determine the extent and maximum chloroethane concentrations. Results of this investigation are discussed in **Section 3.1.4**.

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. 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**.

Based on changes recommended in the *2012 Environmental Monitoring Report, Current and Former Landfill Areas,* all wells except for 106-02 are sampled every two years. Well 106-02 continues to be sampled annually for metals. The Former Landfill Area monitoring wells were last sampled during 2014 and are scheduled for their next sampling in 2016. Only well 106-02 was sampled during 2015. The following is a summary of the results from the sample collected during 2015:

- No metals exceeded the groundwater standards in well 106-02 downgradient of the Former Landfill Area. After replacing the pump in well 106-02 in 2013, the iron concentration has decreased from an historic high of 2,190 µg/L in 2012 to non-detect in 2015. Therefore, it is concluded that the pump was the source of the iron in well 106-02.

3.7.4 Former Landfill Recommendations

The following change is recommended for the Former Landfill Areas monitoring well network:

- Since iron results have returned to background levels in 2014 and 2015, metals sampling in well 106-02 should be reduced to once every two years, making it consistent with the monitoring requirements of the remaining wells in this program.

3.8 g-2 TRITIUM SOURCE AREA AND GROUNDWATER PLUME

In November 1999, tritium was detected in the groundwater near the former 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. The g-2 experiment was decommissioned in April 2001.

The g-2/BLIP/former UST ROD (BNL 2007a) 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 20,000 pCi/L. 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 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 immediately south of Brookhaven Avenue, with a maximum concentration of 58,600 pCi/L. Monitoring conducted since that time has demonstrated that tritium concentrations in the plume segment have attenuated to <20,000 pCi/L.

3.8.1 g-2 Tritium Source Area and Plume Groundwater Monitoring

Well Network

The g-2 tritium plume has been monitored in two areas: the source area (including the area to the east of Building 912), and the downgradient plume segment that had migrated south of Brookhaven Avenue. Monitoring of the source area is accomplished using six wells immediately downgradient of the source, and 12 wells southeast of Building 912 (**Figure 3.8-1**). Monitoring of the downgradient tritium plume segment located south of Brookhaven Avenue was accomplished using temporary wells.

Sampling Frequency and Analysis

During 2015, the wells located immediately downgradient of the g-2 source area were monitored two times, and the samples were analyzed for tritium (**Table 1-6**). The wells located southeast of Building 912 were sampled once during the year. The wells are monitored for tritium because it is more leachable than sodium-22, and it migrates at the same rate as groundwater.

Seven temporary wells were installed in January and May 2015 to track the downgradient portion of the g-2 plume in the area south of Brookhaven Avenue, near the National Synchrotron Light Source II (NSLS II) facility.

3.8.2 g-2 Tritium Source Area and Plume Monitoring Well Results

The extent of the g-2 tritium plume during the fourth quarter of 2015 is depicted on **Figure 3.8-1**.

Source Area Monitoring Results

The maximum tritium concentration in source area wells was 55,000 pCi/L in well 054-184 during the second quarter. **Figure 3.8-2** provides tritium trend charts for wells that monitor the g-2 source area.

Tritium that is traceable to the g-2 source area continues to be detected in monitoring wells located downgradient (southeast) of AGS Building 912. The maximum tritium concentration in this area was 18,100 pCi/L in a sample from well 065-122 collected during the fourth quarter.

Downgradient Plume Segment

From 1999 through 2015, a segment of the g-2 tritium plume (defined by concentrations >20,000 pCi/L) was tracked from the source area to the vicinity of the National Synchrotron Light Source II facility, a distance of approximately 4,000 feet, using temporary wells installed in a series of east west transects (locations Transects A through M are depicted on **Figure 3.8-1**). During this period, tritium in the downgradient plume segment attenuated to concentrations below the 20,000 pCi/L MCL. As described in the *2014 Groundwater Status Report*, tritium was not detected above the 20,000 pCi/L DWS in four temporary wells installed in January 2015 (BNL 2015b). Three additional temporary wells were installed near the NSLS-II facility in May 2015 (**Figure 3.8-1**). The maximum tritium concentration detected in the temporary wells was 18,600 pCi/L. Monitoring results for the temporary wells in stalled in May 2015 are summarized on **Table 3.8-1**.

3.8.3 g-2 Tritium Source Area and Plume Groundwater Monitoring Program Evaluation

The 2015 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 overall reduction in tritium concentrations since 1999 indicates that the cap is effectively preventing rainwater from infiltrating the activated soil shielding. A comparison of tritium levels in the source area monitoring wells and water-table elevation data suggests that periodic natural fluctuations in the water table have released residual tritium from the deep vadose zone (i.e., unsaturated soil immediately above the water table). 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 3.8-3**). 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 decrease by means of the natural water table flushing mechanism and by natural radioactive decay. Temporary wells installed in 2015 verified that tritium in the area south of Brookhaven Avenue have attenuated to concentrations below the 20,000 pCi/L MCL.

3. Is the plume naturally attenuating as expected?

With the effectiveness of the source area controls, the plume segment immediately downgradient of the source area is attenuating as expected. Tritium levels in the plume segment that was located south of Brookhaven Avenue attenuated to concentrations less than 20,000 pCi/L.

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

Not at this time. Tritium concentrations in groundwater immediately downgradient of the g-2 source area continue to routinely exceed the MCL. However, results of monitoring conducted in 2015 indicate that tritium concentrations in the plume segment that was located south of Brookhaven Avenue have attenuated to below the MCL.

3.8.4 g-2 Tritium Source Area and Plume Recommendations

The following are recommended for the g-2 tritium source area and plume groundwater monitoring program:

- As required by the ROD, BNL will continue to conduct routine inspections of the g-2 cap and monitor groundwater quality downgradient of the source area. Wells will continue to be sampled semiannually.
- Continue to sample the wells located downgradient of Building 912 that are used to monitor the leading edge of the g-2 tritium plume annually.
- Because tritium concentrations in the downgradient plume segment have decreased to less than the 20,000 pCi/L DWS, discontinue groundwater monitoring in the area south of Brookhaven Avenue.

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3.9 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 of the targets, radionuclides are produced in the cooling water and the soil immediately outside the tank by the neutrons created at the target.

In 1998, 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. The drinking water standard for tritium is 20,000 pCi/L, and the standard for sodium-22 is 400 pCi/L. 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. 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 constructed a protective cap over the beam line that runs from the Linac to the BLIP facility. The 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.[1] During 2015, this cap section was extended in several areas to provide protection of soil shielding that is expected to become activated following planned changes in beam line operations.

A ROD was signed in early 2007 (BNL 2007a). The 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.

3.9.1 BLIP Groundwater Monitoring

Well Network

The monitoring well network for the BLIP facility consists of one upgradient and three downgradient wells (**Figure 3.9-1**). These wells provide a means of verifying that the stormwater controls described above are effective in protecting groundwater quality.

Sampling Frequency and Analysis

During 2015, the three wells located immediately downgradient of the BLIP facility (064-47, 064-48, 064-67) were monitored twice. The groundwater samples were analyzed for tritium (**Table 1-6**). 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).

3.9.2 BLIP Monitoring Well Results

Monitoring results indicate that the stormwater controls are highly effective in preventing the release of tritium from the activated soil surrounding the BLIP target vessel. Since April 2006, tritium levels

[1] 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).

have remained below the 20,000 pCi/L DWS. During 2015, the maximum tritium concentration was 2,690 pCi/L in the second quarter sampling of well 064-67.

3.9.3 BLIP Groundwater Monitoring Program Evaluation

The 2015 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 low levels of tritium continue 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 decline in tritium concentrations indicates that the stormwater controls are effectively preventing the leaching of tritium from the activated soils.

2. Were unexpected levels of contamination detected?

The observed tritium levels are consistent with previous surveillance results.

3. 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 the continued effectiveness of the stormwater controls.

3.9.4 BLIP Recommendation

The following is recommended for the BLIP groundwater monitoring program:

- 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.
- Because tritium levels in groundwater have remained below the 20,000 pCi/L MCL/DWS since January 2006, the monitoring frequency for downgradient monitoring wells 064-47, 064-48, and 064-67 will continue to be semiannual.

4.0 FACILITY MONITORING PROGRAM SUMMARY

During 2015, the Facility Monitoring Program at BNL monitored groundwater quality at 12 research and support facilities. New York State operating permits require groundwater monitoring at the Major Petroleum Facility, Waste Management Facility, and the Sewage Treatment Plant; the remaining 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) or CERCLA Records of Decision. DOE 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. CERCLA Records of Decision define the monitoring requirements and remedial actions for the Building 452 Freon-11 plume, g-2 tritium source area and plume, and the Brookhaven Linac Isotope Producer (BLIP) source area. BNL uses monitoring data to determine whether current engineered and administrative controls effectively protect groundwater quality, determine whether additional corrective actions are needed, and to determine the effectiveness of remedial actions.

During 2015, 118 groundwater monitoring wells were sampled during 189 sampling events. BNL also installed seven temporary wells to monitor the g-2 Tritium Plume. Approximately 55 groundwater samples were collected using the temporary wells. **Table 1-6** summarizes the Facility Monitoring Program by project. Complete analytical results from groundwater samples collected in 2015 are provided in **Appendix D**. Monitoring results for the Building 452 Freon-11 plume, g-2 source area and tritium plume, and BLIP source area are presented in **Sections 3.2.2, 3.8, and 3.9**, respectively. Information on groundwater quality at each of the remaining monitored research and support facilities is described below.

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4.1 ALTERNATING GRADIENT SYNCHROTRON (AGS) COMPLEX

The structures that constitute the AGS Complex include the AGS Ring, Linear Accelerator (Linac), BLIP, 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 BNL *Accelerator Safety* subject area.[1] BNL uses 57 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 4.1-1**. 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).

In the late 1990's, BNL detected four tritium plumes that originated from the AGS complex: the g-2 experimental area (**Section 3.8**), the BLIP facility (**Section 3.9**), the former U-Line beam stop (**Section 4.1.8**), and the former E-20 Catcher (**Section 4.1.4**). 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 BLIP, former U-Line beam stop, and E-20 Catcher areas. Tritium continues to be detected downgradient of the g-2 soil activation area at concentrations that exceed 20,000 pCi/L.

4.1.1 AGS Building 912

Building 912 consists of five interconnected structures that were used to house four experimental beam lines (A, B, C, and D lines). Although beam line operations ended in 2002, BNL is planning to relocate the Accelerator Test Facility to Building 912.

Beam losses 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.

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 4.1-1**). 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. Some of the

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[1] 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).

downgradient wells are also used to track a section of the g-2 tritium plume that has migrated underneath Building 912 (**Section 3.8**).

Sampling Frequency and Analysis

During 2015, the Building 912 wells were sampled one time. 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 some of the wells located downgradient of Building 912 (**Figure 4.1-1**). During 2015, tritium from the g-2 tritium source area was detected in four wells (065-122, 065-123, 065-323, and 065-324), with a maximum concentration of 18,100 pCi/L detected in a sample collected from well 065-122. Tritium was not detected in the groundwater samples collected from the remainder of the Building 912 area wells.

4.1.1.3 AGS Building 912 Groundwater Monitoring Program Evaluation

The 2015 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?

Activated soils are present below the floor slab at Building 912. During 2015, tritium was not detected in areas not impacted by the g-2 tritium plume, which indicates that the building and associated stormwater management operations are effectively preventing 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 2016, continue sampling all Building 912 monitoring wells 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, 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 allow for 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 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 4.1-1**).

Sampling Frequency and Analysis

During 2015, 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 4.1-2**).

4.1.2.3 AGS Booster Groundwater Monitoring Program Evaluation

The groundwater monitoring results 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?

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 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.[2] Because tritium has not been detected in the Booster area monitoring wells since 2002, the caps have been effectively preventing rainwater infiltration into the activated soil shielding.

4.1.2.4 AGS Booster Recommendation

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

- For 2016, the monitoring frequency for the Booster area monitoring wells will continue to be annually.

4.1.3 NASA Space Radiation Laboratory (NSRL)

The NSRL is jointly managed by the U.S. Department of Energy and NASA's Johnson Space Center. The NSRL uses beams of heavy ions extracted from Booster accelerator for radiobiology studies. NSRL became operational in 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 shallow Upper Glacial aquifer monitoring wells 054-08, 054-62 and 054-191 (**Figure 4.1-1**).

Sampling Frequency and Analysis

During 2015, the NSRL monitoring wells were sampled one time. The samples were analyzed for tritium (**Table 1-6**).

4.1.3.2 NSRL Monitoring Well Results

During 2015, tritium was not detected in the NSRL monitoring wells.

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[2] 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.

4.1.3.3 NSRL Groundwater Monitoring Program Evaluation

The groundwater monitoring results 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?

Activated soil shielding at the NSRL 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 2016, 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 in operation from 1984 to 1999, and was located at the 5 o'clock position of the AGS ring (**Figure 4.1-1**). The E-20 Catcher 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 up to 40,400 pCi/L and 704 pCi/L, respectively. In April 2000, a temporary impermeable cap was installed over the E-20 Catcher area, and a permanent cap was constructed by October 2000. Tritium and sodium-22 concentrations in groundwater 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 continued 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) (**Figure 4.1-1**).

Sampling Frequency and Analysis

During 2015, 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 DWS (**Figure 4.1-3**). During 2015, tritium was not detected in the monitoring wells

4.1.4.3 Former AGS E-20 Catcher Groundwater Monitoring Program Evaluation

The 2015 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?

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 2016, the monitoring frequency for the former E-20 Catcher wells will continue to be annually.

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 facility's 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 4.1-1**).

Sampling Frequency and Analysis

During 2015, 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

Tritium was not detected in the samples collected during 2015, and has not been detected in the Building 914 groundwater monitoring wells since 2008 (**Figure 4.1-4**).

4.1.5.3 AGS Building 914 Groundwater Monitoring Program Evaluation

The 2015 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?

The lack of detectable levels of tritium since 2008 indicates 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 2016, the monitoring frequency for the AGS Building 914 area wells will continue to be annually.

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 shielding. 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. 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. 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 this 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 adjacent to the VQ-12 magnet 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 2007a). The monitoring program for the g-2 tritium source area and plume are described in **Section 3.8**.

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, 054-124, 054-125, and 054-126 (**Figure 4.1-1**). These wells are cross gradient of the VQ-12 source area monitoring wells described in **Section 3.8**.

Sampling Frequency and Analysis

During 2015, former g-2 Beam Stop wells 054-67 and 054-125 were monitored once, and the samples were analyzed for tritium. Wells 054-124 and 054-126 were sampled twice for tritium under the g-2 tritium plume source area program (**Table 1-6**).

4.1.6.2 Former g-2 Beam Stop Monitoring Well Results

During 2015, tritium was not detected in any of the wells.

4.1.6.3 Former g-2 Beam Stop Groundwater Monitoring Program Evaluation

The 2015 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?

Although low levels of tritium are occasionally detected in well 054-124, it is likely due to periodic, short-term easterly shift in groundwater flow directions in that area caused by significant water withdrawals from nearby potable water supply well 10. Overall monitoring results for the past fifteen years indicate that the cap over the former beam stop 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 2016, g-2 beam stop area wells 054-67 and 054-125 will continue to be monitored on an annual basis, whereas wells 054-124 and 054-126 will be monitored semiannually under the g-2 tritium plume source area program.

4.1.7 AGS J-10 Beam Stop

In 1998, BNL established a beam stop at the J-10 (12 o'clock) section of the AGS Ring, replacing the E-20 Catcher as the preferred repository for any beam that might be lost in the AGS Ring (**Figure 4.1-1**). 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. A gunite cap was constructed 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 downgradient wells 054-63 and 054-64 (**Figure 4.1-1**).

Sampling Frequency and Analysis

During 2015, the 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

Tritium has not been detected in the J-10 area wells since 2010 (**Figure 4.1-5**).

4.1.7.3 AGS J-10 Beam Stop Monitoring Program Evaluation

The 2015 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?

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) prior to 2010 indicates some water was periodically 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 2016, the J-10 Beam Stop area wells will continue to be sampled on an annual basis.

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 former U-Line target area to evaluate whether residual activated soil shielding was impacting groundwater quality. Low levels of tritium and sodium-22 were detected, but at concentrations well below the applicable DWS. In early 2000, temporary wells were installed 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 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 downgradient of the former U-Line beam stop area (054-128, 054-168, and 054-169) (**Figure 4.1-1**).

Sampling Frequency and Analysis

During 2015, 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

Tritium has not been detected in the former U-Line Target area wells since 2010 (**Figure 4.1-6**).

Former U-Line Beam Stop Area

Tritium has not been detected in the former U-Line Beam Stop area wells since 2011 (**Figure 4.1-7**).

4.1.8.3 Former AGS U-Line Groundwater Monitoring Program Evaluation

The 2015 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?

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. Tritium has not been detected the groundwater downgradient of the former U-Line target since 2010.

4.1.8.4 Former AGS U-Line Recommendation

The following is recommended for the former AGS U-Line groundwater monitoring program:

- For 2016, the former U-Line area wells will continue to be monitored for tritium on an annual basis.

4.2 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 4.2-1**). 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.

4.2.1 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 4.2-1**). As part of BNL's Environmental Surveillance program, surface water samples are also collected semiannually from the Peconic River downstream of the beam stop area at sample location HV (sample location 026-03). 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 2015, 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 discontinued starting 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 at location HV semiannually, and were analyzed for tritium and gamma emitting radionuclides (such as sodium-22).

4.2.2 RHIC Monitoring Well Results

During 2015, 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.

4.2.3 RHIC Groundwater Monitoring Program Evaluation

The 2015 monitoring data were evaluated using the following Data Quality Objective statement.

<u>1. *Has the source of potential contamination been controlled?*</u>
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.

4.2.4 RHIC Recommendation

The following is recommended for the RHIC groundwater monitoring program:

- During 2016, groundwater samples will continue to be collected on a semiannual basis. Surface water samples will also continue to be collected as part of the Environmental Surveillance program.

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4.3 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 fuel was removed in 2003 and the primary cooling water system was drained.

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 temporary 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 using permanent wells was 17,100 pCi/L in October 1999. The tritium 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.

4.3.1 BMRR Groundwater Monitoring

Well Network

The monitoring well network for the BMRR facility consists of one upgradient and three downgradient wells (**Figure 4.3-1**).

Sampling Frequency and Analysis

The BMRR wells are currently sampled once every two years. Samples were collected in 2014, but were not collected during 2015. When collected, samples are analyzed for tritium, gamma emitting radionuclides, gross alpha, and gross beta.

4.3.2 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 4.3-2**). During the 2014 sample period, tritium was detected in downgradient well 084-27, at a concentration of 593 pCi/L. Furthermore, gamma, gross alpha, and gross beta analyses have not indicated the presence of any other reactor-related radionuclides.

4.3.3 BMRR Groundwater Monitoring Program Evaluation

Monitoring data were evaluated using the following Data Quality Objective statement.

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

Tritium concentrations in groundwater downgradient of the BMRR have never exceeded the 20,000 pCi/L DWS. Tritium concentrations were <5,000 pCi/L from September 2000 through 2010, and <600 pCi/L during the 2012 and 2014 sample periods. The continued decrease in tritium concentrations in the groundwater indicate that the BMRR structure is effectively preventing rainwater infiltration into the underlying soils, or that the amount of residual tritium in the vadose zone has been significantly reduced.

4.3.4 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 2016.

4.4 SEWAGE TREATMENT PLANT (STP)

The STP processes sanitary wastewater from BNL research and support facilities. Until October 2014, treated effluent from the STP was discharged to the Peconic River under a NYSDEC SPDES permit (NY-0005835). Treated wastewater from the STP is now released to nearby groundwater recharge basins (SPDES Outfall 001) (**Figure 4.1.1**).

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 was 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; and 4) filtration for final effluent polishing. Oxygen levels are regulated during the treatment process to remove nitrogen biologically, using nitrate-bound oxygen for respiration. The treated water is released to nearby groundwater recharge basins. As required by the NYS SPDES permit, monitoring wells are used to evaluate groundwater quality near the recharge basins.

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 six 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.

4.4.1 STP Groundwater Monitoring

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. One upgradient well (039-87) and six downgradient wells (039-88, 039-89, 039-115, 048-08, 048-09 and 048-10) are used to monitor groundwater quality in the recharge basin area (**Figure 4.4-1**). Monitoring results from three wells (039-88, 039-89, and 039-90) are also used to evaluate groundwater quality in the holding pond area, when necessary.

Sampling Frequency and Analysis

In accordance with the SPDES permit, the STP recharge basin area monitoring wells are sampled annually. Samples were collected in November 2015. As required by the permit, the samples are analyzed for the following metals: copper, iron, lead, nickel, silver, zinc and mercury. During 2015, samples were also analyzed for pesticides (**Table 1-6**).

4.4.2 STP Monitoring Well Results

All metals concentrations, tracked under the SPDES permit were below the applicable AWQS, and no pesticides were detected. As in previous years, sodium was detected at concentrations above the 20 mg/L AWQS in five of STP recharge basin wells, with a maximum concentration of 61 mg/L in well 039-89.

4.4.3 STP Groundwater Monitoring Program Evaluation

The 2015 monitoring data were evaluated using the following Data Quality Objective statement.

1. Are STP operations impacting groundwater quality?

Monitoring results for 2015 continue to indicate that STP operations are not having a significant impact on groundwater quality, and that the BNL administrative and engineered controls continue to be effective.

4.4.4 STP Recommendation

The following is recommended for the STP groundwater monitoring program:

- In accordance with the SPDES permit, the STP groundwater monitoring wells will be sampled once per year (November), and the samples will be analyzed for metals. BNL may conduct additional analyses as part of its facility surveillance program.

4.5 MOTOR POOL MAINTENANCE AREA

The Motor Pool (Building 423) and Site Maintenance facility (Building 326) are attached structures located along West Princeton Avenue (**Figure 4.5-1**). 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.

4.5.1 Motor Pool Maintenance Area Groundwater Monitoring

Well Network

The Motor Pool facility's groundwater monitoring program for the UST area is used 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 4.5-1**). 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 periodically assesses VOC 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 2015, the two UST area wells were monitored annually, 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.

4.5.2 Motor Pool Monitoring Well Results

Underground Storage Tank Area

During 2015, no VOCs were detected in the UST area monitoring wells. As in previous years, no floating product was detected in the wells.

Building 423/326 Area

During 2015, all VOC concentrations were below the 5 µg/L NYS AWQS (**Figure 4.5-2**). The highest VOC concentrations were detected in well 102-13, with TCA at 1.3 µg/L and DCA at 1 µg/L.

4.5.3 Motor Pool Groundwater Monitoring Program Evaluation

The 2015 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?

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. During 2011 through 2015, 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).

4.5.4 Motor Pool Recommendations

The following are recommendations for the Motor Pool area monitoring program for 2016:

- The sampling frequency for the UST area wells 102-05 and 102-06 will continue to be annually.
- Sample wells 102-10, 102-11, 102-12, and 102-13 once during 2016, and discontinue sampling starting in 2017 if VOC levels remain below the AWQS.

4.6 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.

4.6.1 Service Station Groundwater Monitoring

Well Network

The service station's groundwater monitoring program is used 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 4.6-1**).

Sampling Frequency and Analysis

During 2015, the service station facility wells were monitored one time, and the samples were analyzed for VOCs (**Table 1-6**). Three of the wells near the gasoline USTs were also checked for the presence of floating petroleum hydrocarbons.

4.6.2 Service Station Monitoring Well Results

Although low levels of carbon tetrachloride and its breakdown product chloroform continued to be detected in several of the Service Station monitoring wells during 2015, the concentrations were less than the AWQS of 5 μg/L and 7 μg/L, respectively.

Groundwater monitoring conducted over the past 15 years has shown that groundwater water 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. However, unlike previous years, all VOC concentrations were less than the AWQS during 2015. **Figure 4.6-2** provides a summary of VOC concentrations in the Service Station wells since 1999. As in previous years, no floating product was detected in the wells.

4.6.3 Service Station Groundwater Monitoring Program Evaluation

The 2015 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?
During the past two years, all VOC concentrations have declined to less 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.

4.6.4 Service Station Groundwater Monitoring Program Recommendation

No changes to the monitoring program are proposed for 2015.

4.7 MAJOR PETROLEUM FACILITY (MPF)

The MPF is the storage 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. Fuel-unloading operations occur in a 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 FFA (OU IV); 2) a historical fuel/solvent spill discovered in 2013 near MPF storage tank #3; and 3) apparent historical solvent spills near the CSF.

4.7.1 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 4.7-1**).

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 in groundwater. Based upon these factors, the Special License Conditions for the MPF requires semiannual sampling for VOCs and SVOCs and monthly monitoring for floating petroleum (**Table 1-6**).

4.7.2 MPF Monitoring Well Results

During 2015, the MPF wells were monitored monthly for the presence of floating petroleum, and groundwater samples were collected 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. Although low levels of a number of VOCs not associated with fuel storage activities continued to be detected in some of the MPF area wells, during 2015 all VOC concentrations in upgradient and downgradient wells were less than the applicable AWQS (**Figure 4.7-1**).

4.7.3 MPF Groundwater Monitoring Program Evaluation

The 2015 monitoring data were evaluated using the following Data Quality Objective statement.

1. 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. VOCs that are periodically detected in the groundwater are likely to have originated from historical solvent spills near the Central Steam Facility (Building 610). A number of historical spill sites near the CSF were identified during the 1990s, and the contaminated soils were excavated and disposed of in accordance with regulatory requirements.

4.7.4 MPF Recommendation

For 2016, monitoring will continue as required by the NYS operating permit.

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4.8 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 three buildings: the Operations Building, Reclamation Building (for radioactive waste), and the RCRA 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.

4.8.1 WMF Groundwater Monitoring

Well Network

Groundwater quality at the WMF is monitored using six shallow Upper Glacial aquifer wells. Two wells (055-03 and 055-10) are used to monitor background water quality, and four wells monitor groundwater quality downgradient of the two main waste handling and storage facilities. Wells 066-220 and 066-221 are located downgradient of the RCRA Building, and wells 066-222 and 066-223 are located downgradient of the Reclamation Building. BNL discontinued sampling of well 066-224 following the 2012 closure of the former Mixed Waste Building. Locations of the monitoring wells are shown on **Figure 4.8-1**.

Sampling Frequency and Analysis

During 2015, 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 are presented in the *2015 Groundwater Monitoring Report for the Waste Management Facility* (BNL 2016c).

4.8.2 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 detected.

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 both upgradient wells (055-03 and 055-10) at concentrations up to 34 mg/L, and in three of four downgradient wells (066-220, 066-221, and 066-222) at concentrations up to 110 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 are below the applicable AWQS.

4.8.3 WMF Groundwater Monitoring Program Evaluation

The 2015 monitoring data were evaluated using the following Data Quality Objective statement.

1. Are potential sources of contamination within the WMF being controlled?
Groundwater monitoring results for 2015 continued to show that WMF operations are not affecting groundwater quality. Furthermore, there were no outdoor or indoor spills at the facility during 2015 that could have impacted soil or groundwater quality.

4.8.4 WMF Recommendation

The following are recommended for 2016:

- Continue monitoring the wells at a semiannual frequency as required by the RCRA Part B Permit.

4.9 NATIONAL SYNCHROTRON LIGHT SOURCE II (NSLS-II)

The NSLS-II is an electron accelerator that began full-time operations 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 one to five 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.

4.9.1 NSLS-II Groundwater Monitoring

Well Network

Four monitoring wells are located downgradient of the facility's Linac, Booster and Storage Ring area where beam line operations may result in low level activation of the surrounding soil shielding (**Figure 4.9-1**). Two nearby Major Petroleum Facility (MPF) monitoring wells (076-18 and 076-19) are used as upgradient/background wells for the NSLS-II facility. The monitoring network 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 2015, the four NSLS-II monitoring wells and the two MPF wells were sampled one time, and the samples were analyzed for tritium (**Table 1-5**).

4.9.2 NSLS-II Monitoring Well Results

No tritium was detected in the groundwater samples collected during 2015.

4.9.3 NSLS-II Groundwater Monitoring Program Evaluation

The 2015 monitoring data were evaluated using the following Data Quality Objective statement.

<u>*1. Are the engineered and operational controls effective at preventing or reducing the leaching of radionuclides from activated soils to the groundwater?*</u>

Monitoring results for 2015 indicate that NSLS-II beam line operations conducted to date have not impacted groundwater quality.

4.9.4 NSLS-II Recommendations

For 2016, the four NSLS-II and two MPF (background) monitoring wells will continue to be monitored annually for tritium.

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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 Treatment System

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

- Maintain the extraction wells in standby mode. One or both extraction wells can be restarted if TVOC concentrations rebound above capture goals. Continue to analyze the extraction wells quarterly for Sr-90.
- Install permanent monitoring wells at locations GP-42, GP-40, and GP-30 at which the highest Sr-90 concentrations were observed during the 2015/2016 characterization effort. Initially sample these wells at a quarterly frequency. Monitor the downgradient migration of this high concentration area utilizing up to ten temporary wells. This supplemental monitoring will continue through 2021, followed by a comparison of monitoring data to model simulations in order to evaluate the accuracy of the simulations.
- The shutdown of the OU I South Boundary extraction wells will result in an eastward shift in groundwater flow direction back to the regional flow pattern. Install several temporary wells as necessary in the vicinity of Sr-90 sentinel monitoring wells 107-35 and 108-45 to evaluate the resulting shift in the Sr-90 migration path.
- Install a temporary well approximately 100 feet west of monitoring well 098-59 and follow up with a permanent well at that location to monitor VOCs migrating from the Current Landfill (**Appendix H**).
- Samples from 30 monitoring wells are analyzed for tritium. Tritium has not been detected in these wells above 2,000 pCi/L since 2008. It is recommended that the sampling frequency for 18 of the 30 wells currently analyzed for tritium be reduced from semi-annually to annually. The remaining wells are already being sampled annually.
- VOCs have not been detected above 5 *µg/L* since 2008 in monitoring wells 088-26, 098-33, 098-21, 107-23, 107-24, 107-25, 098-30, 099-04, 115-36, 115-03, 115-50, 115-30, and 115-15. It is recommended to discontinue sampling these wells for VOCs.

5.2 Building 96 Treatment 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. Maintain a monthly sampling frequency of the influent and effluent.
- Maintain treatment wells RTW-2, RTW-3, and RTW-4 in standby mode, and maintain a monthly sampling frequency of the influent. Restart the wells if extraction or monitoring well data indicate that TVOC concentrations exceed 50 µg/L.
- Continue to maintain the RTW-1 resin treatment in standby mode, and if concentrations of hexavalent chromium in the effluent increase to over 50 µg/L (an administrative limit established that is half of the SPDES limit of 100 µg/L), treatment would resume. The maximum hexavalent chromium detected in the effluent in 2015 was 6.5 µg/L.

- Install temporary well(s) just west of monitoring well 095-312 to evaluate the extent of VOC concentrations in Geoprobe B96-GP-01-2016.

5.3 452 Freon-11 Source Area and Groundwater Plume

The following are recommendations for the Building 452 Freon-11 remediation system and monitoring program:

- As defined in the approved Petition for Shutdown for the Building 452 Freon-11 Treatment System, maintain the treatment system in standby mode. Maintain Building 96 treatment well RTW-1 in full-time operation to control the downgradient migration of the remaining plume.
- Reduce the sampling frequency for the groundwater monitoring wells and EW-18 from quarterly to semiannually for the remainder for the shutdown period.

5.4 Middle Road Treatment System Building

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

- Maintain extraction wells RW-1, RW-4, RW-5 and RW-6 in standby mode. Restart the well(s) if extraction or monitoring well data indicate that TVOC concentrations exceed the 50 µg/L capture goal.
- Continue operation of RW-2, RW-3 and RW-7.
- Discontinue sampling of monitoring well 113-06 as this well has not shown VOCs above AWQS since 1997.

5.5 OU III South Boundary Treatment System

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

- Maintain wells EW-3, EW-5, 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.
- Continue to operate wells EW-4 and EW-17 on a full time basis.
- Maintain the routine O&M monitoring frequency implemented last year.
- Stop sampling shallow monitoring wells 121-09, 121-22, 121-13. Well 121-09 has never exceeded the MCL since its installation in 1997. VOCs in well 121-13 have been below MCL's since 2006 and well 121-22 has been below MCLs since 1998. These wells are shallower than the depth of this plume and are no longer providing useful information.

5.6 Western South Boundary Treatment 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.
- Based on the low TVOC concentrations below the capture goal of 20 µg/L, shut down extraction well WSB-2. If TVOC concentrations greater than 20 µg/L are observed in WSB-2 or the adjacent core monitoring wells, extraction well WSB-2 may be put into full time operation.

- As a follow-up to the February 2016 characterization, install additional temporary and permanent monitoring wells to define the width and extent of the higher VOCs between monitoring wells 103-15 and 119-10.
- Following the characterization, perform an update to the groundwater model to determine the downgradient migration and attenuation of the VOCs to the DWS.
- Maintain the routine O&M monitoring frequency for the monitoring wells.

5.7 Industrial Park Treatment System

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

- Continue operation of the two new extraction wells IP-EW8 and IP-EW9.
- Continue to operate pumping wells UVB-3,UVB-4, UVB-5 and UVB-6. If TVOC concentrations drop below the capture goal in the adjacent monitoring wells these wells may be shut down.
- Wells UVB-1, UVB-2 and UVB-7 should remain in standby.
- Discontinue sampling of monitoring wells 000-260, 000-257, 000-263, 000-266, 000-269, as these wells have all had concentrations below AWQS for over ten years and are screened shallower then the plume that is associated with this project.

5.8 Industrial Park East Treatment System

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

- Continue monitoring wells 000-494, 000-526, 000427, and 000-429 for VOCs in accordance with the post closure monitoring requirements.
- Discontinue sampling wells 000-211, 000-426, 000-490, 000-492, 000-495, 122-24, and 122-25. Rationale is presented in **Table 3.2.7-1**.

5.9 North Street Treatment System

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

- Based upon the continued analysis showing well 000-465 below the capture goal of 50 µg/L in November 2015 and February 2016 shutdown well NS-1. If concentrations in any core monitoring wells increase to over the 50 µg/L capture goal, the extraction well(s) may be restarted.
- Continue the current groundwater monitoring well schedule for the North Street system.

5.10 North Street East Treatment System

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

- Maintain the treatment system in standby mode. The extraction wells will continue to be sampled on a quarterly basis. One or both extraction wells can be restarted if TVOC concentrations in the core monitoring wells or extraction wells rebound to concentrations above the capture goal of 50 µg/L.
- The following actions will be implemented in response to the EDB detection in well 000-394:
    - Continue to implement the Groundwater Contingency Plan.

- Begin sampling well 000-394 quarterly for EDB using Method 504 in 2016.
- Continue sampling well 000-394 annually for VOCs using Method 524.2
- Obtain one round of samples from NSE monitoring wells 000-138, 000-477, 000-478, 000-479, 000-480, 000-481, 000-484 and analyze for EDB using Method 504.
- Continue to evaluate the monitoring data and recommend any follow up actions including the restart and temporary operation of extraction well NSE-1.

5.11 LIPA/Airport Treatment System

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

- Continue the Airport extraction wells pulsed 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 TVOC 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.
- 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. Continue operation of Magothy well EW-4L, if no rebound in concentrations for well EW-4L are observed in 2016 shut down this extraction well in 2017.
- Stop pulse pumping and shutdown Well RTW-5A in August 2016 as based upon the plume configuration and monitoring data concentrations are well below the 10 µg/L capture goal in this area.

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 Middle Road, LIPA/Airport and new IP wells. The North Street, North Street East and South Boundary Magothy extraction wells are currently in standby as they have reached the OU III cleanup goals identified for shutdown of these wells. The IPE extraction well was abandoned as it had reached its cleanup goal.
- Discontinue sampling of wells identified in S**ection 3.2.8** associated with the Industrial Park East groundwater monitoring program.

5.13 Central Monitoring

The following change is recommended for the OU III Central Monitoring Program:

- Since the MCLs have been achieved, discontinue sampling for VOCs in all wells except for wells 109-03 and 109-04. Wells 109-03 and 109-04 serve as SCWA William Floyd Parkway Well Field sentinel wells and monitoring of these wells will continue.

5.14 Off-Site Monitoring

The following change is recommended for the OU III Off-Site Monitoring Program:

- Since the MCLs have been achieved, discontinue sampling for VOCs in all wells.

5.15 South Boundary Radionuclide Monitoring Program

The following change is recommended to the South Boundary Radionuclide Groundwater Monitoring Program:

- Since there have never been any confirmed detections of tritium in wells 099-11, 100-12, and 100-13 since they were installed in 1997, it is recommended that monitoring for tritium be discontinued in these wells.

5.16 BGRR/WCF Strontium-90 Treatment System

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

- Continue to monitor source area Sr-90 concentrations on a monthly basis immediately downgradient of the BGRR.
- Maintain the sampling frequency for BGRR cap monitoring wells 075-699 and 075-700 at semi-annual due to elevated Sr-90 concentrations from 2012-2014.
- Characterize the Sr-90 concentrations along Temple Avenue immediately south of the HFBR Building using several temporary wells.
- Install temporary wells as needed to fill in data gaps and characterize the BGRR Sr-90 plume segment south of Cornell Avenue and just to the north of Building 725.
- Continue operating wells SR-1, SR-2, SR-3, SR-7, SR-8, and SR-9 in full time mode.
- Due to low Sr-90 concentrations in BGRR extraction well SR-6, continue this well in a pulsed pumping mode (one month on and one month off).
- Place BGRR extraction wells SR-4 and SR-5 in standby due to low concentrations and the cutting off of the plume to the north by SR-3.
- Discontinue sampling monitoring wells 065-173, 065-18, 065-19, 065-20, 065-165, 065-166, 065-167, 065-171, 065-40, 065-172, 075-188, 075-667, 075-668, 075-680, 075-663, 075-09, 075-10, 075-190, 075-191, 075-192, 075-202, 075-203, 075-195, 075-196, 075-197, 075-198, 075-199, and 075-200. There have been no detections greater than 3 pCi/L in any of these wells since 2009. The eastward shift of the plume since these wells were installed has resulted in their locations not being optimal to monitor segments of the Sr-90 plumes. Utilize temporary wells as needed.
- Install temporary wells as needed to evaluate whether the BGRR cap monitoring wells have been impacted by a shift in groundwater flow direction.
- Maintain well 065-175 semi-annual sampling frequency to monitor for Sr-90 migrating south from the WCF yard.

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 well EW-1 in full time mode.
- Due to low Sr-90 concentrations in the extraction wells and adjacent monitoring wells, shut down EW-2 and EW-3 and place in standby mode. If significant rebound is identified, these extraction wells may be restarted.

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:

- The extraction wells remain in standby mode. One or more extraction wells can be restarted if tritium concentrations in the extraction wells rebound to concentrations above 20,000 pCi/L.

5.19 Building 650 (Sump Outfall) Strontium-90 Monitoring

The following is recommended for the Building 650 and Sump Outfall Strontium-90 Monitoring Program:

- Continue the current monitoring frequency stated in **Table 1-5,** including quarterly monitoring for well 076-13.

5.20 Operable Unit V

Based on the recommendation in the *2013 Groundwater Status Report*, sampling of well 000-122 was discontinued. This completed the groundwater sampling requirements for OU V.

5.21 Operable Unit VI EDB Treatment System

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

- Maintain operation of the treatment system.
- Since there have been no detections of EDB or other compounds above the DWS or AWQS since 2003, it is recommended that sampling of upgradient monitoring wells 099-11, 100-12, and 100-13 for VOCs be discontinued.

5.22 Site Background Monitoring

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

5.23 Current Landfill Groundwater Monitoring

Due to the consistent elevated levels of chloroethane in monitoring well 088-109, temporary wells were drilled in early 2016, north and south of this location to determine the extent and maximum chloroethane concentrations. Results of this investigation are discussed in **Section 3.1.4**.

5.24 Former Landfill Groundwater Monitoring

The following change is recommended for the Former Landfill Areas monitoring well network:

- Since iron results have returned to background levels in 2014 and 2015, metals sampling in well 106-02 should be reduced to once every two years, making it consistent with the monitoring requirements of the remaining wells in this program.

5.25 g-2 Tritium Source Area and Groundwater Plume

The following are recommended for the g-2 tritium source area and plume groundwater monitoring program:

- The groundwater monitoring program for the g-2 source area is adequate at this time, and no changes are required.
- Because tritium concentrations in the g-2 plume segment south of Brookhaven Avenue have decreased to less than the 20,000 pCi/L DWS, discontinue monitoring the remnants of this plume.

5.26 Brookhaven Linac Isotope Producer (BLIP) Facility

The groundwater monitoring well network is adequate at this time, and no changes are required.

5.27 Alternating Gradient Synchrotron (AGS) Complex

The groundwater monitoring program is adequate at this time, and no changes are required.

5.28 Relativistic Heavy Ion Collider (RHIC) Facility

The groundwater monitoring program is adequate at this time, and no changes are required.

5.29 Brookhaven Medical Research Reactor (BMRR) Facility

The groundwater monitoring program is adequate at this time, and no changes are required.

5.30 Sewage Treatment Plant (STP) Facility

The groundwater monitoring program is adequate at this time, and no changes are required.

5.31 Motor Pool Maintenance Area

The following are recommended for the Motor Pool monitoring program:

- The groundwater monitoring program for the UST area is adequate at this time, and no changes are required.
- Because VOC concentrations in the area downgradient of Building 423/326 have been below NYS AWQS for the past two years, discontinuing the monitoring program after 2016 if VOC concentration remain below the NYS AWQS.

5.32 On-Site Service Station

The groundwater monitoring program is adequate at this time, and no changes are required.

5.33 Major Petroleum Facility (MPF) Area

The groundwater monitoring program is adequate at this time, and no changes are required.

5.34 Waste Management Facility (WMF)

The groundwater monitoring program is adequate at this time, and no changes are required.

5.35 National Synchrotron Light Source II (NSLS-II)

The groundwater monitoring program is adequate at this time, and no changes are required.

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