BROOKHAVEN NATIONAL LABORATORY

2017

Site Environmental Report

GROUNDWATER STATUS REPORT

VOLUME II

2017
SITE ENVIRONMENTAL REPORT
VOLUME II
GROUNDWATER STATUS REPORT

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Environmental Protection Division
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Acronyms and Abbreviations

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

AGS	Alternating Gradient Synchrotron
AOC	Area of Concern
AS/SVE	Air Sparge/Soil Vapor Extraction
AWQS	NYS Ambient Water Quality Standards
BGD	Below Ground Ducts
BGRR	Brookhaven Graphite Research Reactor
BLIP	Brookhaven Linac Isotope Producer
bls	below land surface
BMRR	Brookhaven Medical Research Reactor
BNL	Brookhaven National Laboratory
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
cfm	cubic feet per minute
CFR	Code of Federal Regulations
Ci	curies
COC	Chain of Custody
Co-60	cobalt-60
CRDL	Contract Required Detection Limit
CSF	Central Steam Facility
DCA	1,1-dichloroethane
DCE	1,1-dichloroethylene
DCG	Derived Concentration Guide
DAR	Division of Air Resources
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
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
Freon-11	Trichlorofluoromethane
Freon-12	Dichlorodifluoromethane
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
IPE	Industrial Park East
lb/gal	pounds per gallon
lb/hr	pounds per hour
lbs	pounds
LIE	Long Island Expressway
Linac	Linear Accelerator
LIPA	Long Island Power Authority
LISF	Long Island Solar Farm
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
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
Na-22	Sodium-22
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
WSB	Western South Boundary

2017 BROOKHAVEN NATIONAL LABORATORY

GROUNDWATER STATUS REPORT

Executive Summary

The *2017 BNL Groundwater Status Report* is a comprehensive summary of data collected during the 2017 calendar year supplemented with relevant investigation data collected during the first quarter 2018, and an evaluation of Groundwater Protection Program performance. This is the twenty second 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 2017, nine volatile organic compound (VOC) groundwater remediation systems were in operation, along with two strontium-90 (Sr-90) treatment systems. In 2017, 71 pounds of VOCs were removed from the Upper Glacial and Magothy aquifers by the treatment systems. To date, 7,526 pounds of VOCs have been removed from the aquifers. The Sr-90 treatment systems removed 0.51 milliCuries (mCi) of Sr-90 from the Upper Glacial aquifer in 2017, for a total of 32.23 mCi since operations began. Approximately 0.9 billion gallons of groundwater were treated (**Table E-1**).

There were 558 monitoring wells were sampled as part of the CERCLA Groundwater Monitoring Program, comprising a total of 1,309 groundwater samples. In 2017, 27 temporary wells were also installed and sampled. Groundwater remediation activities 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 – 2017.

	1997 – 2016		2017	
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	(Shutdown) 0	0
OU III Carbon Tetrachloride (Oct. 1999) (e)	153,538,075	349	Decommissioned	0
OU III Building 96 (Feb. 2001)	463,688,416	140	15,008,540	1
OU III Building 452 Freon-11 (March 2012)	118,521,000	105	6,476,400	1
OU III Middle Road (Oct. 2001)	3,097,517,790	1,195	179,029,460	34
OU III South Boundary (June 1997)	4,934,766,950	3,027	72,384,330	14
OU III W. South Boundary (Sept. 2002)	1,587,387,000	135	104,668,000	5
OU III Industrial Park (Sept. 1999)	2,362,923,330	1,071	116,738,200	3
OU III Industrial Park East (May 2004)(f)	357,192,000	38	Decommissioned	0
OU III North Street (June 2004)	1,680,942,000	342	(Shutdown) 0	0
OU III North Street East (June 2004)	1,009,798,000	44	(Shutdown) 0	0
OU III LIPA/Airport (June 2004)	2,924,751,240	425	196,393,810	13
OU III HFBR Tritium Plume (May 1997) (a)	721,795,000	180	(Shutdown) 0	0
OU IV AS/SVE (Nov. 1997)	NA (b)	35	Decommissioned	0
OU VI EDB (August 2004)	1,936,811,300	NA(d)	170,246,000	NA (d)
Totals	25,527,105,101	7,455	860,944,740	71

	2003 – 2016		2017	
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)	63,387,436	4.92	1,575,120	0.013
OU III BGRR (June 2005)	126,427,800	26.8	23,375,000	0.5
Totals	189,815,236	31.72	24,950,120	0.513

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 2017, are summarized on **Figures E-1** and **E-2**, respectively. The water table elevation was relatively stable during 2017 and remained close to historically low levels. The impact of this low water table condition on source area contaminant concentrations including the BGRR, WCF, Building 96 and former HWMF where a flushing effect has been observed in the past is unclear. These areas will be monitored closely when water table elevations return towards more normal levels. The water table has responded to above normal precipitation during the first quarter of 2018 and increased by nearly three feet in elevation.

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 2017, 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.

GROUNDWATER STATUS REPORT RECOMMENDATION HIGHLIGHTS

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

- **OU I South Boundary Treatment System** –
    - There has been no significant rebound in VOC concentrations since system shutdown in 2013. Any remaining VOC concentrations in area monitoring wells are very low and are either approaching or below DWS. A petition to decommission the OU I South Boundary Treatment System is being submitted to the regulators in 2018.
    - Continue to monitor the leading edge of the Sr-90 plume for an eastward shift due to the change in groundwater flow direction back to the regional flow pattern. This resulted from the shutdown of the OU I South Boundary extraction wells. 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.
- **OU III Building 96 Treatment System –**
    - VOC concentrations remain elevated in source area groundwater. Since elevated PCE concentrations were identified in soil gas monitoring well 085-359 in 2017, perform a soil vapor extraction pilot study to evaluate the effectiveness of reducing the persistent contamination in the former source area.
    - Modify the pumping rate to expand the capture zone of RTW-1 to ensure that VOCs in well 095-159 are being fully captured. Submit modified SPDES Equivalency Permit request to NYSDEC for an increase in the maximum flow rate.
    - Install a temporary well at the location of B96-GP02-2018 to determine the vertical extent of the VOCs observed in the deepest samples in this temporary well.

- **452 Freon-11 Source Area and Groundwater Plume**
  - Maintain the Building 452 Treatment System in standby mode for one more year. If there isn't a rebound in Freon-11 concentrations, with concentrations exceeding 50 µg/L, prepare a Petition for Closure by 2019. It is anticipated that the Building 96 treatment well RTW-1 will remain in full-time operation for several more years.
- **OU III Middle Road Treatment System –**
  - Persistent elevated VOC concentrations have been observed in the deep Upper Glacial aquifer for several years in well 104-37. Install temporary vertical profile wells as necessary to define the upgradient extent of these VOCs.
- **OU III South Boundary Treatment System –**
  - VOC concentrations have persisted at higher than expected levels in the area between RW-7 and well 121-54 and may impact the pumping duration of EW-17. Install a vertical profile between to evaluate persistently high VOC concentrations in this area.
- **OU III Western South Boundary Treatment System –**
  - Submit a system modification request to the regulators. Complete the design and construction of four new extraction wells and associated modifications to the treatment system to allow for the capture and treatment of deeper VOCs and the ability to meet the OU III ROD cleanup goals.
- **OU III Industrial Park Treatment System –**
  - Despite the high VOC concentrations observed several years ago in monitoring well 000-528, there has been no evidence of these higher concentrations in downgradient monitoring. Install a vertical profile well between wells 000-529 and 000-541 to look for the higher concentrations observed previously in well 000-528. If concentrations from the vertical profile well are low, evaluate shut down of extraction wells EW-8 and EW-9 in 2019.
- **OU III Industrial Park East Treatment System –**
  - In accordance with the *2013 Petition for Closure of the Industrial Park East Groundwater Treatment System* and the *2016 Groundwater Status Report*, since monitoring wells 000-494, 000-526, 000-427, and 000-429 have been below the AWQS for a minimum of four consecutive sampling events, further monitoring will be discontinued.
- **OU III North Street Treatment System –**
  - Extraction wells NS-1 and NS-2 will remain in standby. If concentrations remain below the capture goal through 2018 a Petition for Closure will be submitted in 2019.
- **OU III North Street East Treatment System –**
  - Continue the characterization of the extent of EDB observed in well 000-394. Upon completion of characterization determine the feasibility of achieving the OU III ROD cleanup goals by performing updated model simulations.
- **BGRR/WCF Sr-90 Treatment System –**
  - Place extraction wells SR-3 and SR-7 in standby mode based on low Sr-90 concentrations. Place SR-8 in pulsed pumping mode (one month on and one month off) based on low Sr-90 concentrations.

- Supplement the current monitoring network with temporary well data in order to get a comprehensive status of the plumes and account for well network gaps and groundwater flow related plume shifts.

- **Chemical/Animal Holes Sr-90 Treatment System –**
  - A petition for shutdown of this system has been submitted to the regulators. Until regulatory approval of the petition, continue to operate extraction well EW-1 in pulsed pumping mode (one month on and one month off) and maintain EW-2 and EW-3 in standby. If significant rebound is identified, these extraction wells may be restarted.
- **HFBR Tritium Pump and Recharge System –**
  - Based on the attenuation of the downgradient portion of the plume to barely detectable levels over the past several years, a petition for closure was submitted to the regulators in June 2018.
  - Source area monitoring of the plume will be the most effective means of tracking any future tritium releases to groundwater given the attenuation of the downgradient segment. Seven new permanent monitoring wells will be installed on the lawn of the HFBR at approximate 30-foot intervals to continue to assess the decreasing levels and inventory of tritium beneath the HFBR that is affected by the water table flushing. The wells will be positioned in an east-west line perpendicular to groundwater flow immediately south of the HFBR. This array will account for expected fluctuations in groundwater flow directions.
  - 55 monitoring and four extraction wells are proposed for abandonment/ decommissioning in the petition for closure.
- **Building 650 (Sump Outfall) Strontium-90 Monitoring –**
  - Install up to eight temporary wells to verify whether there has been any southeast shift of the plume due to changes in groundwater flow direction in the area.
- **Operable Unit VI EDB Treatment System –**
  - A data gap exists upgradient of well 000-507. Install two vertical profiles and a monitoring well to the west of well 000-178. This information will assist in evaluating the operational duration of extraction well EW-1E. Update the groundwater model based on the analytical results.
- **Miscellaneous Groundwater Monitoring –**
  - Following a request from NYSDEC, a sampling event for 1,4-dioxane of 22 monitoring wells on and off of BNL property that have or had detected TCA was performed in January 2017. Sample results showed that 1,4-dioxane was detected in 17 of the 22 groundwater-monitoring wells sampled, at levels below the current NY State unspecified organic contaminant groundwater water standard of 50 µg/L. After reviewing these results, the SCDHS requested further sampling to obtain additional data on the distribution of 1,4-dioxane at BNL. SCDHS requested that samples be collected from treatment system effluent, the STP, and monitoring wells downgradient from the Former Landfill, the Current Landfill and the STP. Therefore, samples from seven additional monitoring wells, the effluent from five treatment systems and the STP were analyzed for 1,4-dioxane in December 2017 and January 2018. During the December 2017 sampling event, five of the seven monitoring wells and four of the six effluent samples detected 1,4-dioxane. All detections were below the current standard

of 50 µg/L. NYSDEC has stated that the State is evaluating a new and lower groundwater standard for 1,4-dioxane.

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 2017, groundwater samples were collected from 93 wells during 121 individual sampling events.

Highlights of the Facility Monitoring Program are as follows:

- Monitoring conducted during 2017 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 five support facilities (Sewage Treatment Plant, Waste Management Facility, Major Petroleum Facility, Upton Service Station, and Motor Pool) has not identified any new impacts to groundwater quality.
- Following the November 2017 reactivation of the Building 452 Freon-11 Treatment System due to a rebound in Freon-11 concentrations, the system was placed back into standby mode in March 2017.
- During 2017, tritium continued to be detected in g-2 source area monitoring wells at concentrations above the 20,000 pCi/L drinking water standard (DWS), with a maximum concentration of 33,200 pCi/L.

- Per-fluorinated Compounds (PFCs) are emerging contaminants of concern in groundwater, and were recently tested for in BNL potable water supply wells under the Third Unregulated Contaminant Monitoring Rule (UCMR3) program. During 2017, PFCs were detected in water samples collected by the SCDHS from BNL potable supply wells 6, 10 and 11. The maximum combined concentrations of the chemicals perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA), was 24.26 ng/L in the August 2017 sample from supply well 10. The EPA Health Advisory Level (HAL) for combined PFOS and PFOA concentrations is 70 ng/L.

  The use of fire suppression foam has been linked to a number of PFC groundwater plumes recently discovered on Long Island. Based upon historical records and employee recollections there are a number of areas where firefighting foam may have been released to the environment at BNL. However, documentation on the chemical formulations for the foam is not available. In 2018, BNL will install temporary Geoprobe wells to characterize the distribution of PFCs in groundwater within the 2-year source water contributing areas of BNL potable supply wells. Furthermore, quarterly PFC analyses will be added to the BNL potable well monitoring program.

Table E-2.
Groundwater Restoration Progress.

Project	Target	Mode	Treatment Type	Expected System Shutdown	Highlights
OU I					
OU I South Boundary (RA V)	VOCs	Standby	Pump and Treat (P&T) with Air Stripping (AS)	2013 (Actual)	No rebound in VOC concentrations has been observed. Petition for Closure being submitted in 2018.
Current Landfill	VOCs tritium	Long Term Monitoring & Maintenance	Landfill capping	NA	Remaining issue is periodic VOC increases in monitoring well 088-110 adjacent to the landfill.
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	Continue to monitor a plume of elevated Sr-90 concentrations.
OU III					
Chemical/Animal Holes	Sr-90	Operational (EW-1 pulsed pumping)	P&T with ion exchange (IE)	2018	Petition for Shutdown is awaiting regulatory approval.
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.	2020	Monitoring persistent elevated PCE concentrations in monitoring wells immediately downgradient of source area. SVE pilot test to be done in 2018.
Building 452	VOCs (Freon-11)	Standby	P&T with AS	2017 (Actual)	After being reactivated for a period of five months starting in November 2016, the system was placed back into standby mode in March 2017. The system has effectively remediated the plume.
South Boundary	VOCs	Operational (EW-6, EW-7, EW-8 and EW-12 on standby)	P&T with AS	2021	Extraction well EW-17 is capturing and treating deep VOCs at site boundary.
Middle Road	VOCs	Operational (RW-4, RW-5, and RW-6 on standby)	P&T with AS	2025	Monitoring persistent elevated deep VOCs near Princeton Avenue. System is effectively capturing and treating 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	2026	Groundwater characterization in 2016/2017 resulted in the detection of a deeper area of elevated VOCs which has now been tracked south of the site boundary. Four new extraction wells planned in 2018.
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	Monitoring well concentrations show a gradual reduction in VOCs during 2017.
Industrial Park East	VOCs	Decommissi-oned	P&T with carbon	2009 (Actual)	Treatment system was decommissioned in 2014.
North Street	VOCs	Standby	P&T with carbon	2013 (Actual)	VOC concentrations remained below capture goal in 2017.
North Street East	VOCs	Standby	P&T with carbon	2014 (Actual)	Extraction wells on standby (System Shutdown). Characterizing in 2018, elevated EDB observed in well 000-394.
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	2017 LIPA (Actual) 2026 Airport	Increasing TVOC concentrations in LIPA wells EW-1L and EW-2L however both remain below capture goal of 50 µg/L. Persistently elevated VOC concentrations in wells 800-94 and 800-95 may impact system shutdown.
HFBR Tritium	Tritium	Standby	Pump and recharge	2012 (Actual)	Source and downgradient area tritium concentrations remain low. Submitting petition for closure in 2018.
BGRR/Waste Concentration Facility (WCF)	Sr-90	Operational (Pulsed Sr-4, Sr-5, and Sr-6)	P&T with IE	2026	Characterization of the plume will be supplemented with temporary wells.
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 attenuate. Monitor east shift in groundwater flow directions in this area due to changes in on-site pumping and recharge.
OU V					
STP	VOCs, tritium	Completed	MNA	NA	Monitoring completed in 2014.

continued

Project	Target	Mode	Treatment Type	Expected System Shutdown	Highlights
OU VI					
Ethylene Dibromide (EDB)	EDB	Operational	P&T with carbon	2021	The 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.
BLIP Tritium Plume	Tritium	Long Term Monitoring & Maintenance	MNA	NA	Tritium concentrations continue to be less than DWS.

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1.0 INTRODUCTION AND OBJECTIVES

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

- Pollution prevention–preventing the potential pollution of groundwater at the source
- Restoration–restoring groundwater that 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 2017 Groundwater Status Report* is a comprehensive summary of groundwater data collected in calendar year 2017 that provides an interpretation of information on the performance of the Groundwater Protection Program. This is the 22nd 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 2017, 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 2017. 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 3,000 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 2017 Environmental Monitoring Plan* (BNL 2017a). 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 2017 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 2017 Environmental Monitoring Plan (BNL 2017a).*

Modifications are implemented to specific wells to adjust sample frequencies or parameters in order to account for changing conditions or unexpected results. These modifications may temporarily alter the monitoring of a well from specifications associated with the general phase of monitoring stated for that well.

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
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

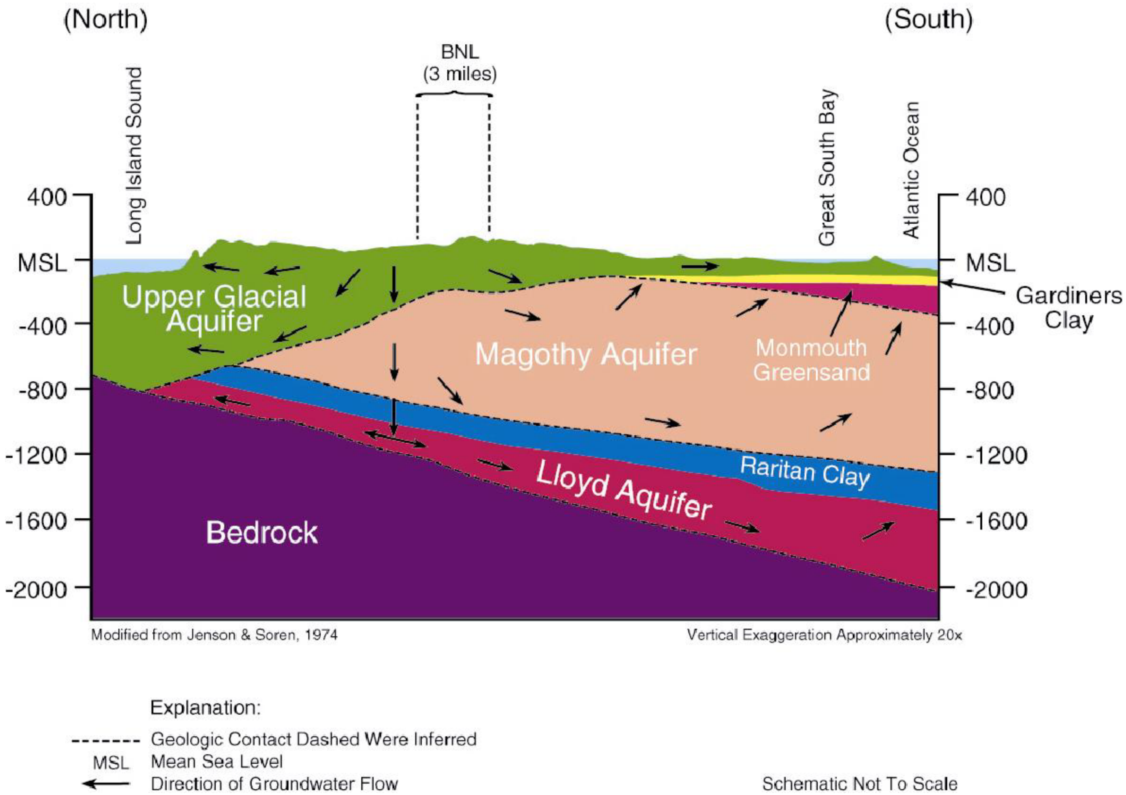
During 2017, there were seven known homeowners in the residential area overlying the plumes who continue to use their private wells for drinking water purposes. In accordance with the OU III and OU VI RODs, DOE formally offers these homeowners free testing of their private drinking water wells on an annual basis. SCDHS coordinates and performs the sampling and analysis. During 2017, 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 2017, 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 2017 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 was conducted during November 27 – December 1, 2017 using approximately 750 on-site and off-site 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**.

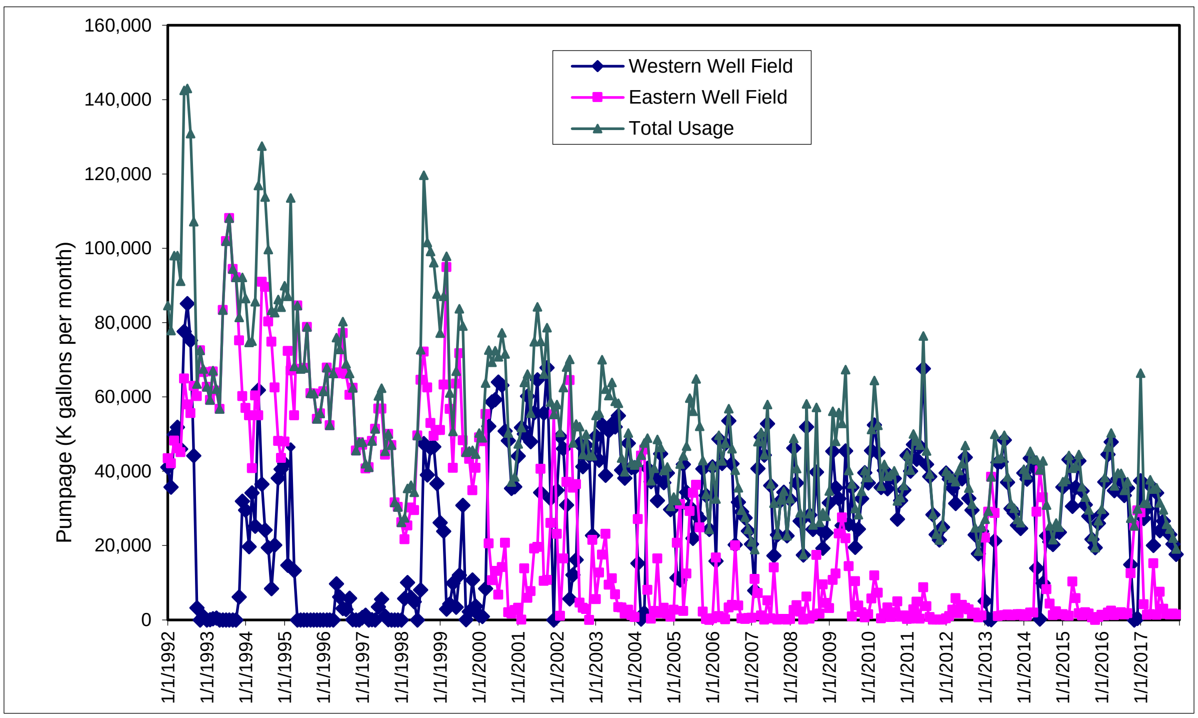
2.1.2 Pumpage of On-Site Water Supply and Remediation Wells

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 2017, 15 of the 64 treatment wells were in full time operation, 8 treatment wells were in pulsed pumping operation and 41 treatment 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 2017 for 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. Pumpage from supply well 10 has been limited since 2000 due to the impacts it might have on contaminant plume flow directions in the central portion of the site (specifically on the Waste Concentration Facility Sr-90 plume). However, with the loss of well 12, well 10 is used for short periods of time.

The water supply operating protocols have been established by the BNL Water and Sanitary Planning Team to minimize pumping induced changes in groundwater flow directions. Under this protocol, the goal is to have the western well field provide 75 percent or more of the site-wide water supply. Water from these wells has naturally high levels of iron, and must be treated before distribution. **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 2017.



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 2017, a total of 390 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 82 percent of the water for 2017. **Table 2-2** summarizes the 2017 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

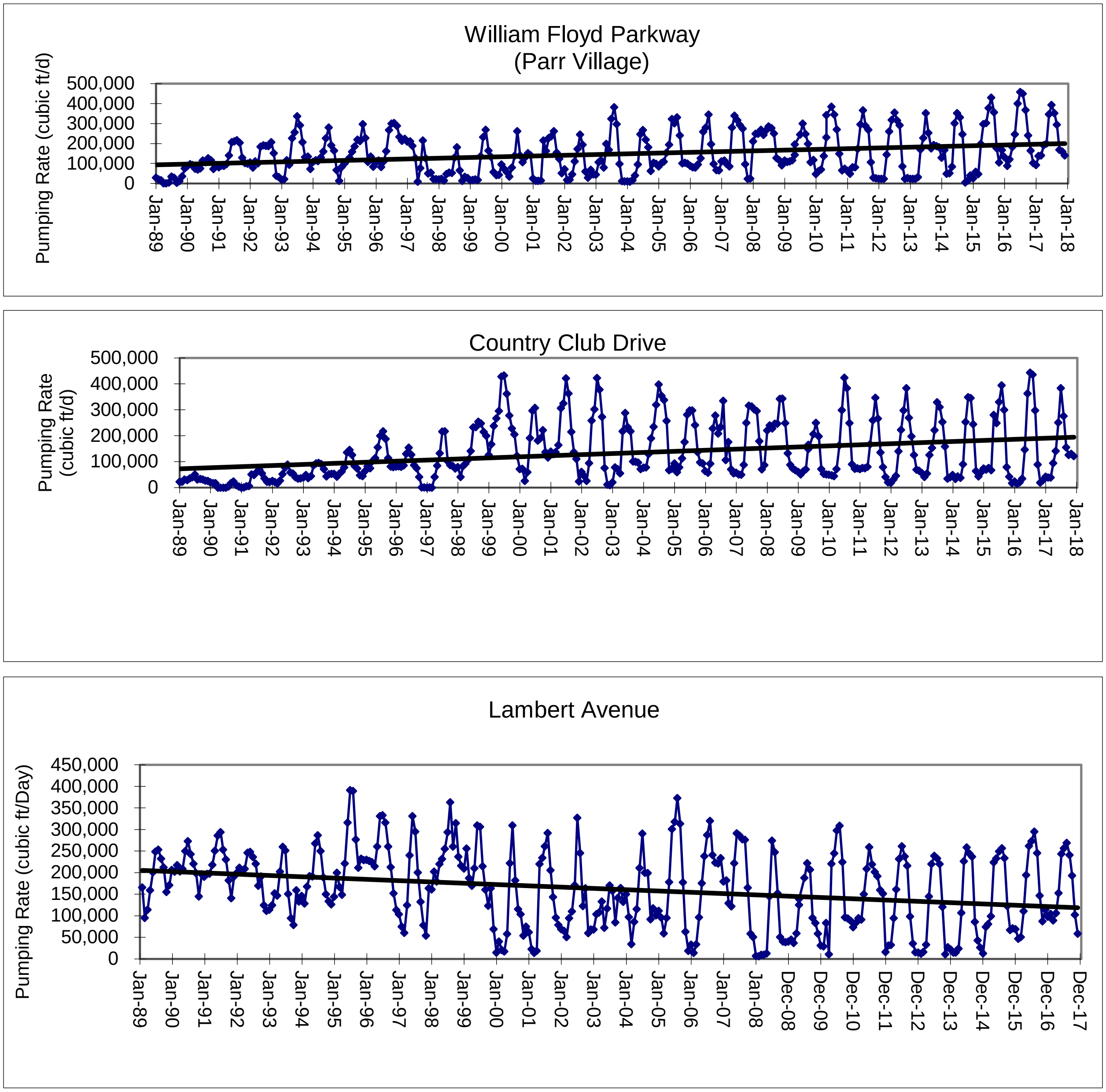
Several Suffolk County Water Authority (SCWA) well fields are located near BNL. The William Floyd Parkway Well Field is west/southwest of BNL (**Figures 2-2 and 2-3**), and consists of three water supply wells that withdraw groundwater from the mid Upper Glacial aquifer and the upper portion of the Magothy 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 2017 is provided as **Figure 2-5.** In 2017, the William Floyd Parkway (Parr Village) and Country Club Drive Well Fields produced 595 and 412 million gallons for the year, respectively. The Lambert Avenue Well Field, located south of BNL, has two wells that produced 437 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 2017. 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. Details on the SPDES program are provided 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, treated 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 demonstrated that this effort was successful for several years. However with additional reductions in water discharged from the OU III Treatment System, the groundwater flow direction in the Building 650 area have shifted more to the southeast over the past several years (**Figure 2-2** and **Figure 2-6**). **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 contributed to localized mounding of the water table caused by shallow clay and silt deposits. 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. 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 located along the eastern portion of the plant. Because the recharge basins are located in an area containing highly permeable soils, these discharges are not causing significant mounding of the water table below the recharge basins. A groundwater mound is still present in the former filter beds due to persistent perched water table conditions resulting from near surface clay and silt deposits.

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 2017, it is estimated that the recharge at BNL was approximately 25 inches. **Table 2-4** summarizes monthly and annual precipitation results from 1949 to 2017 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 2017 was 50.35 inches, which was above the long-term yearly average of 48.70 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 November 27 - December 1, 2017. 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 2017 was generally 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 generally been effective in maintaining a more stable south-southeast groundwater flow direction in the central portion of the site.

In addition to pumping induced cones of depression near groundwater supply and remediation wells, 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**. Groundwater mounding is also evident at the Sewage Treatment Plant, and is a result of perched water table conditions resulting from near surface clay and silt deposits.

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 November 27 - December 1, 2017. 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 2017 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 because the mounding is controlled by shallow, near-surface clay and silt deposits. 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 1950–2017) 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. Since 2010, when water levels at BNL reached the highest level on record, a nearly 10 foot variation in water table elevations has been observed. 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 of the Upper Glacial aquifer is estimated to be approximately 0.75 ft/day, but velocities can be lower in some portions of the deep Upper Glacial aquifer where finer-grained sands are present. 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

During 2017, a number of new permanent monitoring wells and temporary vertical profile wells were drilled for the Western South Boundary plume characterization effort. The geologic information obtained during their installation was incorporated into Western South Boundary cross section.

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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 2017. 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

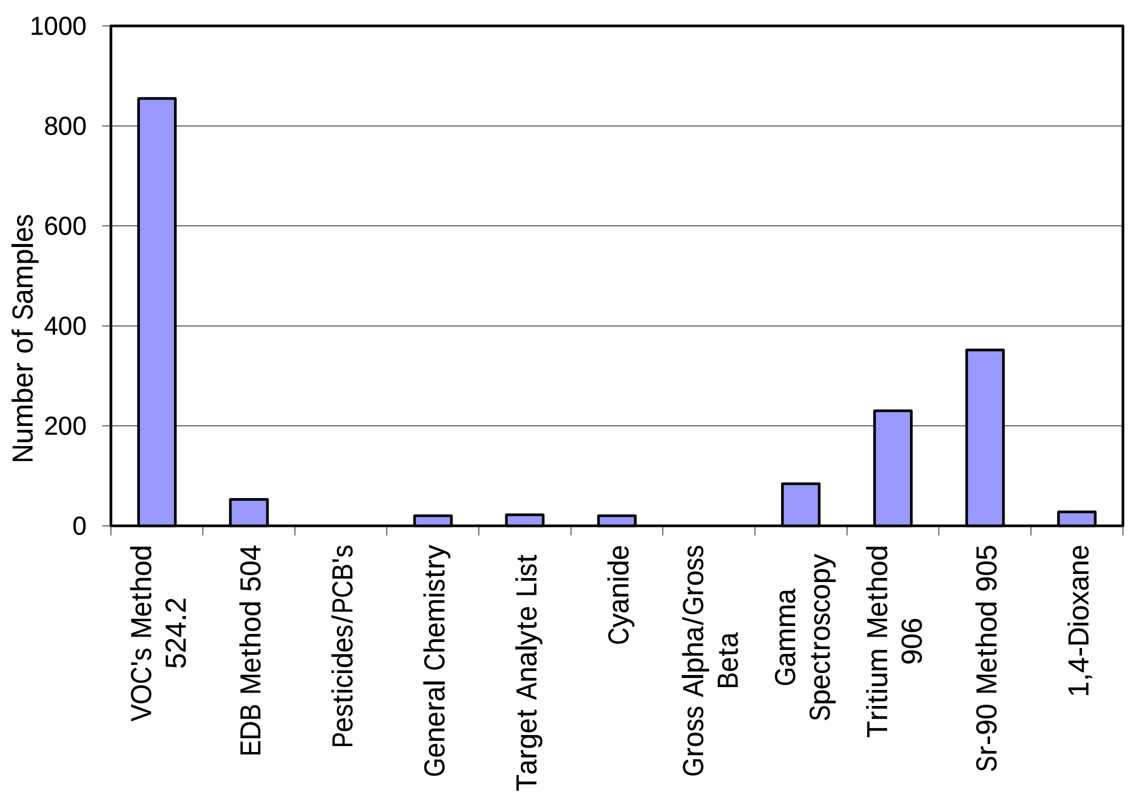
Additionally, BNL's ability to accurately depict these plumes has been enhanced over the years by the:

- 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 2017, the contaminant plumes were tracked by collecting 1,309 groundwater samples obtained from 558 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 2017 data from permanent monitoring wells. Contaminant plumes associated with OU I South Boundary, Current Landfill, Brookhaven Graphite Research Reactor (BGRR), and Western South Boundary projects were further defined in 2017 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 2017.



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 11 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 2017, 922 treatment system samples were obtained from 106 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 inspection logs. The 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.

Table 3.0-1 summarizes the existing remediation systems. 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.

Groundwater Sampling Methodology Summary

Groundwater sampling, analysis methods, quality assurance reviews and database methodologies are detailed in **Appendix E**. A summary of the techniques used are as follows:

Monitoring well groundwater samples are collected from dedicated bladder pumps using a low flow purge technique. A minimum of two times the volume of the sample pump and tubing are purged prior to the sampling of the well. Samples are collected once water quality parameters (pH, specific conductance and dissolved oxygen) stabilize or when an amount of groundwater equal to 25 percent of a casing volume has been purged. Depending on the parameter, purge flow rates are adjusted to approximately 100 milliliters per minute for sample collection.

The collection of groundwater samples from temporary wells is dependent on the drilling method used. When using an auger rig, hollow stem augers are advanced to the deepest sampling interval. A stainless-steel well screen is connected to two-inch diameter steel well pipe and lowered through the center of the augers to the required sampling depth. The augers are then withdrawn above the well screen. A submersible pump is lowered to the well screen and three well volumes of groundwater are purged prior to sampling. Groundwater samples are collected from the operating pump discharge tubing into laboratory-supplied bottles and preserved according to analysis requirements. This procedure is repeated at each depth interval required by the work plan.

When collecting groundwater samples via a Geoprobe , a screen is placed inside a sampler sheath and a expendable drive point is attached to the bottom of the sheath and then threaded onto a steel rod. . The probe is advanced to the deepest sample collection level and the screen is released using a trip rod. A length of Zelite™ (or equivalent) tubing sized to fit inside the probe rods is attached to a check valve. The check valve and tubing are sent down the probe rod until they reach the bottom of the screen, and then withdrawn 12 inches. An inertial pump (e.g., Waterra) is used to purge the Geoprobe well. Three casing volumes of groundwater are typically removed prior to sampling. Samples are collected with the inertial pump running continuously.

Table 3.0-1. 2017 Summary of Existing Groundwater Remediation Systems at BNL.

Operable Unit System	Type	Target Contaminant	No. of Wells	Years in Operation	Recharge Method	Pounds VOCs Removed in 2017/Cumulative
Operable Unit I						
South Boundary	P&T, AS	VOC	2	Operated: 16 Standby: 4	Basin	0/369
Operable Unit III						
South Boundary	P&T, (AS)	VOC	8	20	Basin	14/3,041
HFBR Pump and Recharge	Pump and Recirculate	Tritium	4	Operate: 8.0 Standby: 12.5	Basin	0/180
Industrial Park	Recirculation/ In-Well (AS/Carbon)	VOC	9	17.5	Recirculation Well	3/1,074
****Building 96	Recirculation Well (AS/Carbon)	VOC	4	Operate: 14 Standby: 3	Recirculation Well	1/141
Middle Road	P&T (AS)	VOC	7	16	Basin	34/1,230
Western South Boundary	P&T (AS)	VOC	2	15	Basin	5/140
Chemical Holes	P&T (IE)	Sr-90	3	15	Dry Well	0.013**/4.93
North Street	P&T (Carbon)	VOC	2	12 Standby: 1	Wells	0/342
North Street East	P&T (Carbon)	VOC	2	Operate:10 Standby: 3	Wells	0/44
LIPA/Airport	P&T and Recirc. Wells (Carbon)	VOC	10	13	Wells and Recirculation Well	13/439
Industrial Park East	P&T (Carbon)	VOC	2*	Shutdown Operate: 5 Standby: 4	Wells	0/37
BGRR/WCF	P&T (IE)	Sr-90	9	12	Dry Wells	0.5**/27.3
Building 452 Freon-11	P&T (AS)	Freon-11	1	6	Basin	1/105*****
Operable Unit VI						
EDB	P&T (Carbon)	EDB	2	13	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.

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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.

VOC 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** and the cross sectional view in **Figure 3.1-2**.

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 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 2017 from the OU I South Boundary Groundwater Treatment System. This system began operating in December 1996. 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 46 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 2017. 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 landfill was capped in November 1995. A detailed discussion of the landfill monitoring well data is provided in the *2017 Environmental Monitoring Report, Current and Former Landfill Areas (BNL 2018a).* The downgradient portion of the OU I South Boundary plume (as defined by TVOC concentrations greater than 5 µg/L) has been largely degraded due to 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.

Figure 3.1-3 gives the historical trends in VOC concentrations for key plume core and bypass wells. **Appendix C** has a complete set of 2017 analytical results. Significant findings for 2017 include:

- Monitoring well 088-109 is the only remaining Current Landfill source area well consistently exhibiting TVOC concentrations above 5 µg/L. This well is located immediately east of the Current Landfill footprint, and approximately 3,500 feet north of the BNL site boundary (**Figure 3.1-1**). In 2017, TVOC concentrations in this well ranged from 65 µg/L to 81 µg/L. Monitoring well OUI-MW01-2017 was installed in 2016 to provide a monitoring point approximately 1,200 feet downgradient of the Current Landfill and well 088-109. TVOC concentrations in this well have ranged from 5 µg/L to 11 µg/L.
- Well 107-40 was located along the center line of the plume, approximately 500 feet north of the site boundary. This was the last remaining downgradient well on-site containing TVOC concentrations above the capture goal. TVOC concentrations in this well have been below the capture goal of 50 µg/L since 2013. The TVOC concentration in this well during the fourth quarter of 2017 was 9.5 µg/L.
- The only remaining downgradient plume core wells with individual VOC concentrations above AWQS are 107-40 and 115-16. Both wells are located near the south boundary, and during the fourth quarter of 2017 had chloroethane and DCA concentrations in the 6 µg/L -7 µg/L range (**Figure 3.1-3**).
- 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**.

The tritium concentrations in this well network have diminished, with no detections observed since 2014.

Forty permanent wells are monitored for Sr-90 contamination from the former HWMF **(Table 1-5)**. The highest Sr-90 detected in 2017 from a monitoring well was 39 pCi/L in well 098-30 during September (the Sr-90 DWS is 8 pCi/L). Three temporary wells were installed as part of an annual effort to enhance the permanent well network and track the migration of Sr-90 from the former HWMF. The well locations are shown on **Figure 3.1-4.** The data are included in **Table 3.1-1**. Due to unfavorable weather and access conditions in the solar farm area during the winter and spring of 2018, a full temporary well characterization was not possible. This work will be completed later in the spring and the data will be shared with the regulatory agencies as part of the annual briefings. Data and maps generated from this work will be documented in the 2018 Groundwater Status Report.

Sampling was conducted during the fourth quarter of 2017 at three temporary well locations within the former HWMF source area. Each of these locations has been sampled previously. Temporary well location GP-42 has decreased from 302 pCi/L when it was initially sampled in 2015, to 69 pCi/L in 2017. Temporary well location GP-40, which is located approximately 400 feet south, at the edge of the former HWMF yard, has shown a Sr-90 increase from 217 pCi/L in 2015 to 442 pCi/L in 2017 (**Figure 3.1-5**). In general, the available data from both the permanent and temporary wells show the Sr-90 to be slowly migrating to the southeast as expected (**Figure 3.1-4**).

Weather and access conditions also delayed the installation of temporary wells to assess any southeasterly shift in the area of the leading edge of the plume. This shift is expected due to the placement of the OU I South Boundary extraction wells in stand-by mode in 2013. This resulted in a return to natural groundwater flow conditions in this area of the site. These temporary wells will be installed in 2018, and also reported to the regulatory agencies and documented as discussed above. The location of monitoring wells and the extent of Sr-90 concentrations is shown on **Figure 3.1-4**. Sr-90 concentration trends for key monitoring wells are provided on **Figure 3.1-5**.

3.1.6 System Operations

The extraction wells are currently sampled quarterly as the system was in standby mode for 2017. **Table 3.1-2** provides the effluent limitations for meeting the requirements of the SPDES equivalency permit. Since the system was in standby mode in 2017 no influent/effluent samples were collected.

The following is a summary of the OU I system operations for 2017:

January–December 2017

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 3.1-2.
OU I South Boundary Treatment System
2017 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 2017, the extraction wells did not operate. The wells were sampled quarterly during the year. 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 2017. TVOC levels in EW-1 and EW-2 remained low with maximum concentrations of 6.6 µg/L and 1.4 µg/L, respectively (**Figure 3.1-6**).

System Influent and Effluent

There were no influent or effluent samples as the system was in standby mode during 2017.

Cumulative Mass Removal

Approximately 369 pounds of VOCs were removed from the aquifer during system operation from 1996 through 2013 (**Figure 3.1-7**).

Air Discharge

There were no air emissions as the system was in standby in 2017 (**Table 3.1-3**).

3.1.8 System Evaluation

Although the system remains in standby, groundwater monitoring is ongoing and no rebound of VOC concentrations has been observed. The OU I South Boundary Treatment System performance can be evaluated based on the decisions identified by applying 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. 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

2017 groundwater monitoring data indicate that the area of higher Sr-90 concentrations observed during the 2015 characterization effort is slowly migrating south. Sr-90 concentration are decreasing at GP-42 as concentrations increase downgradient at GP-40. 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 1947 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). It should also be noted that the water table was observed at low levels in 2017, and may be attributable to the decreasing Sr-90 concentration at GP-42.

2. Were unexpected levels or types of contamination detected?

Current Landfill

No unexpected results were observed.

Former HWMF

No, Sr-90 concentrations were as expected during 2017. Concentrations observed at GP-40 increased significantly and may indicate that the area of high concentrations initially characterized in 2015 in the central area of the yard (GP-42) may have extended slightly further to the south than originally mapped following the initial characterization.

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

Current Landfill

Yes, monitoring results indicate that the OU I onsite VOC plume has been remediated. VOCs periodically released from the Current Landfill are attenuating as they migrate south. 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 indicate that VOC concentrations from the Current Landfill will attenuate to below 5 µg/L TVOC prior to reaching the site boundary. The modeling results are supported by the TVOC concentration in newly installed monitoring well OUI-MW01-2017.

Former HWMF

A plume of Sr-90 exceeding the 8 pCi/L DWS extends from the former HWMF 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 as verified by monitoring data obtained over the past several years. Groundwater model simulations have the leading edge of this area of Sr-90 above DWS arriving at the site boundary in approximately 42 years (2058) and decaying to below DWS by approximately 2081.

4. Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?
Yes, the system was placed in standby mode in July 2013 following regulatory approval of the Petition for Shutdown. There has been no significant VOC concentration rebound observed in either the extraction wells or monitoring wells since system shutdown. There are only two plume core wells exhibiting individual VOCs (slightly) above the AWQS. Based on the data obtained during the period of system shutdown, a recommendation will be made to decommission this system.

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 periodically shown TVOC concentrations exceeding 50 µg/L over the past several years. Based on plume core well data, TVOC concentrations throughout the downgradient portion of the plume have been less than the system capture goal of 50 µg/L since January 2013.

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 3.1-4**.

Table 3.1-3
OU I South Boundary
2017 Air Stripper VOC Emissions Data

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

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.
NS= Not Sampled

4b. Is there a significant concentration rebound in core wells and/or extraction wells following shutdown?
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 107-40 and 115-16 continue to exceed MCLs for individual VOCs. A comparison of groundwater quality conditions are shown on **Figure 3.1-8** which compares the VOC plume from 1997 to 2017.

3.1.9 Recommendations

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

- Based on the lack of significant rebound in VOC concentrations since system shutdown in 2013 and very low remaining VOC concentrations in area monitoring wells, submit a petition to decommission the OU I South Boundary Treatment System in 2018.

- Complete the 2017 annual characterization (delayed by weather conditions) of the former HWMF Sr-90 plume by installing temporary wells downgradient of this area.
- Maintain the VOC groundwater monitoring program of an annual sample collection from plume core wells: 107-40, 107-41, 115-13, 115-16, and 115-51. Maintain quarterly sampling of OUI-MW01-2017.
- Install several temporary wells as necessary in the vicinity of Sr-90 sentinel monitoring wells 107-35 and 108-45 to evaluate the resulting eastward shift in the Sr-90 migration path. Install permanent monitoring wells, as needed.
- Discontinue Sr-90 sampling from monitoring wells 099-04, 107-10, 107-24, 107-26, 107-40, 115-03, 115-13, 115-14, 115-15, 115-16, 115-28, 115-29, 115-30, and 115-31. Sr-90 concentrations have been either non-detect or barely detectable for at least five years in these wells. In addition, several of the wells are located significantly to the west of the established plume pathway or are significantly deeper than the observed plume depth.

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–B′, which is drawn through the north–south center-line of the primary OU III VOC plumes, as shown in **Figure 3.2-1**.

The primary chemical contaminants found in OU III groundwater are 1,1,1-trichloroethane (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 2017. 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 19-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 **3.2.17** summarize and evaluate the groundwater monitoring and system operations data for the OU III VOC and radiological plumes, including both operational groundwater treatment systems and the monitoring-only programs.

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3.2.1 Building 96 Treatment System

This section summarizes the 2017 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 16 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 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 below land surface (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 originally expected within three to six years of the soil excavation (by 2016). However, due to the persistence of elevated VOC concentrations in former source area monitoring well 085-379 over the last several years, RTW-1 will continue to operate. Excavation of the soil and continued operation of the system 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 2017 VOC groundwater plume. **Figure 3.2.1-2** shows a cross section of the area.

3.2.1.3 Groundwater Monitoring

A network of 30 wells is used to monitor the VOC plume and the effectiveness of the Building 96 groundwater remediation system (**Figure 3.2.1-1**). As recommended in the *2016 Groundwater Status Report*, since VOC concentrations have remained less than AWQS for several years, starting in the fourth quarter of 2017 monitoring was discontinued in wells 095-161, 095-164, 095-167, and 095-295. The majority of the wells are sampled quarterly and analyzed for VOCs as noted in **Table 1-5**. Sampling for hexavalent chromium in the monitoring wells was discontinued in 2015.

3.2.1.4 Monitoring Well Results

Complete VOC results are provided in **Appendix C**. The fourth quarter 2017 plume is shown on **Figure 3.2.1-1** and trends for several wells are presented on **Figure 3.2.1-3**. A summary of key monitoring well data for 2017 follows:

Former Source Area to RTW-1:

- Since detecting a maximum TVOC concentration of 2,435 μg/L in 2011, monitoring well 085-379 has dropped to less than 130 μg/L in 2017. 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.

- Core well 095-305, located approximately 100 feet downgradient of the former soil excavation has declined significantly since mid-2016. The maximum TVOC concentration was 99 µg/L in 2017. Well 085-347, located approximately 60 feet upgradient of 095-305 and screened at the same depth, has seen a sharp decline of TVOC concentrations following detections up to 3,000 µg/L in 2010. TVOC concentrations in this well were less than the capture goal of 50 µg/L in 2017.
- Maximum TVOC concentrations in well 095-84, located immediately upgradient of extraction well RTW-1 were 130 µg/L in the third quarter 2017. 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 3.2.1-3**, 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 110 µg/L in 2017. 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 100 to 200 feet downgradient of the former soil excavation area.
- Two monitoring wells were not able to be sampled due to the lowering of the water table below the screens from drought conditions. The well screens from several other monitoring wells were also barely in the water table.
- As recommended in the *2016 Groundwater Status Report*, two temporary wells were installed in March 2018 to further assess the extent of PCE in the former source area. Temporary well B96-GP01-2018 was installed immediately downgradient of well 085-379. The maximum PCE concentration was 62 µg/L at 26 feet below land surface. Temporary well B96-GP02-2018 was installed immediately upgradient of well 095-305. Elevated PCE was detected in four of the six sampling intervals, with a maximum concentration of 180 µg/L at 38 feet bls. The deepest sample interval at 42 feet bls continued to detect PCE up to 99 µg/L. The data are included in **Table 3.2.1-4.**
- As recommended in the *2016 Groundwater Status Report*, two soil gas samples (purged of one and two tubing volumes, respectively) from soil gas monitoring well 085-359 were collected in September 2017. These samples were collected since PCE concentrations continue to remain elevated in core wells downgradient of the former source area. The results from the sample with one tubing volume purged prior to collection identified PCE at 6,900 $\mu g/m^3$ (1,000 ppb by volume). The second sample with two tubing volumes purged detected PCE at 6,100 $\mu g/m^3$ (910 ppb by volume). 1,1,1-Trichloroethane was detected at 61 $\mu g/m^3$ (11 ppb by volume) and 55 $\mu g/m^{3*}$ (10 ppb by volume), respectively. The PCE concentrations are sufficiently elevated that the feasibility of performing a soil vapor extraction pilot study should be evaluated. The data are shown in **Table 3.2.1-5**.

<u>RTW-1 to Downgradient Recirculation Wells RTW-2 through RTW-4:</u>

- Elevated VOC concentrations continue to be detected in monitoring well 095-159, located downgradient of RTW-1. The highest TVOC concentration seen in the plume in 2017 was 280 µg/L in well 095-159. Following a slow decline since 2010, VOCs in this well have significantly increased in 2017. These concentrations are consistent with the elevated VOCs detected in temporary well B96-GP-01-2016 installed between wells 095-159 and 095-162 in March 2016. This contamination will be captured by RTW-2 and RTW-3. These recovery wells will be restarted if this contamination reaches them above a TVOC concentration of 50 µg/L.

- As recommended in the *2016 Groundwater Status Report,* temporary well B96-GP03-2018 was installed in March 2018 just west of monitoring well 095-312 to evaluate the extent of VOC concentrations in Geoprobe B96-GP-01-2016, and to track its movement prior to reaching RTW-2. As noted on **Table 3.2.1-4**, the maximum VOC concentration was 37 µg/L of PCE at 50 feet bls.

Wells Downgradient of RTW-2 through RTW-4:

- The four bypass wells, located immediately downgradient of RTW-2 have not seen detections of VOCs above the AWQS from 2011 through 2015. Starting in 2016, VOC concentrations began slowly increasing and reached a maximum value of 28 µg/L in January 2017 in well 095-166. These concentrations are below the capture goal of 50 µg/L TVOCs, and are not unexpected since RTW-2 is in standby mode. The bypass monitoring wells immediately downgradient of extraction wells RTW-3 and RTW-4 showed reduced TVOC concentrations since 2007. Individual VOCs in these wells have been below standards since 2010.
- VOCs were not detected above AWQS in 2017 in sentinel monitoring well 095-318, located along Weaver Drive. TVOC concentrations in this well have significantly declined since the well was installed in 2010 and detected 143 µg/L. This contamination will be addressed by the Middle Road treatment system.

Freon-11:

- As further described in **Section 3.2.2**, Building 96 extraction well RTW-1 is also being used to address the remaining low level Freon-11 concentrations.

3.2.1.5 System Operations

Operating Parameters

Treatment well RTW-1 operated full time during 2017. Treatment wells RTW-2 and RTW-3 remained in stand-by mode since January 2016 due to low VOC concentrations. RTW-4 has been in stand-by mode since October 2012.

January – September 2017

During January and February, RTW-1 ran intermittently due to a problem with the programmable logic controller (PLC) processor. The system operated normally the remainder of this period and treated approximately 11.5 million gallons of water.

October – December 2017

Well RTW-1 was off for half of November due to electrical problems. During this period, the system treated approximately 3.5 million gallons of water.

During 2017 the system treated approximately 15 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 well RTW-1, and the influent concentrations for wells RT-2 through RTW-4. The highest TVOC concentration from the influent of these wells was 42 µg/L in RTW-1 in the first quarter of 2017. The maximum TVOC concentration in the influent of the downgradient wells was 21 µg/L in RTW-2, in the second quarter. **Figures 3.2.1-4 and 3.2.1-5** show 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

2017. In March 2017, a request for renewal of the SPDES equivalency permit was submitted to NYSDEC. The renewal for five additional years was granted by NYSDEC in July.

The maximum hexavalent chromium level detected in the effluent in RTW-1 in 2017 was 6.5 µg/L in May. This concentration is less than the contract required detection limit of 10 µg/L but greater than the instrument detection limit. 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, 2017 SPDES Equivalency Permit Levels

Parameter	Permit Level (µg/L)	Max. Measured Value (µg/L)
pH range	5.0–8.5 SU	6.2–81 SU
chromium (hexavalent)	100	6.5
tetrachloroethylene	5.0	<0.5
1,1,1-trichloroethane	5.0	<0.5
thallium	Monitor	<0.5
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 2017, 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 (RTW-1) was 29 gpm. The pumping and mass removal data are summarized on **Table F-7**. In 2017, approximately 1 pound of VOCs was removed. Since February 2001, the system has removed approximately 141 pounds of VOCs.

3.2.1.7 System Evaluation

The Building 96 Treatment System performance can be evaluated based on the 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?

Although the previously identified high PCE concentrations in soil were excavated in the summer of 2010, there continues to be residual contamination persisting in the vadose zone and the silt and sand lenses. PCE concentrations in well 085-379 (located in the former source area) and well 095-305, located 100 feet downgradient have declined since 2016. However, they continue to remain elevated with PCE concentrations up to 130 µg/L and 100 µg/L in 2017, respectively.

As a result of the elevated PCE concentrations detected in the soil gas monitoring well, conduct a pilot study to determine the effectiveness of soil vapor extraction.

2. Were unexpected levels or types of contamination detected?

There were no unexpected levels or types of contaminants detected, however the persistently elevated PCE levels will result in operating RTW-1 longer than planned.

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

Yes, through a combination of RTW-1 and the downgradient extraction wells, the PCE plume is controlled. However, an area of elevated PCE located near well 095-159 (up to 300 µg/L) has been increasing since 2016. This contamination would be captured by downgradient extraction well RTW-2. This well will be restarted if TVOC concentrations exceed the capture goal of 50 µg/L at this area. See **Figure 3.2.1-6** for a comparison of the plume from 2000 and 2017.

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. From 2015 through 2017, PCE has remained below 25 µg/L in this well.

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. Although RTW-1 has not exceeded the TVOC capture goal of 50 µg/L in 2016 and 2017, core monitoring wells have. Groundwater modeling 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 monitoring well data, RTW-1 is now projected to run through at least 2020.

Table 3.2.1-2
OU III Building 96 Area
2017 Average VOC Emission Rates

Parameter	Allowable ERP* (lb/hr)	Actual** ER (lb/hr)
dichlorodifluoromethane	0.0000187	ND
acetone	0.000674	ND
methylene chloride	0.000749	ND
2-butanone	0.000187	ND
benzene	0.000112	0.0000047
tetrachloroethylene	0.000165	0.0000021
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	ND
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-3 and RTW-4 have been below 50 µg/L since 2008. The maximum TVOC concentration detected since 2016 in RTW-2 was 21 µg/L in April 2017. The maximum TVOC concentration detected in nearby up-gradient monitoring wells 095-312 and 095-172 over the past two years was 40 µg/L (in October 2017). Due to these consistently low levels, extraction wells RTW-2 through RTW-4 have remained in standby mode.

Since hexavalent chromium concentrations have remained below the detection limit of 10 µg/L since 2012, in July 2017, a request was submitted to the NYSDEC under the existing SPDES equivalency permit to discontinue sampling of hexavalent chromium in the effluent of RTW-1. On July 25, 2017, NYSDEC subsequently removed the requirement for hexavalent chromium sampling from the approved effluent criteria. As a result, the hexavalent chromium ion-exchange treatment system will be decommissioned.

4a. Are TVOC concentrations in plume core wells above or below 50 µg/L?
TVOC concentrations in eight of 21 core wells were above 50 µg/L in 2017.

4b. Is there a significant concentration rebound in core wells and/or extraction wells following shutdown?
No, however RTW-2 has seen a slight rebound in VOC concentrations above AWQS since 2016. The bypass monitoring wells downgradient of RTW-2 have also seen similar increases, but below the 50 µg/L TVOC capture goal.

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.
- Modify the pumping rate to expand the capture zone of RTW-1 to ensure that VOCs in well 095-159 are being fully captured. May need to submit modified SPDES Equivalency Permit request to NYSDEC for an increase in the maximum flow rate.
- Maintain treatment wells RTW-2, RTW-3, and RTW-4 in standby mode, and restart the wells if extraction or monitoring well data indicate that TVOC concentrations exceed 50 µg/L.
- Since elevated PCE concentrations were identified in soil gas monitoring well 085-359 in 2017, perform a soil vapor extraction pilot study to evaluate the effectiveness of reducing the persistent contamination in the former source area.
- Install a temporary well at the location of B96-GP02-2018 to determine the vertical extent of the VOCs observed in the deepest samples in this temporary well.
- Decommission the hexavalent chromium ion-exchange treatment system in the spring of 2018.

3.2.2 Building 452 Freon-11 Treatment System

This section summarizes the 2017 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-11in 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 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 were used to remediate the main portion of the Freon-11 plume. The goal of the remediation system is to reduce Freon-11 concentrations to <50 µg/L, which would then be followed by a period of monitored natural attenuation.

The Building 452 treatment system began operation in March 2012. Groundwater from extraction well EW-18 is treated using a tray air stripper 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 (**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 would 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 Groundwater Monitoring

Well Network

The monitoring well network for the Building 452 program consists of 13 wells, all of which are screened in the shallow portion of the Upper Glacial aquifer (**Figure 3.2.2-1**). Monitoring results from twelve Building 96 wells are also used to evaluate the effectiveness of the treatment system.

Sampling Frequency and Analysis

During 2017, the Building 452 monitoring wells were sampled two times, and the samples were analyzed for VOCs (**Table 1-6**). The twelve Building 96 monitoring wells were sampled quarterly (**Table 1-5**).

3.2.2.3 Monitoring Well Results

Complete VOC results are provided in **Appendix C**. Monitoring results for the third quarter 2017 are shown on **Figure 3.2.2-1**. Freon-11 concentration trends for key monitoring wells are presented on **Figure 3.2.2-2**. A summary of key monitoring results for 2017 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. Monitoring results for the third quarter 2017 indicate that all Freon-11 concentrations were below the 5 µg/L AWQS.

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, and were less than the 5 µg/L AWQS during the third quarter of 2017.
- Freon-11 concentrations in core well 085-387 declined from 12.7 µg/L during the first quarter of 2017 to less than the 5 µg/L AWQS by the third quarter.
- During 2017, the maximum influent Freon-11 concentrations in extraction wells EW-18 and RTW-1 were 26.6 µg/L and 1.6 µg/L, respectively. Influent concentrations in EW-18 decreased to less than the 5 µg/L AWQS by July 2017.

Bypass Wells:

- During the third quarter 2017, Freon-11 was detected in bypass well 095-162 at concentration of 2 µg/L. Freon-11 was not detected in the remaining by-pass wells during the third quarter.
- Low levels of Freon-11 continued to be detected in Building 96 treatment well RTW-2, with an estimated concentration of 0.4 µg/L detected during the fourth quarter of 2017. Freon-11 was not detected in RTW-3 or RTW-4, or in the nearby monitoring wells.

3.2.2.4 System Operations

Operating Parameters

From February 2015 until March 2016, extraction well EW-18 operated in a pulsed pumping mode of one month on, one month off. Because Freon-11 concentrations remained below the 50 µg/L cleanup goal during the pulsed-pumping operation, the system was in placed standby mode in March 2016 (BNL 2016a). However, due to a rebound of Freon-11 concentrations in extraction well EW-18 to 91.7 µg/L in October 2016, the system was placed back into full time operation in November 2016, and remained in full time operation until March 2017 when Freon-11 concentrations decreased to less than 8 µg/L. Operating conditions for Building 96 extraction well RTW-1 are presented in **Section 3.2.1**.

During 2017, the Building 452 Freon-11 groundwater treatment system treated approximately 6.5 million gallons of groundwater (**Table 2-2**).

January – March 2017

The system operated normally for this period, and was placed back into standby mode in late March. During this period the system treated approximately 6.5 million gallons of groundwater.

April – December 2017

The system remained in standby mode.

3.2.2.5 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 26.6 µg/L in January. **Figures 3.2.2-3** and **3.2.2-4** show the Freon-11 concentrations in the extraction 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 2017.

During 2017, the maximum Freon-11 influent concentration in Building 96 extraction well RTW-1 was 1.6 µg/L. Freon-11 was detected in the other Building 96 treatment well RTW-2 at concentrations up to 0.4 µg/L (**Section 3.2.1**).

Table 3.2.2-1
Building 452 EW-18 Treatment Well
2017 SPDES Equivalency Permit Levels

Parameter	Permit Level (µg/L)	Max. Measured Value (µg/L)
pH range	5.0–8.5 SU	5.9–7.8 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. While in operation, the average pumping rate for EW-18 was 50 gpm. The pumping and mass removal data for the Building 452 treatment system are summarized on **Table F-10**. During 2017, approximately one pound of Freon-11 was removed from the aquifer by the Building 452 treatment system. Since the start of treatment operations in March 2012, approximately 105 pounds of Freon-11 have been removed. The system has also remediated low concentration of several other VOCs (e.g., chloroform, trichloroethene (TCE) and TCA) for a total removal of approximately 108 pounds of VOCs. The cumulative total of VOCs removed over time is plotted on **Figure 3.2.2-5**. Low levels of Freon-11 have been continuously detected in Building 96 treatment well RTW-1 since December 2010. Approximately 5 pounds of Freon-11 has been removed by this treatment system. Combined, the two treatment systems have removed approximately 110 pounds of Freon-11 from the aquifer.

3.2.2.6 System Evaluation

The Building 452 Freon-11 Treatment System performance can be evaluated based on the 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?

Although low levels of Freon-11 are still entering the groundwater from the vadose zone in the source area, the resulting concentrations are below the 5 µg/L AWQS. All Freon-11 concentrations in source area monitoring wells were below the 5 µg/L AWQS during the third quarter 2017. **Figure 3.2.2-6** shows a comparison of the plume in 2011 and the remaining Freon-11 concentrations detected during 2017.

2. Were unexpected levels or types of contamination detected?
No. After March 2017, when the Freon-11 treatment system was placed back into standby mode, all Freon-11 concentrations in groundwater have been less than the 50 µg/L treatment system capture goal.

3. Has the downgradient migration of the plume been controlled?
Yes. Plume migration was successfully controlled by the combined operations of extraction wells EW-18 and RTW-1, and all Freon-11 concentrations decreased to less than the 5 µg/L AWQS by the 3rd Quarter of 2017.

4. Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?
The treatment system was placed back into standby mode in late March 2017. The treatment system will remain in standby mode.

4a. Are Freon-11 concentrations in plume core wells above or below 50 µg/L?
During 2017, Freon-11 concentrations in all plume core wells and extraction wells EW-18 and RTW-1 were below the 50 µg/L TVOC capture goal. As noted above, all Freon-11 concentrations have been reduced to less than the 5 µg/L AWQS by the 3rd Quarter of 2017.

4b. Was there a significant concentration rebound in core wells and/or extraction wells following shutdown?
Since March 2017, when the treatment system was returned to shutdown mode, there has been no rebound in Freon-11 concentrations in any of the core wells or extraction wells.

5. Has the groundwater cleanup goal of meeting MCLs been achieved?
Based upon current data, the 5 µg/L MCL for Freon-11 has been achieved. Additional monitoring will be conducted during 2018 to verify that Freon-11 concentrations remain below the MCL.

3.2.2.7 Recommendations

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

- Maintain the Building 452 Treatment System in standby mode for one more year. If there isn't a rebound in Freon-11 concentrations, with concentrations exceeding 50 µg/L, prepare a Petition for Closure by 2019. It is anticipated that the Building 96 treatment well RTW-1 will remain in full-time operation for several more years.
- Maintain the semiannual sampling frequency for the groundwater monitoring wells and quarterly sampling frequency for EW-18 for the remainder of the standby period.

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 2017 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 placed in standby mode due to low VOC concentrations. Well RW-1 was placed in standby in 2016 due to low VOC concentrations. Extraction well (RW-7) was installed and began operations in November 2013. The system is currently operating utilizing wells RW-2, RW-3, and RW-7 at a total pumping rate of approximately 400 gpm. A complete description of the system is included in the *Operation and Maintenance Manual for the OU III Middle Road and South Boundary Groundwater Treatment Systems, Revision 2* (BNL 2014a).

3.2.3.2 Groundwater Monitoring

The Middle Road Monitoring Program consists of a network of 33 monitoring wells located between Weaver drive 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 33 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 area between extraction wells RW-7 and RW-2 (**Figure 3.2.3-1**). TVOC concentrations in monitoring wells east of RW-2 are well below the 50 µg/L capture goal for this system. The highest TVOC concentration in Middle Road monitoring wells during 2017 was 580 µg/L in well 105-68 during the July sampling round. 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 shown 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/shallow portions of the Magothy aquifer. **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 2017 for this well was 129 µg/L. TVOC concentrations increased to 263 µg/L in January 2018.
- Well 105-68 was installed approximately 500 feet north of the extraction well RW-7 in May 2013. This well contains elevated TVOC concentrations with the highest concentration of 580 µg/L in July 2017. The data from this location along with data from monitoring wells 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 Middle Road and then south of RW-7 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 in 2017 with maximum values of 252 µg/L in November and 228µg/L in April respectively.

- 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 2017.
- Wells 095-322 and 095-323 were installed along Weaver Drive in 2014 (**Figure 3.2.3-1**). These wells were installed to monitor VOCs in the deep Upper Glacial Aquifer. Well 095-323 had a TVOC concentration of 28 µg/L in November 2017 and well 095-322 had a TVOC concentration of 51 µg/L in 2017.

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 179 million gallons of water were treated in 2017 by the Middle Road Treatment System.

The following is a summary of the Middle Road System operations for 2017.

January – September 2017

The system was down for seven days in January for maintenance of the effluent sample port and the systems blower motor. In February, EW-2 was off for maintenance for two weeks. In March, EW-2 was off line for two weeks for repair. In May, the system was down for one week for the removal of the two submersible pumps in the wet well. In August the system was off for the installation of two replacement submersible pumps in the wet well. Approximately 131 million gallons of water were treated.

October – December 2017

The system was operational for most of the fourth quarter of 2017. The system was off for approximately 2 weeks for repair of a pressure gauge in November. The effluent sample was taken from the sample port of the operational tower for each sampling event. During the fourth quarter the system pumped and treated approximately 48 million gallons of water.

Table 3.2.3-1.
Middle Road Air Stripping Tower
2017 SPDES Equivalency Permit Levels

Parameters	Permit Limit (µg/L)	Max. Observed Value (µg/L)
pH range (SU)	6.5–8.5	6.6 – 7.8
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.

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 2017 was 23 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 extraction 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 346 gpm during 2017 (**Table 3.2.3-3**, and **Table F-14)**, and approximately

34 pounds of VOCs were removed. Approximately 1,230 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 2017 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 2017, 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-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. RW-6 was shut down in September 2006. Well RW-1 was shut down in November 2015. The extraction wells are sampled quarterly. TVOC concentrations in wells RW-1, RW-4, RW-5 and RW-6 are all below the capture goal of 50 µg/L in 2017 with a maximum concentration of 37 µg/L in well RW-6 in July. However, 31 µg/L of the RW-6 concentration was Toluene. The maximum concentration observed in the operating wells in 2017 was in Well RW-7 with a peak TVOC concentration of 44 µg/L in October. See **Figure 3.2.3-6** 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
2017 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	0.0030
1,1,1-trichloroethane	10***	0.0002
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 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 source area and they have been remediated or controlled. The elevated VOC concentrations in monitoring well 104-37 (that is screened in the deep Upper Glacial aquifer) are of concern and could indicate that a source of contamination is still present upgradient of this well. This may be due to either the slower than expected movement of groundwater in this deeper zone or to a continuing upgradient source.

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

Yes, the plume in the deep Upper Glacial aquifer is being captured by 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. Low TVOC 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 µg/L?
A number 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 slower than expected decline in upgradient well 104-37 is of concern to meeting this goal.

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.
- Install vertical profiles as necessary upgradient of well 104-37 to determine the cause for the persistently elevated VOC concentrations observed in this well.

3.2.4 OU III South Boundary Treatment System

This section summarizes the operational data from the South Boundary Treatment System for 2017, 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 315 gpm, utilizing two 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 wells EW-4 and EW-17. EW-4 was placed into a pulsed pumping mode in October 2017. 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 3.2.14**.

3.2.4.3 Monitoring Well Results

The south boundary segment of the OU III VOC plume continued to be bounded by the existing monitoring well network. 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 2017.

The plume core wells continued to show a trend of decreasing VOC concentrations. The exception is several wells located in the deep Upper Glacial aquifer in the vicinity 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 follows:

- Bypass detection well 121-43, located several hundred feet south of extraction wells EW-4 and EW-17, had shown **e**levated levels of VOCs. Extraction well EW-17 was installed to address the high VOC concentrations that had been observed in well 121-43 (**Figure 3.2.4-1**) and began operations in July 2012. In April 2011 the TVOC concentration in well 121-43 was 338 µg/L and has declined to 17 µg/L in November 2017.
- Three monitoring wells are used to monitor the performance of extraction well EW-17. They are 121-47 a western plume perimeter well, 121-48 an eastern plume perimeter well, and 121-49 located upgradient of this extraction well. The upgradient monitoring well 121-49 showed elevated TVOC concentrations in 2017 with the highest concentration in November of 740 µg/L.
- Monitoring well 121-45 was installed to monitor the plume between the Middle Road and South Boundary. TVOC concentrations were at 37 µg/L in November, this is a significant reduction from the initial concentration of 613 µg/L in 2006.

- Well 121-54 was installed to monitor VOC concentrations upgradient of extraction well EW-17. This well had TVOC concentrations of up to 243 µg/L in May 2017. Well 121-53 was also installed up gradient of EW-17 and it showed a peak TVOC concentration of 126 µg/L in April.
- Plume core well 122-05 is a Magothy monitoring well west of EW-8. TVOC concentrations in this well have been steady with a concentration of 11 µg/L in November 2017.

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.

System Operations

In 2017, approximately 133 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.

Table 3.2.4-1.
OU III South Boundary Air Stripping Tower
2017 SPDES Equivalency Permit Levels

Parameters	Permit Limit* (µg/L)	Max. Observed Value (µg/L)
pH range (SU)	6.5 – 8.5	6.6–7.8
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.

January – September 2017

Approximately 105 million gallons of water were pumped and treated. In February extraction wells EW-4 and EW-17 were off for one and two weeks respectively for maintenance. The system was down for one week in May, for maintenance of two submersible pumps in the wet well. In August EW-4 and EW-17 were off for two weeks for the replacement of the two submersible pumps in the wet well.

October – December 2017

The OU III South Boundary System pumped and treated approximately 28 million gallons of water. In October, EW-4 was placed into a pulsed pump mode with a one month on one month off schedule.

3.2.4.5 System Operational Data

System Influent and Effluent

Figures 3.2.4-3 and 3.2.4-4 plot the TVOC concentrations in the extraction wells versus time. The overall influent water quality and the individual extraction wells show a 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 3.2.4-5**. The 2017 total was approximately 14 pounds. Cumulatively, the system has removed approximately 3,041 pounds since it was started in June 1997.

Air Discharge

Table 3.2.4-2 shows the air emissions data from the OU III South Boundary system for 2017, 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.

Table 3.2.4-2.
OU III South Boundary Air Stripper
2017 Average VOC Emission Rates

Parameter	Allowable ERP*	Actual** ER
carbon tetrachloride	0.022	0.0002
chloroform	0.0031	0.0001
1,1-dichloroethane	10***	0.0000
1,2-dichloroethane	0.008	0
1,1-dichloroethylene	0.034	0.0000
cis-1,2-dichloroethylene	10***	0.0000
trans-1,2-dichloroethylene	10***	0
tetrachloroethylene	0.387	0.0012
1,1,1-trichloroethane	10***	0.0000
trichloroethylene	0.143	0.0000

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.

Extraction Wells

There are two extraction wells that are currently operating. Well EW-4 continued to show slowly decreasing TVOC concentrations in 2017 from 3 µg/L in January to 1.5 µg/L in December. EW-17 showed TVOC concentrations ranging from 33 µg/L in January to 19.5 µg/L in December. This well is located slightly down gradient and deeper than well EW-4. EW-4 was placed into a pulsed pumping mode in October 2017. **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 257 gpm in 2017.

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 has resulted in reduced VOC concentrations in bypass well 121-43 (**Figure 3.2.3-3**). Western plume perimeter well 121-08 had a TVOC concentration of 6 µg/L in October and eastern

perimeter well 114-07 had a concentration of <0.5 µg/L in November. Individual VOC concentrations in the remaining plume perimeter wells were less than 5 µg/L in the fourth quarter of 2017.

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. Well EW-4 will continue to be pulse pumped one month on and one month off. Well EW-17 continues to operate on a full time basis.

4. Are TVOC concentrations in plume core wells above or below 50 µg/L?
There are still three upgradient plume core wells with persistent TVOCs above 50 µg/L in the capture zones of wells EW-4 and EW-17.

5. Is there a significant concentration rebound in core wells and/or extraction wells following shutdown?
A concentration rebound has not been observed in the monitoring or extraction wells in the eastern segment of this system. Two of the western 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 well EW-17 on a full time basis. Continue pulsed pumping of well EW-4 one month on and one month off.
- Maintain the routine O&M monitoring frequency implemented last year.
- Install a vertical profile between RW-7 and well 121-54 to evaluate persistently high TVOC concentrations in this area.

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 2017. Extraction well WSB-2 was placed in standby in October 2016.

3.2.5.1 System Description

A complete description of the Western South Boundary (WSB) 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 28 wells is used to monitor this plume. The well locations are shown on **Figure 3.2.5-1**. A total of 21 temporary vertical profile wells and 10 monitoring wells were installed from late 2016 through the winter of 2018 to characterize and monitor the extent of deeper VOC contamination in the WSB plume area. The wells are sampled at the O&M phase frequency (**Table 1-5** for details). Several of the new monitoring wells had not been sampled in time for this report.

The primary VOCs associated with this plume are dichlorodifluoromethane (Freon-12), TCA, and DCE. These VOCs were observed in vertical profile wells installed throughout the WSB area in the late 1990s as part of the OU III RI/FS. TVOC concentrations ranging from 20 µg/L to 40 µg/L were encountered at depths between 120-170 ft bls throughout the area.

Monitoring of this plume has identified several specific areas of higher VOC concentrations than were observed during the RI/FS. An area of TVOC concentrations higher than previously seen (up to 170 µg/L) was characterized beginning in 2008, from the Middle Road area south to WSB-1 at the south boundary. This plume segment of higher concentrations was primarily focused at depths between 130 and 150 feet bls. During 2008 and 2009 an area of Freon-12, with concentrations up to 55 µg/L, was characterized in the deep Upper Glacial aquifer at depths of 180-200 feet bls approximately 800 feet south of Princeton Avenue.

3.2.5.3 Monitoring Well Results

During characterization efforts in 2016-2017 to define the southern extent of the deeper Freon-12, a zone of high TVOC concentrations was encountered with most of the plume at slightly greater depths than previously seen in this area (140-210 feet bls). The primary VOCs were TCA and 1,1-dichloroethene (DCE), although Freon-12 was observed at concentrations up to 69 µg/L (WSB-VP-16-2017). A total of 21 temporary vertical profile wells were installed from 2016 through the end of 2017 to characterize these VOCs and a total of 10 new monitoring wells were installed. **Figure 3.2.5-1** presents fourth quarter 2017 monitoring well and 2016-2017 temporary vertical profile well concentrations. **Figure 3.2.5-2** provides a north-south cross section (H- H') of the plume. **Figure 3.2.5-6** provides an east-west cross section (H1-H1') along the site boundary and **Figure 3.2.5-3** provides trend graphs for key monitoring wells. The 21 temporary vertical profile well locations WSBVP-01-2016 through WSBVP-21-2017 are shown on **Figure 3.2.5-1** and the data for these wells (WSB-VP-17-2017 through WSBVP-21-2017) is summarized in **Table 3.2.5-4**. The data for the first sixteen vertical profiles was provided in the ***2016 Groundwater Status Report***. A summary of key monitoring well and temporary vertical profile well data for 2017/early 2018 follows:

- Four off-site vertical profiles located on the west end of Carleton Drive are labeled WSBVP-17-2017 through WSBVP-20-2017. The maximum TVOC concentration in these wells was 31.5 µg/L. However the maximum individual VOC was in vertical profile WSBVP-20-2017 was Freon at 13 µg/L at 145 to 150 feet. These vertical profiles confirmed that the leading edge of the higher concentration plume on site has not reached this location. Three new monitoring wells were subsequently installed to monitor the leading edge of the plume. They are identified as WSB-MW05-2017, WSB-MW06-2017, WSB-MW07-2017.
- Significant VOC detections were observed in one new on site vertical profile located between the Middle Road and South Boundary. This VP is identified as WSBVP-21-2017. TVOC concentrations (140 feet bls) up to 286 µg/L were detected, which was comprised of primarily TCA at 130 µg/L and DCE at 150 µg/L. This was the highest concentration of TVOCs detected during this investigation. A permanent monitoring well was installed at this location and is identified as WSB–MW03-2018.
- Two additional permanent monitoring wells were also installed to the north near Princeton Avenue to monitor any up-gradient contamination. They are identified as WSB-MW01-2018 and WSB-MW02-2017.
- The twenty one temporary vertical profile wells have delineated a deeper zone of higher VOC concentrations from approximately 800 feet south of Princeton Avenue to an area just past the south boundary. The investigation identified a maximum TVOC concentration of 286 µg/L and the primary VOCs are TCA, DCE and Freon 12. Based on the monitoring well and characterization data, the areas of higher TCA and DCE concentrations are slugs of contamination that may have originated from periodic releases. The deeper zones of elevated Freon-12 are even more isolated. **Figure 3.2.5-2** is a vertical cross section from north to south that depicts the data collected. It clearly shows that an area of deeper VOC contamination is present at the Western South Boundary.
- **Figure 3.2.5-6** shows an east west cross section near the BNL site boundary. This figure shows that the higher concentrations identified during the recent characterization is slightly deeper than extraction well WSB-1 and further to the west.
- The area of higher TCA and DCE concentrations that was first characterized in 2008-2009, extending at that time from well 119-06 at the Middle Road south to WSB-1, has now decreased to a small area in the vicinity of WSB-1. TVOC concentrations in wells 119-06 and 126-17 have significantly declined as the plume segment has migrated towards WSB-1 as shown on **Figure 3.2.5-3**.
- TVOC concentrations in well 126-14 ranged between 39 µg/L and 172 µg/L in 2017. This well is approximately 200 feet north of WSB-1. This appears to be the end of the area of higher TVOC concentrations tracked from well 119-06 over the past eight years to be captured by this extraction well.
- Groundwater modeling was performed to evaluate the fate and transport of the recently characterized VOC plume and what actions if any would be required to meet the cleanup goals. Based upon this modeling a four extraction well scenario with each of the wells operating at 75 gpm is recommended to be able to achieve the ROD cleanup objective of 2030 for the VOC and Freon-12 groundwater plumes. **Figure 3.2.5-1** shows the recommended well locations for the four proposed new extraction wells. Two will be at the site boundary identified as WSB-5 and WSB-6 one near the Middle Road WSB-4 and one about 1200 feet north of this WSB-3. The well locations and pumping rates were optimized utilizing the BNL groundwater model to achieve the cleanup goals in the most efficient and cost-effective manner, while taking advantage of the

existing groundwater treatment systems and infrastructure. The modeling report is included as **Appendix H.**

3.2.5.4 System Operations

During 2017, 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 2017. Extraction well WSB-2 continued in standby mode in 2017 based on the TVOC concentrations below the capture goal of 20 μg/L. 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 2017. The system operations are summarized below.

January – September 2017

WSB-1 extraction well operated normally. The WSB-2 extraction well remained in standby mode. In February WSB-1 was off for one week for maintenance to the programmable logic controller. During the first three quarters, the system treated approximately 78 million gallons of water.

October – December 2017

The system operated normally for the fourth quarter. The system treated approximately 26 million gallons of water.

Table 3.2.5-1
Western South Boundary Treatment System
2017 SPDES Equivalency Permit Levels

Parameter	Permit Level (μg/L)	Max. Measured Value (μg/L)
pH range	6.5–8.5 SU	6.5-8.0 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

3.2.5.5 System Operational Data

Extraction Wells

During 2017, the Western South Boundary System treated approximately 104 million gallons of water, with an average flow rate of approximately 202 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 wells WSB-1 and WSB-2 were below AWQS in 2017 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 below the AWQS during the year, with a maximum TCA value of 3.1 μg/L in March and December 2017, and maximum DCE value of 3.8 μg/L in March (**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 2017.

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 2017, five pounds of VOCs were removed. A total of 140 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 2017 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.

Table 3.2.5-3
Western South Boundary
2017 Air Stripper VOC Emissions Data

Parameter	Allowable ERP* (lb/hr)	Actual ERP (lb/hr)
carbon tetrachloride	0.016	0
chloroform	0.0086	0.00010
1,1-dichloroethane	10**	0.00000
1,2-dichloroethane	0.011	0
1,1-dichloroethene	0.194	0
chloroethane	10**	0
1,1,1-trichloroethane	10**	0.00002
trichloroethylene	0.119	0.00007

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.

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, as discussed above, unexpected levels of TCA, DCE and Freon-12 were detected at numerous temporary vertical profile well locations (**Figure 3.2.5-1)**. Higher than expected VOCs were detected in the deep Upper Glacial aquifer near the site boundary. Higher TCA and DCE concentrations were also detected to the north of the Middle Road at a slightly greater depth than previously observed in the WSB area.

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

TVOC concentrations during the fourth quarter of 2017 increased to 173 μg/L in well 126-14 located just to the north of WSB-1 within the capture zone of the extraction well. The deeper VOCs in the recent temporary wells are generally too deep and further to the west to be captured by WSB-1. The groundwater modeling showed the need to add four new extraction wells in order to control the plume.

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

The WSB extraction wells WSB-1 and WSB-2 were originally intended to target specific areas of elevated VOCs near the site boundary and were not intended to provide for complete capture of contaminants at the site boundary. WSB-2 is currently in standby mode and VOC concentrations in this area are well below the capture goal of 20 μg/L. TVOC concentrations in WSB-1 have declined to below the capture goal. However continued operation of WSB-1 is necessary to insure the capture of the high VOC concentrations migrating south from well 126-14.

3a. Are TVOC concentrations in plume core wells above or below 20 µg/L?
The recent characterization has identified a large area of groundwater contamination significantly above 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 or since the placement of this well in standby.

4. Has the groundwater cleanup goal of meeting MCLs been achieved?
MCLs have not been achieved for individual VOCs in plume core wells. Temporary vertical profile well data also exceeded MCLs at many locations. With the addition of the four new extraction wells is expected to meet the groundwater cleanup goals of meeting MCLs 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 elevated concentrations persisting at well 126-14.
- Based on the low TVOC concentrations below the capture goal of 20 µg/L, maintain extraction well WSB-2 in standby mode. 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 per the groundwater modeling report install four new groundwater extraction wells in 2018. The addition of these wells are projected to meet the groundwater cleanup goal of meeting MCLs by 2030.
- Submit a modification request to the regulators documenting the design details for the four new extraction wells recommended in the groundwater modeling report.
- Move to startup monitoring frequency (quarterly) for all wells associated with WSB-1 and the new extraction wells. For wells to the east monitoring WSB-2 continue the O&M phase (127-04, 127-06, and 121-42).

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3.2.6 Industrial Park Groundwater Treatment System

This section summarizes the operational data from the Industrial Park Groundwater Treatment System for 2017 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 shut down 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. It was again shut down in January 2017. 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 consisted 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 3.2-2**). 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 2015a).

3.2.6.2 Groundwater Monitoring

Well Network

The monitoring well network consists of 48 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**.

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 remained below AWQS during 2017. 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 2017 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**.

The 2017 results for key monitoring wells are shown on **Figure 3.2.6-3**:

Plume Core Wells

- Well 000-548, installed in 2015 to supplement the monitoring of the deeper VOCs, is located between well 000-528 and extraction well IP-EW-9 and had a TVOC concentration of 38 µg/L in November 2017. Only a slight variation in concentrations was observed in this well in 2017.
- 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 2017, well 000-253 had a maximum TVOC concentration of 4 µg/L and well 000-256 had a high TVOC concentration of 10 µg/L.
- Well 000-259 is located between UVB-2 and UVB-3. It had TVOC concentrations ranging from 8 µg/L in February to 21 µg/L in August.
- Well 000-262 is located just west of well IP-EW-9. In 2017, the TVOC concentrations ranged from 2 µg/L in January to 11 µg/L in August.
- Monitoring wells 000-528 and 000-529 are used 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 75 µg/L in January and well 000-529 had a maximum TVOC concentration of 33 µg/L in May. These wells are about 1000 feet upgradient of the two newer extraction wells. Well 000-528 showed a significant decline in concentrations in 2017.
- 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 2017 sampling results for well 000-530 showed a maximum TVOC concentration of 35 µg/L in August, Sampling from well 000-531 showed a maximum TVOC concentration of 55 µg/L in May.

Plume Bypass Wells

- TVOC concentrations in the wells located near Carleton Drive were stable or decreasing during 2017. Wells 000-431 and 000-432 serve as bypass monitoring points. VOC concentrations in 000-431 and 000-432 were below AWQS during 2017. VOC concentrations in bypass wells 000-275, 000-276, and 000-277 were below AWQS, indicating that the system has been effective in capturing the plume. Well 000-278 is directly downgradient of well UVB-4 and in 2017 had VOC concentrations below AWQS.
- Well 000-544 is a bypass well on Carleton Drive. It detected TVOC concentrations up to 54 µg/L in August. However, concentrations dropped to 5 µg/L in January 2018. This well was installed as a deep bypass well and this contamination migrated south of the new extraction wells (IP-EW-8 and IP-EW-9) before they were installed.

3.2.6.4 System Operations

In 2017, approximately 7.7 million gallons of groundwater were treated by the Industrial Park In-Well Air Stripping System and 109 million gallons by new extraction wells IP-EW-8 and IP-EW-9 . Wells UVB-1, UVB-2 and UVB-7 remained in standby mode throughout the year and the other UVB wells placed back in standby in January 2017.

Operating Parameters

Water samples are obtained monthly when the system was operating from each of the seven extraction wells before air stripping in each UVB tray and after treatment. Influent samples from these wells are obtained on a quarterly basis after shutdown. The samples are analyzed for VOCs. These sample results determine the systems 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 3.2.6-2).** 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 2017.

Table 3.2.6.2
OU III Industrial Park Treatment System
2017 SPDES Equivalency Permit Levels

Parameters	Permit Limit (µg/L)	Max. Measured Value (µg/L)
pH (range)	5.0 – 8.5 SU	5.7 – 7.6 SU
carbon tetrachloride	5.0	<0.50
chloroform	7.0	<0.50
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
trichloroethene	5.0	<0.50

Notes:

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

SU = Standard Units

January – September 2017

Wells UVB-1 through UVB-7 were placed in stand-by mode in January. Wells EW-8 and EW-9 operated normally this period. The system pumped and treated a total of approximately 87 million gallons of water during this period.

October – December 2017

Wells UVB-1 through UVB-7 remained in standby. Wells IP-EW-8 and IP-EW-9 ran normally for this period. The system pumped and treated a total of approximately 29 million gallons of water during this period.

3.2.6.5 System Operational Data

Well Influent and Effluent

During 2017, influent TVOC concentrations in the treatment system wells were below the capture goal of 50 µg/L TVOC concentrations (**Figure 3.2.6-4**). The corresponding effluent well concentrations are shown on **Figure 3.2.6-5**.

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 2017, flow averaged approximately 233 gpm in 2017 with primarily wells EW-8 and EW-9 operating. **Figure 3.2.6-6** plots the total pounds of VOCs removed by the treatment system vs. time. During 2017, approximately three pounds of VOCs were removed from the aquifer, with a total of 1,074 pounds of VOCs removed since 1999.

Air Treatment System

Air samples were not collected due to wells UVB-1 to UVB-7 being in stand-by mode beginning in February.

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 high VOC concentrations observed in the monitoring wells or extraction wells associated with the OU III Industrial Park System during 2017. However, lower than expected concentrations are being observed in the vicinity of the new extraction wells IP-EW-8 and IP-EW-9.

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 2017 with the exception of well 000-544 which detected a concentration of 54 µg/L in August but dropped to 5 µg/L in January 2018. 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 2017 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, 2013a) 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 (IP-EW-8 and IP-EW-9) to capture identified deeper up gradient VOCs. The UVB wells were placed back in stand-by in January 2017 based on a return to low VOC concentrations.

4. Are TVOC concentrations in plume core wells above or below 50 µg/L?
There were several plume core wells above the 50 µg/L TVOC capture goal in 2017.

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

- Wells UVB-3 through UVB-6 were restarted in March 2014 due to a rebound in concentrations above the 50 µg/L capture goal. These wells were placed back in standby in January 2017. Although one monitoring well (000-530) is slightly above the capture goal at 54 µg/L, this well is within the capture zone of the two extraction wells IP-EW-8 and IP-EW-9 which are still operating. These new extraction wells are screened deeper and are able to capture the contamination in this area.

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 Treatment System and groundwater monitoring program:

- Continue pulsed pumping operation of the deeper extraction wells IP-EW-8 and IP-EW-9.
- Maintain the seven UVB wells in standby. If TVOC concentrations exceed the 50 µg/L capture goal near any of these wells they may be restarted.
- Install a vertical profile well between wells 000-529 and 000-541 to address a potential data gap

west of well 000-529. If concentrations are low, evaluate shutdown of extraction wells EW-8 and EW-9 in 2019.

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3.2.7 Industrial Park East Monitoring Program

This section summarizes the 2017 monitoring well data for the Industrial Park East (IPE) plume and presents conclusions and recommendations for future monitoring. As noted in 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 four wells (**Figure 1-2**) where three wells are sampled annually and one sampled semi-annually for VOCs (**Table 1-5**). The data from the four wells are also evaluated as part of the Magothy monitoring program.

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 2017 TVOC well data are posted on **Figure 3.2.7-1**. Individual VOCs were below AWQS for all wells in 2017. **Figure 3.2.7-2** presents the maximum individual VOC data for each well in 2017. The complete analytical results are in **Appendix C.** Results for key monitoring wells are as follows:

- All four wells have shown a declining trend in VOC concentrations for the last several years, and they have remained below AWQS from 2015 through 2017. The declining VOC concentration trends for wells 000-427, 000-429, and 000-494 shown on **Figure 3.2.7-3** indicates that the plume has dissipated. 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. VOC concentrations near EW-8 barely exceeded AWQS in 2017.
- 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 MCLs in the Upper Glacial aquifer by 2030. According to the *OU III Explanation of Significant Differences* (BNL 2005a), MCLs 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 based on 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 Monitoring Program during 2017.

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 and Magothy aquifers have been reduced to less than AWQS.

4. Has the groundwater cleanup goal of meeting MCLs been achieved?
Yes, individual VOC concentrations in the monitoring wells have been below MCLs since 2015.

3.2.7.4 Recommendations

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

- In accordance with the *2013 Petition for Closure of the Industrial Park East Groundwater Treatment System* and the *2016 Groundwater Status Report*, since monitoring wells 000-494, 000-526, 000-427, and 000-429 have been below the AWQS for a minimum of four consecutive sampling events, further monitoring will be discontinued.

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 shut down 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. Well NS-1 was shut down in August 2016 due to a reduction in VOC concentrations.

Groundwater treatment presently consists of one extraction well operating at a pumping rate of approximately 200 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 18 wells monitors the North Street VOC plume (**Figure 1-2 and Figure 3.2.8-1**). Wells sampled under the Airport program are also utilized for tracking the North Street VOC plume.

Sampling Frequency and Analysis

Sampling of the 18 monitoring wells for VOCs is performed as per the schedule on **Table 1-5**.

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 2017 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 time-concentration plots for key monitoring wells. A summary of key monitoring well data for 2017 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 2017 the TVOC concentration in this well was initially reported at 147 µg/L during August. However, a resample of this well in August showed a result of 8 µg/L. This result is consistent with the recent historical data as the May sample was 7 µg/L and the November sample was 10 µg/L.

- TVOC concentration in core well 000-474, located approximately 500 feet upgradient of extraction well NS-2, was 15 µg/L in November.
- VOC concentrations in plume core well 000-463, located approximately 200 feet north of NS-1, were below AWQS during 2017.
- 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. However, they have steadily declined since then, and VOC concentrations have been below AWQS. The trailing edge of the higher concentration segment of this plume has migrated south of this location.
- The plume continues to be bounded as shown on **Figure 3.2.8-1** by the plume perimeter wells.
- **Figure 3.2.8-6** compares the TVOC plume from 1997 to 2017. The southern portion of the plume that migrated south of the North Street system prior to system start-up is being captured by the Airport Treatment system eastern extraction wells.

3.2.8.4 System Operations

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 – December 2017

Both extraction wells NS-1 and NS-2 remained in standby mode in 2017.

3.2.8.5 System Operational Data

The system was in standby mode in 2017.

Extraction Wells

Table F-27 contains no monthly pumping data and mass removal data as the system was in standby for the year. **Table 3.2.8-2** shows no monthly extraction well pumping rates as the system was in standby for the year. Well NS-1, and NS-2 were in standby mode in 2017, however they were sampled on a quarterly basis. **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**. NS-1 was being repaired in the second and third quarter and was not sampled. TVOC values in well NS-1 have steadily dropped from a high of 599 µg/L in 2004 to approximately 5 µg/L. Well NS-2 remained below 15 µg/L in 2017. There was no tritium detected in the extraction wells in 2017.

Table 3.2.8-1
OU III North Street Treatment System
2017 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:
NS = Not Sampled as the system was not operating.
SU= Standard Units

System Influent and Effluent

There were no influent or effluent samples as the system was in standby mode during 2017.

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**. Since May 2004, the system has removed 342 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 2017, except for the one August sample from well 000-465. This result could not be reproduced as noted in **Section 3.2.8.3**.

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 2017; 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-1 and NS-2 remained in standby in 2017.

3a. Are TVOC concentrations in plume core wells above or below 50 µg/L?

None of the 11 plume core wells of the North Street system showed TVOC concentrations greater than 50 µg/L during 2017.

3b. Is there a significant concentration rebound in core wells and/or extraction wells following shutdown?

No rebound in concentrations was detected during 2017 in NS-1. NS-2 has been below the capture goal since 2013. Well NS-1 was restarted in August 2015 due to increased VOC concentrations in monitoring well 000-465 directly up-gradient of extraction well NS-1. However, these concentrations are now well below the capture goal of NS-1. All other monitoring wells associated with this extraction well are also below the capture goal, thus the well was shut down, in August 2016 and has remained in standby since then.

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 2017, five of 11 core wells had VOCs above the MCL but below the system capture goal. Based on these data and groundwater modeling simulations, MCLs are expected to be achieved in all wells by 2030.

3.2.8.7 Recommendations

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

- If TVOC concentrations in any core monitoring wells increase to over the 50 µg/L capture goal, the extraction well(s) may be restarted.
- Change the groundwater monitoring well schedule for the North Street system to standby.
- NS-1 and NS-2 will remain in standby. If TVOC concentrations remain below the capture goal through 2018, a Petition for Closure will be submitted in 2019.

3.2.9 North Street East Treatment System

This section summarizes the 2017 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 (BNL 2014b)*, 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 15 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. As recommended in the *2016 Groundwater Status Report*, since AWQS have been achieved in all monitoring wells (except for 000-394) since 2011, the sampling frequency for the remaining semi-annual wells was reduced to annual starting in the fourth quarter 2017. However, due to the detection of EDB in perimeter well 000-394 above the DWS since August 2015, this well is sampled quarterly for EDB using Method 504, and annually starting in the fourth quarter of 2017 for VOCs using Method 524.2. See **Table 1-5** for details.

3.2.9.3 Monitoring Well Results

Figure 3.2.9-1 shows the extent of the VOC contamination. The plume contaminants originated from the Current Landfill and former HWMF (sources in OU I). See **Figure 3.1-1** for the extent of the on-site portion of the OU I plume.

Figure 3.1-2 depicts the vertical distribution of VOCs within the deep Upper Glacial aquifer. The transect line for cross section A–A' is shown on **Figure 3.1-1**. **Figure 3.1-3** gives the historical trends in VOC concentrations for key core and bypass wells along the NSE area. **Appendix C** contains a complete set of 2017 analytical results for the 15 NSE program wells. A summary of key monitoring well data for 2017 follows:

- Since 2011, individual VOCs continue to remain below AWQS in all monitoring wells, except for upgradient well 000-394. This well is located just south of the LIPA right-of-way. The maximum VOC detected in 2017 was 7.9 μg/L of PCE in well 000-394 in July.
- Since August 2015, EDB continued to be detected above the DWS of 0.05 μg/L in well 000-394, with a maximum detection of 1.06 μg/L in the fourth quarter 2017.
- Since EDB concentrations in well 000-394 have increased slightly in 2017, as recommended in the *2016 Groundwater Status Report*, groundwater characterization of this area was initiated in early 2018. Starting in March 2018, six temporary vertical profile wells were installed up and downgradient of well 000-394 (**Figure 3.2.9-2)**. Samples were collected at 10-foot intervals at each location and analyzed for EDB using Method 504 and VOCs using Method 524.2. Between

11 to 12 samples were obtained at each location. The data collected to date identified EDB upgradient of well 000-394 between 140 feet and 195 feet bls. Two of the six locations exceeded the DWS (NSE-VP04-2018 and NSE-VP06-2018). The maximum EDB concentration was 0.46 µg/L in NSE-VP06-2018. The two vertical profiles installed between well 000-394 and extraction well NSE-1 (NSE-VP02-2018 and NSE-VP03-2018) detected EDB in only one of the 24 samples, at a concentration below the DWS. The data are provided in **Table 3.2.9-1** and the maximum detection at each location is posted on **Figure 3.2.9-2**. Additional vertical profiles are being planned.

In addition to EDB, detections of PCE above the AWQS were identified in well 000-394 in 2017 and three of the vertical profiles. Although the concentrations were low (up to 7.9 µg/L in well 000-394), and 7.1 µg/L in NSE-VP05-2018) PCE has not been detected above the AWQS in the NSE area from 2005 through 2016. Similar PCE concentrations have been seen historically in upgradient south boundary monitoring wells prior to shutdown of the OU I extraction wells in 2014. The PCE was most likely held up in the stagnation zone of the system prior to shut down, and has since migrated to the NSE wells. The concentrations will continue to be monitored.

3.2.9.4 System Operations

The extraction wells were sampled quarterly throughout the year for VOCs and tritium. **Table 3.2.9-2** 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 3.2.9-2.
OU III North Street East Treatment System
2017 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 December 2017

The system remained shut down and in standby mode.

Extraction Wells

During 2017, the extraction wells did not operate. The wells were sampled quarterly during the year using Method 524.2 for VOCs, Method 504 for EDB, and tritium. **Table 2-2** shows no monthly pumping data for the two extraction wells as they were on standby for the year. **Table 3.2.9-3** shows the monthly extraction well pumping rates, however NSE-1 and NSE-2 remained in standby mode. **Figure 3.2.9-3** plots the TVOC concentrations in the extraction wells. VOC concentrations for NSE-1 and NSE-2 are provided in **Table F-31**. Following an increase in concentrations in mid-2016, TVOC levels in NSE-1 slightly decreased starting in the fourth quarter 2017. The maximum TVOC concentration in NSE-1 was 12 µg/L. TVOC concentrations in NSE-2 remained low during 2017, with concentrations below 2 µg/L. All individual VOCs were below their AWQS, and EDB was not detected in either extraction well. Tritium was not detected in the extraction wells in 2017.

System Influent and Effluent

No influent and effluent samples were collected since 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 3.2.9-4**. 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.

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**, EDB continued to be detected in plume perimeter well 000-394 in 2017 above the DWS, at a slight increase from 2016 values. EDB had not been detected historically in the off-site NSE plume. The temporary vertical profiles installed in the spring of 2018 confirmed the detections of EDB upgradient of well 000-394.

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

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 2017, 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 3.2.9-5** shows the overall plume size reduction from 2004 to 2017.

The monitoring data indicates that the slug of EDB contamination reached well 000-394 between June and August 2015. Upgradient well 000-138, screened 10 feet shallower than well 000-394 has not detected EDB since it was installed in 1997. The leading edge of this slug is migrating south to between NSE-1 and NSE-VP02-2018. There are no existing monitoring wells downgradient that are screened deep enough to detect the EDB identified in well 000-394. As discussed in **Section 3.2.9.3** above, characterization of the extent of the EDB contamination was initiated in March 2018. EDB was not detected above the DWS in the two vertical profiles installed between well 000-394 and NSE-1 (NSE-VP02-2018 and NSE-VP03-2018). EDB was not detected in NSE-1 in the 2017 quarterly samples using Method 504.

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**, following regulatory approval, the system was shut down since June 2014 and has remained in standby mode. Since 2014, there has been no rebound of VOCs in any of the monitoring wells or extraction wells, and there were no exceedances above the AWQS except for PCE (in 2017), and EDB. Due to the EDB detections above the DWS in well 000-394 since August 2015 and in the recent vertical profiles, the planned closure of the NSE system has been delayed.

3a. Are TVOC concentrations in plume core wells above or below 50 ug/L?
TVOC concentrations in all monitoring wells and extraction wells are below 50 μg/L. The maximum TVOC concentration detected in 2017 was in monitoring well 000-394 at 10.9 μg/L in the third quarter.

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 14 of the 15 plume monitoring wells from 2011 through 2017. Well 000-394 detected EDB above the DWS since 2015, and PCE above the AWQS in 2017.

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, or if EDB is detected in NSE-1. Continue quarterly sampling of NSE-1 for EDB and analyze using Method 504.
- Continue characterization of EDB around well 000-394 with vertical profiles, and install additional permanent monitoring wells, as appropriate.
- Update the groundwater model based on the EDB characterization data.
- Since VOCs have not been detected above AWQS in wells downgradient of extraction NSE-1 since 2005, further monitoring of these wells will be discontinued. These wells include 000-482, 000-483, 000-484, 000-485, and 000-486. Well 000-481 will continue to be sampled as a bypass monitoring well for NSE-1.
- Since VOCs have not been detected above AWQS in shallow perimeter well 000-137 since 2000, further monitoring of this well will be discontinued.

3.2.10 LIPA/Airport Treatment System

This section summarizes the 2017 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 south of 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 other 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 (EW-4L) on Stratler Drive has six monitoring wells associated with its operation. There are 12 wells associated with the Upper Glacial portion of the LIPA 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 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 2017 well data are posted on **Figures 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 2017 TVOC concentrations for the Magothy extraction well EW-4L on Stratler Drive were between 6 µg/L and 8 µg/L. As per a recommendation in the 2015 Groundwater Status Report this well was shut down in January 2017 due to achieving its capture goal of 50 µg/L TVOC concentrations.
- The Magothy monitoring wells located in the vicinity of extraction well EW-4L all detected concentrations below 50 µg/L TVOC during 2017. The highest TVOC concentration observed during 2017 was in well 000-460 at 8 µg/L in the fourth quarter.
- All of the LIPA monitoring wells are below the capture goal of 50 µg/L for the system. With the highest TVOC concentration in 2017 of 12 µg/L in well 000-131.
- Well EW-3L remained below AWQS throughout 2017. Extraction well EW-2L has shown a significant increase in TVOC concentrations during 2016 and 2017 with concentrations in 2017 ranging from 36 µg/L in April to 49 µg/L in October. Well EW-2L was restarted and operated for one Month in December 2017 due to the recent increase in concentrations. The January sampling event showed concentrations down to 18 µg/L. Well EW-1L also showed an increase in concentrations from 17 µg/L in April to 40 µg/L in October. The increases in concentrations may warrant restart of wells EW-1L or EW-2L. **Figure 3.2.10-3** plots the TVOC influent trends for the LIPA extraction wells.

Airport Monitoring

- Monitoring wells 800-94 and 800-95, are approximately 1,500 feet north of wells RTW-1A, RTW-2A, and RW-6A. In 2017, well 800-94 had TVOC concentrations of 76 µg/L in December and well 800-95 was 28 µg/L (**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 2017. Extraction well RW-6A showed TVOC concentrations up to 11 µg/L in 2017, with carbon tetrachloride exceeding the AWQS of 5 µg/L.
- Well 800-96 detected carbon tetrachloride concentrations ranging up to 57 µg/L in 2017 (**Figure 3.2.10-1**, **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 the capture goals for the past several years. In 2017, the TVOC concentration ranged from 7 µg/L to 15 µg/L. The concentrations are showing a downward trend in 2017. 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 deeper, detected TVOC concentrations up to 36 µg/L in May 2017.
- 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 24 µg/L to 31 µg/L in 2017. This is above the capture goal of 10 µg/L for the Airport extraction wells and warrants the continued operation of well RTW-4A, a Magothy extraction well.

- 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 is used to monitor higher concentrations of VOCs identified in upgradient well 800-92. VOC concentrations in this well were below AWQS in 2017.

3.2.10.4 System Operations

In 2017, 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. Two of the Airport extraction wells are on a pulsed pumping schedule (RTW-2A, RTW-3A), being pumped one week per month. Well RTW-5A is shut down. Wells RTW-1A, RTW-4A and RW-6A are pumped on a full-time basis. For the LIPA extraction wells Magothy extraction well EW-4L was put into standby mode in January 2017. Since TVOC concentrations remained below the capture goal of 50 μg/L. The other three LIPA wells are currently shut down as they have achieved the cleanup goals. However, EW-2L was temporarily placed into operation in December 2017 for one month due to elevated levels of VOCs (49 μg/L TVOC) just below the capture goal of 50 μg/L TVOC concentrations.

The following is a summary of the Airport/LIPA Treatment System operations for 2017:

January – September 2017

The Airport/LIPA System was operational in the first three quarters with RTW-1A, RTW-4A, and EW-6A operating on a full-time basis RTW-5A, and all four LIPA extraction wells were in standby. The remainder of the extraction wells at the Airport System were run one week per month on a pulsed pumping schedule. In January, the LIPA\Airport system was off for three days for a scheduled carbon change out. In February, RTW-3A was not operated due to an electrical repair. In March the system was off for five days for maintenance on RTW-2A. The system was off in April for two weeks to complete RTW-2A repair. The system was off for three days for a scheduled carbon change out in April. In July RTW-2A and RTW-3A were operated due to a communication malfunction. R In August RW-6A was off for one week due to an electrical repair. In September RTW-1A was down for one week for repairs.

October – December 2017

The Airport/LIPA system was down periodically in the fourth quarter for routine maintenance and a scheduled carbon change out in November.

Extraction Wells Operational Data

During 2017, approximately 196 million gallons of groundwater were pumped and treated by the Airport/LIPA system, with an average flow rate of 363 gpm (**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**

3.2.10.5 System Operational Data

System Influent and Effluent

VOC concentrations for the carbon influent and effluent in 2017 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 samples 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 shows that 13 pounds of VOCs were removed during 2017, with a total of 439 pounds removed since system start-up (**Figure 3.2.10-5)**.

Table 3.2.10-1
OU III LIPA/Airport Treatment System
2017 SPDES Equivalency Permit Levels

Parameters	Permit Level (µg/L)	Max. Measured Value (µg/L)
pH	5.5–7.5 SU	5.8-7.6 SU
carbon tetrachloride	5	<0.5
chloroform	7	1
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

3.2.10.6 System Evaluation

The Airport/LIPA system performance can be evaluated based on the 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 2017. However, LIPA extraction wells EW-1L and EW-2L continued to show an increasing concentration trend during 2017. Due to this increasing trend, well EW-2L was operated in December 2017. This well showed a reduction in TVOC concentrations from 49 µg/L in October to 17 µg/L in January 2018 when the well was shut down.

2. Has the downgradient migration of the plume been controlled?
Yes. 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 the 10 µg/L capture goal have been detected in the bypass monitoring wells at the Airport. Based upon these 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 all four LIPA wells are shut down as they have reached their capture goals. Two of the six Airport extraction wells are being pulsed pumped and one is shut down.

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 all of the monitoring wells on 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 57 µg/L in December. Wells 800-94 and 800-95 showed maximum TVOC concentrations of 83 µg/L and 34 µg/L, respectively. Well 800-90 showed a peak TVOC concentration of 36 µg/L in 2017.

4a. Is there a significant concentration rebound in core wells and/or extraction wells following shutdown?
Yes, a rebound in LIPA extraction wells EW-1L and EW-2L was observed in 2016 and 2017. Although the levels are still below the capture goal of 50 µg/L, EW-2L was operated for one month

as noted above. If this trend continues, restart of either or both of these wells may be required. None of the monitoring wells in this area show an increasing trend.

5. Has the groundwater cleanup goal of meeting MCLs been achieved?
No, the cleanup goal has not been met. Based on monitoring 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 for wells RTW-2A and RTW-3A and continue full time operation of wells RTW-1A, RTW-4A and RW-6A. Keep well RTW-5A in shutdown mode. 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 wells that are not operating, the well(s) will be put back into full-time operation.
- Maintain LIPA wells EW-1L, EW-2L, EW-3L and EW-4L in standby mode. These extraction wells may be restarted if TVOC concentrations rebound above the 50 µg/L capture goal in either the plume core monitoring wells or the extraction wells.
- The Airport monitoring wells changed to the O&M phase monitoring frequency. Change the LIPA monitoring wells to the standby monitoring frequency.

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3.2.11 Magothy Aquifer

This section provides a brief summary of the Magothy Aquifer Groundwater Monitoring and Cleanup Program and the remedial approach for addressing VOC contamination. The 40 monitoring wells and nine extraction 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, OU III South Boundary, Industrial Park, Industrial Park East and OU III Central monitoring. A brief summary of the results is provided on **Table 3.2.11-1 and Figure 3.2.11-2**.

Table 3.2.11-1. Magothy Aquifer Contamination (Historical and 2017).

	Max. TVOC (in µg/L)			
Location	2017	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	110	340	PCE, CCl_4	VOCs identified in upper 20 to 40 feet of Magothy at the Middle Road area where Magothy brown clay is absent (Figure 3.2-2). Well 113-09 had 110 µg/L TVOC in April 2017, and well 113-19 had 41 µg/L in April 2017. VOCs not detected at South Boundary beneath the clay.
Industrial Park	63	268	PCE TCA	VOCs identified in the upper Magothy south of the south boundary system. Two Magothy extraction wells were installed in the Industrial Park in 2014 to capture and treat this contamination. Maximum TVOC concentrations were detected in well 127-08 at 63 µg/L in January 2017.
North Street	36	123	TCE, DCA	VOCs have been detected in localized areas in the upper 30 feet of the Magothy aquifer along North Street and downgradient near Vita Drive (Figure 3.2.8-2). Well 800-90 had a TVOC concentration of 36 µg/L in May 2017. The leading edge of this contamination is at the eastern portion of the Airport system, with 31 µg/L TVOC in well 800-101 in December 2017, which is adjacent to Airport extraction well RTW-4A. 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. A TVOC concentration of 10 µg/L was detected in well 000-343 in May 2017.
South boundary Industrial Park East	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 Magothy 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 November 2017. This is the highest TVOC concentration identified in this area. The monitoring well located on the corner of Boxwood and Stratler Drives (000-526) had no VOCs above MCLs.
South of Carleton Drive	16	7,200	CCl_4	Historically high VOC concentrations just south of Carleton Drive where the Magothy brown clay is absent. Contamination is continuous between Magothy and Upper Glacial aquifers. Well 000-130 showed a maximum TVOC concentration of 2 µg/L in December 2017. Well 000-460 located on Stratler Drive showed a TVOC concentration of 9 µg/L in January. These concentrations have declined significantly from the historical highs.

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

1. Reaching MCLs in the Magothy aquifer by 2065 by active groundwater treatment and natural attenuation.
2. Operation of the nine extraction wells until cleanup objectives are met as part of the treatment systems that provide capture of Magothy VOC contamination at Middle Road (RW-7 and RW-3), South Boundary (EW-17 and EW-8), Airport (RTW-3A and RTW-4A), Industrial Park (IP-EW-8 and IP-EW-9), and LIPA (EW-4L).
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 wells at Middle Road (RW-3 and RW-7). Continue to monitor the three Magothy monitoring wells at Middle Road and five at the South Boundary until cleanup goals are met. Continue to operate South Boundary well EW-17.
North Street	The Airport extraction wells (RTW-3A and RTW-4A) to continue to capture contaminants that were past the North Street 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	The LIPA Magothy extraction well (EW-4L) on Stratler Drive has met cleanup goals and is now in standby. Continue monitoring until MCLs are met.
Industrial Park	Continue operation of the two industrial park extraction wells (IP-EW-8 and IP-EW-9). Continue monitoring and data evaluation.

3.2.11.1 Monitoring Well Results

See the appropriate sections for detailed discussion of the monitoring well results.

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. See **Table 1-5**.
- Continue pumping the Magothy extraction wells at Middle Road, South Boundary, Airport and the new IP wells. The North Street, North Street East and LIPA Magothy extraction wells are currently in standby as they have reached the OU III capture goals identified for shutdown of these wells. The IPE extraction well was abandoned as it had reached its cleanup goal.

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 were not large enough to warrant a dedicated monitoring program, they were 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. In 2015, due to low concentrations of VOCs, all monitoring was discontinued in this program except for monitoring wells 109-03 and 109-04.

3.2.12.1 Groundwater Monitoring

Well Network

The monitoring well network is comprised of two wells, 109-03 and 109-04 (**Figure 3.2.12-1**).

Sampling Frequency and Analysis

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 SCDHS.

3.2.12.2 Monitoring Well Results

No VOCs were detected above AWQS in 2017. The highest VOC detected was 3.3 µg/L of TCE in well 109-03. There were no confirmed detections of radionuclides in wells 109-03 and 109-04 during 2017.

3.2.12.3 Groundwater Monitoring Program Evaluation

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

1. Have the SCWA William Floyd Well Field sentinel wells remained below the MCLs?
Yes, during 2017, no VOCs or radionuclides were detected at concentrations exceeding the MCLs.

3.2.12.4 Recommendation

No changes are recommended for the OU III Central Monitoring Program.

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3.2.13 Miscellaneous Sampling

This section details the non-routine sampling activities conducted during 2017.

3.2.13.1 1,4-Dioxane Sampling

Based on a request from the NYSDEC, BNL sampled 22 monitoring wells for 1,4-dioxane in January 2017 (**Figure 3.2.13-1)**. These data was reported in the *2016 Annual Groundwater Status Report*. USEPA Method 522 was used to obtain low level detection limits. Seventeen of the 22 samples collected from monitoring wells in January 2017 had detectable levels of 1,4-dioxane. All results were below the current NY State unspecified organic contaminant groundwater water standard of 50 µg/L (**Table 3.2.13-1**).

After reviewing these results, the SCDHS requested further sampling to obtain additional baseline data on the distribution of 1,4-dioxane at BNL. SCDHS requested that samples be collected from treatment system effluent, the STP, and monitoring wells downgradient from the Former Landfill, the Current Landfill and the STP. Therefore, samples from seven additional monitoring wells, the effluent from five treatment systems and the STP were collected and analyzed for 1,4-dioxane in December 2017 and January 2018. The monitoring wells are located downgradient of the STP, in the area of the former OU V monitoring program and downgradient of the Current and Former Landfills. The treatment system effluent samples included Building 96, Western South Boundary, combined Middle Road and OU III South Boundary, Industrial Park, and Airport/LIPA. All 1,4-dioxane results were below the current NY State unspecified organic contaminant groundwater water standard of 50 µg/L (**Table 3.2.13-1**). The locations for all sampling points are on **Figure 3.2.13-1**.

During the January 2017 sampling event, the highest 1,4-dioxane result was 18.6 µg/L detected in monitoring well 000-530 located in the OU III Industrial Park. During the December 2017 sampling event, five of the seven monitoring wells detected 1,4-dioxane. The highest 1,4-dioxane results was 9.08 µg/L detected in monitoring well 000-122 located in the former OU V monitoring program area. Four of the five treatment system effluent samples detected 1,4-dioxane with the highest concentration of 7.14 µg/L reported at the OU III Industrial Park. 1,4-Dioxane was not detected in the STP effluent.

3.2.13.2 Perfluorinated Compounds (PFCs)

Per-fluorinated Compounds (PFCs) are emerging contaminants of concern in groundwater, and were recently tested for in BNL potable water supply wells under the Third Unregulated Contaminant Monitoring Rule (UCMR3) program. During 2017, PFCs were detected in water samples collected by the SCDHS from BNL potable supply wells 6, 10 and 11. The maximum combined concentrations of the chemicals perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA), was 24.26 ng/L in the August 2017 sample from supply well 10. The EPA Health Advisory Level (HAL) for combined PFOS and PFOA concentrations is 70 ng/L.

The use of fire suppression foam has been linked to a number of PFC groundwater plumes recently discovered on Long Island. Based upon historical records and employee recollections there are a number of areas where firefighting foam may have been released to the environment at BNL. However, documentation on the chemical formulations for the foam is not available. In 2018, BNL will install temporary Geoprobe wells to characterize the distribution of PFCs in groundwater within the 2-year source water contributing areas of BNL potable supply wells. Furthermore, quarterly PFC analyses will be added to the BNL potable well monitoring program.

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3.2.14 OU III South Boundary Radionuclide Monitoring Program

The South Boundary Radionuclide Monitoring Program is used to confirm that radionuclides are not currently migrating south of the BNL site. The sampling was conducted in conjunction with the OU III South Boundary, and Western South Boundary Programs. The OU I portion of the south boundary is discussed in **Section 3.1**.

3.2.14.1 Groundwater Monitoring

A network of 42 monitoring wells is used to monitor radionuclides from the OU III South Boundary, and OU III Western South Boundary programs. The well locations along the southern property boundary are shown 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 2017.

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 OU III South Boundary Radionuclide Groundwater Monitoring Program during 2017.

3.2.14.4 Recommendations

No changes are recommended for South Boundary Radionuclide Groundwater Monitoring Program.

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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**).

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 were placed in standby mode in 2016. 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. SR-6 was placed in a pulsed pumping mode in 2016. During 2017, wells SR-4, SR-5 and SR-6 were in stand-by mode. Wells SR-3 and SR-7 operated in a one month on, one month off pulsed pumping schedule.

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 69 monitoring wells is used to monitor the Sr-90 plumes associated with the BGRR, WCF, and PFS/Building 801 areas. Three temporary wells (see **Figure 3.2.15-1** for locations) were installed in April 2017 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 2017, 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 2017 sampling round supplemented with data from the temporary wells which were sampled during April of 2017. **Table 3.2.15-1** contains the temporary well data for 2017. In addition, historical Sr-90 concentration trends for key wells are plotted on **Figure 3.2.15-2**.

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 former 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 former WCF (Building 811). The highest historical Sr-90 concentration in the former PFS/Building 801 Area (566 pCi/L) occurred in 1997 in a temporary well installed immediately downgradient of this area.
A comparison of the plume from 2004 through 2017 is provided on **Figure 3.2.15-7.** The three Sr-90 plumes were characterized extensively for the first time with numerous temporary wells in 1998. The permanent monitoring network was enhanced significantly in 2004 prior to the startup of groundwater treatment operations. Groundwater flow conditions have changed significantly in this area since the late 1990s. This is due to changes in supply, process, and remediation pumping and recharge in the east-central portion of the site. Flow has shifted from a southerly to southeasterly direction in response to the changes. As a result, a number of permanent wells are no longer in optimal locations for monitoring Sr-90. Some older wells have been dropped from the monitoring network over the past several years and temporary wells are increasingly required to fill data gaps. The following is a summary of the 2017 monitoring data for the three Sr-90 plumes:

WCF Plume

The removal of Building 811 and associated radiologically contaminated structures and soils was completed in 2016. Extraction wells SR-1 and SR-2 have been effective at capturing source area contamination and preventing any further migration of the plume as can be viewed on **Figure 3.2.15-7**. **Section 3.2.15-6** discusses Sr-90 concentration increases in SR-1 that may have been related to the 2016 remediation activities. The downgradient portion of this plume over the past several years has been influenced by the easterly shift in groundwater flow, particularly in the vicinity of the HFBR and areas just to the west of that building.

- Monitoring well 065-175 has historically shown the highest Sr-90 concentrations immediately downgradient of the WCF source area. 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 since 2014 and has been below 33 pCi/L since October 2015 **(Figure 3.2.15-2)**. There is the potential for an increase in Sr-90 following building decommissioning and soil remediation work in the WCF yard that was completed in 2016 however, no significant increase has been observed to date in this well.
- Monitoring well 065-160 had a concentration of 27 pCi/L in October 2017. There was an uptick in Sr-90 concentrations in this well over the past year. The increase is likely due to the shutdown of extraction well SR-1 (located between the well and the source area) for six months during 2016. The shutdown was associated due to a steam leak which was heating the subsurface in the vicinity of SR-1. The Sr-90 concentration in SR-1 increased significantly during the December 2017 sampling round up to 100 pCi/L. The highest concentration in this well over the five previous years was 27 pCi/L. This increase could be due to the recent soil remediation activities in the source area (**Figure 3.2.15-6**).
- Three temporary wells were installed immediately southeast of the HFBR building to supplement the permanent monitoring well network, and evaluate the leading edge of higher concentrations

originating from the WCF. The highest Sr-90 concentration in this area was 34 pCi/L in BGRR GP-108. A shift in groundwater flow to a more southeasterly direction has been observed in this area, and seems to be correlated with the approximate 80% reduction of water to recharge Basins HO and RAV in recent years. The shift is most pronounced from the WCF source area **(Figure 2-2)** south to the vicinity of the HFBR. Flow then resumes a more traditional southerly direction near Temple Place and Brookhaven Avenues. Based on the 2017 data, it is apparent that the shifting groundwater flow direction is impacting the monitoring network and a more extensive supplementing of temporary wells will be necessary in 2018.

BGRR (Building 701 Area) Plume

Source area monitoring wells 075-664 (screened 65-75 ft. bls) and 075-701 (screened 48-68 ft. bls) have been sampled on a monthly basis since late 2012. The increased sample frequency is to obtain sufficient data to establish the relationship between water table elevations and Sr-90 concentration increases in the source area. Sr-90 concentrations in well 075-664 have been slightly above detectable levels since January 2016. Concentrations in well 075-701 have been below the DWS over the same time period, with the exception of one sampling event. This data correlates with the steadily decreasing water table elevations observed over the previous eight years. 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.

- **Figure 3.2.15-3** plots water table elevation data against Sr-90 concentrations over time and shows a correlation between high water table periods and increased Sr-90 concentrations in the source area monitoring wells and SR-3. The water table elevation across the site continued to decline throughout 2017. Sr-90 concentrations in SR-3 have been declining slowly the past several years and are currently just above detectable levels.
- The BGRR cap monitoring wells have now been in place for seven years. Sr-90 concentrations in monitoring wells 075-699 and 075-700 have dropped off significantly. Initial high concentrations in these wells were 40 pCi/L (April 2012) and 104 pCi/L (April 2013), respectively. Concentrations over the past three years are just over detectable levels.
- Wells 085-398 and 085-403 monitor the leading edge of the Building 701 Sr-90 plume. Concentrations have been steadily increasing in both wells from barely detectable levels several years ago to 9 pCi/L in 085-398 and 20 pCi/L in 085-403 during October 2017.
- Much of the plume mapping from Cornell Avenue to the leading edge is based on the projection of temporary well data from several years ago. A recommendation will be made in this report to install additional temporary wells to better assess the status of the plume in this area.

Former Pile Fan Sump/Building 801 Plume

- Sr-90 concentrations have remained low in the area just south of the former Pile Fan Sump and Building 801 during the past several years. Based on previous monitoring there is an area of inferred Sr-90 concentrations greater than 50 pCi/L that has now migrated to the south of the source area well network (**Figure 3.2.15-1**).

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 2017 while the system was operating, samples from the influent, effluent, and midpoint locations of the treatment system were collected twice a month. The influent was also analyzed for tritium. Extraction well Sr-90 concentrations from 2017 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 2017, wells SR-4, SR-5 and SR-6 were in stand-by mode. Wells SR-3 and SR-7 operated in a one month on, one month off pulsed pumping schedule. Operating details are given in the O&M manual for this system (BNL 2012c). Below is a summary of the system operations for 2017.

January – September 2017

The system was off from February 8 to February 24 for a resin vessel change-out. In March, the system was turned off February 21 for a bag filter change out and restarted on February 28. Well SR-6 was off from July 14 to July 25 due to equipment repairs. The system was off from September 6 to September 19 for a resin vessel change out. During this period wells SR-3 and SR-7 ran on a one month on, one month off pulsed pumping schedule while wells SR-4, SR-5 and SR-6 remained in standby. The system treated approximately 18 million gallons of water during this period.

October – December 2017

The system was off from November 21 to December 13 for a resin vessel change out. The system operated normally for the remainder of this period. During this period, wells SR-3 and SR-7 ran on a one month on, one month off pulsed pumping schedule while wells SR-4, SR-5 and SR-6 remained in standby. The system treated approximately 5 million gallons of water during this period.

Extraction Well Operational Data

During 2017, approximately 23 million gallons of water were treated by the remediation system, with an average flow rate of 45 gpm. **Table 3.2.15-2** shows the monthly extraction well pumping rates while **Table F-39** shows Sr-90 concentrations.

3.2.15.5 System Operational Data

During 2017, influent concentrations of Sr-90 ranged from 3.5 pCi/L to 9.7 pCi/L. The highest influent tritium concentration during 2017 was 940 pCi/L in May (**Table F-40**). During 2017, Sr-90 was detected in the effluent at a maximum concentration of 3.3 pCi/L. There were no VOCs or Sr-90 detected above the SPDES Equivalency Permit discharge limits in the 2017 effluent samples (**Table 3.2.15-3**).

Extraction Wells

Maximum Sr-90 concentrations in each of the extraction wells during 2017 were as follows:

- SR-1 99.5 pCi/L in December
- SR-2 17.9 pCi/L in July
- SR-3 1.2 pCi/L in February
- SR-4 1.4 pCi/L in January
- SR-5 2.1 pCi/L in October
- SR-6 6.9 pCi/L in January
- SR-7 6.4 pCi/L in April
- SR-8 8.2 pCi/L in January
- SR-9 15.2 pCi/L in January

Table 3.2.15-3
BGRR Sr-90 Treatment System
2017 SPDES Equivalency Permit Levels

Parameter	Permit Level	Max. Measured Value
pH range	5.5–8.5 SU	5.8–7.8 SU
Sr-90	8.0 pCi/L	3.3
Chloroform	7.0 µg/L	<0.5
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	<0.5
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	0.9
1,2,4-Trimethylbenzene	5.0 µg/L	<0.5
Xylene, total	10.0 µg/L	<0.5

Notes:

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SU = Standard Units

Required sampling frequency is monthly for Sr-90 and VOCs, and weekly for pH.

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 2017, the flow averaged 44 gpm. Approximately 0.5 mCi of Sr-90 was removed during 2017, for a total of 27.3 mCi removed since system start-up in 2005 (**Table F-42**). Cumulative mass removal of Sr-90 is shown on **Figure 3.2.15-4**. **Figures 3.2.15-5** and **3.2.15-6** 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: 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. The excavated areas were backfilled in September 2016. Sr-90 concentrations in monitoring well 065-175 (located immediately downgradient of the WCF yard) dropped off significantly in 2014-2015 from levels previously greater than 300 pCi/L. Concentrations have stabilized in the range of 14 to 33 pCi/l over the past three years. There was a sharp increase in Sr-90 concentration in extraction well SR-1 up to 100 pCi/L in December 2017. Concentrations have since declined to 25 pCi/L in March 2018, but these levels are higher than what was being observed for several years prior to December 2017. One explanation for this increase could be the mobilization of Sr-90 to the water table as a result of recently concluded remediation activities in the source area.

BGRR Plume: The source area is capped by a combination of Building 701 and an engineered cap that was completed in 2011. The source area is being monitored to determine whether there are continuing releases of Sr-90 beneath the building. Concentrations in source area monitoring wells have been low since 2015. Sr-90 concentrations in source area extraction well SR-3 have been just above detectable levels since late 2016. The BNL site has observed declining water table conditions since 2010. The low Sr-90 values in source area wells could have several explanations. Capping and/or depletion of the inventory remaining in the vadose zone beneath Building 701 and the BGD are possibilities. The absence of any water table increase over the past several years that could flush the vadose zone of residual Sr-90 is another. Monitoring will continue in this area in 2018.

PFS/Building 801 Area Plume: Sr-90 concentrations in source area monitoring wells showed slight increases in 2017. Sr-90 concentrations in this plume are expected to attenuate and 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 part of the plume bypassing the capture zone of SR-9. The Sr-90 concentrations to the east of SR-9 are well below the system capture goal of 175 pCi/L and are expected to naturally attenuate and meet the ROD cleanup goals.

BGRR Plume: Extraction well SR-3 is positioned to capture the migration of Sr-90 from the source area. Due to the low Sr-90 concentrations in this area the well was pulsed pumped on a monthly basis during 2017.

PFS/Building 801 Area Plume: This plume is not being actively remediated. 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 residual Sr-90 contamination immediately downgradient from the WCF source. Extraction well SR-6 is currently in stand-by mode. SR-7 is currently in a pulsed pumping mode and should be placed in standby mode based on the consistently low Sr-90 concentrations and absence of any significant rebound over the past year. SR-8 can be shifted to a pulsed pumping mode based on the low Sr-90 concentrations observed over the past year.

BGRR Plume: Based on Sr-90 concentrations just above detectable levels over the past eighteen months, place extraction well SR-3 in standby mode. Extraction wells SR-4 and SR-5 will be maintained in standby mode.

PFS/Building 801 Area Plume: This plume is not being actively remediated.

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

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:

- Place extraction wells SR-3 and SR-7 in standby mode based on low Sr-90 concentrations. Place SR-8 in pulsed pumping mode (one month on and one month off) based on low Sr-90 concentrations.
- Maintain source area monitoring frequency of monthly for BGRR source area well 075-701.
- Continue operating wells SR-1, SR-2, and SR-9 in full time mode. Maintain wells SR-4, SR-5, and SR-6 in standby mode.
- Change SPDES sampling frequency from bi-monthly to monthly.
- Maintain the semi-annual sampling frequency of WCF well 065-160 to due to increased concentrations in 2016-17. Maintain semi-annual sampling frequency of 085-398 and 085-403 based on the advance of the leading edge of plume into this area.

- Supplement the current monitoring network with temporary well data in order to get a comprehensive status of the plumes and account for well network gaps and groundwater flow related plume shifts. Areas of focus will include:
    - Immediately south of Building 701/BGDs and cap.
    - Areas in between Buildings 535 and 725 in line with BGRR/BGDs and PFS plumes.
    - Center line of BGRR/BGD plume south of Brookhaven Avenue.
    - Approximately 150 feet south of PFS and Building 801 source area.
    - Southeastern edge of former WCF yard.
    - Areas just north and south of HFBR and south of Temple Place in high concentration and leading edge portions of the WCF plume.
- 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 2017 and gives conclusions and recommendations for future operation. This system began operation in February 2003. Due to the declining Sr-90 concentrations over the last several years, a *Petition for Shutdown of the OU III Chemical Holes Strontium-90 Groundwater Treatment System* was submitted to the regulators in March 2018 for review and approval.

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 the 8 pCi/L DWS by 2040.
3. Continued monitoring and evaluation of the data to ensure protectiveness.

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

3.2.16.2 Groundwater Monitoring

Well Network

The Chemical/Animal Holes monitoring network consists of 33 wells. As recommended in the *2016 Groundwater Status Report*, due to Sr-90 concentrations remaining less than DWS for several years, monitoring of three wells were discontinued in the fourth quarter 2017 (106-04, 106-15, and 106-97). **Figures 1-2** and **3.2.16-1** show the monitoring well locations.

Sampling Frequency and Analysis

To help support a decision for shutdown, the sampling frequency for the monitoring wells is semi-annual (shutdown phase). However, the three upgradient wells that monitor the former source area have been monitored quarterly since they were installed in 2015.

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 and fourth quarter 2017 monitoring well data and the temporary well data from late 2015 in the area upgradient of EW-1.

The area of highest concentration (up to 40 pCi/L) is currently located immediately upgradient of extraction well EW-1. Lower concentrations are identified south of the Princeton Avenue firebreak. Overall, the plume concentrations have significantly decreased. 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 50 pCi/L since mid-2015. As shown on **Figure 3.2.16-6**, the plume is now discontinuous as a result of the operation of the treatment system. See **Figure 3.2.16-2** for concentration trends of key monitoring wells and **Figure 3.2.16-3** for a cross-sectional view. The complete monitoring results for all wells in this program are in **Appendix C**.

Sr-90 concentrations in monitoring wells have been significantly reduced over the last ten years. It should be noted that drought conditions over the last few years has resulted in the lowering of the water table which may impact flushing of Sr-90 from the vadose zone in the former source area. This could have an effect on the Sr-90 concentrations in the monitoring wells between the former source area and EW-1. From system startup in 2003 through 2016, the water table elevation in the Chemical Holes area has decreased from approximately 40 feet above mean sea level (MSL) to 33 feet above MSL.

A summary of key monitoring well data for 2017 follows:

Former Source Area to EW-1:

- Sr-90 concentrations in all plume core wells have declined over the past several years as evidenced in the trends. The maximum Sr-90 concentration detected in a monitoring well in 2017 was 28 pCi/L in 106-94. This well is located between the former source area and EW-1. As seen on the plume comparison on **Figure 3.2.16-6**, the plume has become discontinuous and Sr-90 concentrations have been significantly reduced as a result of the groundwater remediation efforts in this area.
- Sr-90 concentrations in plume core well 106-95, located between 106-94 and EW-1 have declined following a spike in concentration in 2015 of 178 pCi/L. Concentrations of Sr-90 in this well ranged from 5 pCi/L in the first quarter 2017 to 30 pCi/L in January 2018.
- Sr-90 concentration trends in plume core wells 106-16 and 106-99 have significantly declined over time to less than 20 pCi/L since 2016. These wells are also located immediately upgradient of EW-1.
- Although Sr-90 has been detected up to 96 pCi/L in monitoring well 097-314 in 2015 at the former source area, concentrations have decreased from those that were observed in the 2008 and 2012 temporary wells installed at this location. Since 2016, Sr-90 concentrations in this well were less than the DWS. Wells 097-313 and 097-315 did not detect Sr-90 in 2017.

Downgradient of EW-1:

- Perimeter monitoring well 106-135 remained less than the DWS since 2014. The temporary well installed at this location in 2010 identified Sr-90 at 85 pCi/L. Monitoring well 106-136, installed in June 2015 south of Princeton Avenue further defines the plume segment downgradient of well 106-135. Sr-90 was detected in this well up to 14 pCi/L in 2017.
- Plume core well 106-125, located upgradient of EW-2, detected a peak concentration of 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 2017 up to 9 pCi/L. Plume core well 106-119, located upgradient of the southern-most extraction well EW-3 has remained below the DWS since 2013.

By-pass Wells:

- Sr-90 was only detected twice in bypass wells 106-120, 106-121, and 106-122 since 2013. Well 106-121 detected 2 pCi/L and 0.8 pCi/L in 2015 and 2016, respectively. There were no detections in these wells in 2017. These wells are approximately 100 feet downgradient of EW-3.
- Sr-90 concentrations in wells 106-23, 106-62, 106-63 have remained less than the DWS for several years. Bypass well 106-22 detected Sr-90 at 16 pCi/L in the third quarter 2017. However, the rounds prior to and after did not detect Sr-90. These wells are located along Middle Path approximately 600 feet downgradient and to the southwest of extraction well EW-3.

3.2.16.4 System Operations

In April 2016, extraction well EW-1 began to run in a one month on, one month off pulsed pumping mode. In October 2016, wells EW-2 and EW-3 were placed in stand-by mode. During 2017, the influent, midpoint, and effluent locations were sampled twice per month when the system was operating. The samples were analyzed for Sr-90 and the effluent samples were also 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 5.2 pCi/L in EW-2.

Sr-90 concentrations for the system influent and effluent in 2017 are presented in **Tables F-44** and **F-45**. The maximum Sr-90 influent concentration in 2017 was 3.8 pCi/L. There were two detections of Sr-90 in the system effluent in 2017 with a maximum of 3.2 pCi/L in March. A resin vessel change-out was performed in the second quarter 2017. **Table F-46** contains a summary of the monthly Sr-90 mass removal for the system.

Summarized below are the system operations data for 2017.

January – September 2017

The system was off from May 1st to May 4th for a vessel change-out and May 18th to 30th to replace a flow meter. The system ran normally the rest of this period. The system treated approximately 1.4 million gallons of water from January through September.

Table 3.2.16-1.
Chemical Holes Sr-90 Treatment System
2017 SPDES Equivalency Permit Levels

Parameter	Permit Level	Max. Measured Value
pH range (SU)	5.0–8.5	5.2–7.3
Sr-90 (pCi/L)	8.0	3.2

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

October – December 2017

The system operated normally October through December. Approximately two hundred and twenty thousand gallons of water was treated during this period.

3.2.16.5 System Operational Data

In April 2016, extraction well EW-1 began to run in a one month on, one month off pulsed pumping mode and in October 2016 wells EW-2 and EW-3 were placed in stand-by mode. Concentrations of Sr-90 in EW-1 have steadily dropped-off since 2009 and were less than 3 pCi/L in 2017. 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 were below the DWS in 2017. **Figure 3.2.16-4** presents the extraction well data over time. The 2017 analytical data show that influent Sr-90 concentrations ranged from 0.8 pCi/L to 3.8 pCi/L (**Table F-44**). The effluent samples had two Sr-90 detections at 1.5 pCi/L and 3.2 pCi/L. Approximately 1.6 million gallons of groundwater were treated during 2017.

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 3 gpm during 2017. **Table 3.2.16-2** shows the monthly extraction well pumping rates. The cumulative total mass of Sr-90 removed was approximately 0.013 mCi during 2017, with a total of approximately 4.93 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 106-314 in 2015 in the upgradient portion of the plume, concentrations have decreased from those that were observed in the 2008 and 2012 temporary wells installed at this location. Since 2016, Sr-90 concentrations in this well were less than the DWS. 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 ten years. This is indicative of the progress of the active remediation.

2. Were unexpected levels or types of contamination detected?
There were no unexpected levels or types of contamination detected in 2017.

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. Operation of EW-2 and EW-3 controlled the downgradient portion of the plume.

4*. Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?*
The groundwater modeling performed for this plume during the system design 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 EW-1 have declined in recent years, due to the elevated detection in early 2015 at 178 pCi/L, the system needed to continue operating. Sr-90 concentrations have significantly dropped off in the former source area and upgradient core monitoring wells since late 2015. Influent Sr-90 concentrations have also been significantly reduced to less than 4 pCi/L in 2017. The conditions outlined in the *Operation and Maintenance Manual for the Chemical Holes Groundwater Treatment System* (BNL 2008b) for shutdown have been met. As a result, a *Petition for Shutdown of the OU III Chemical Holes Strontium-90 Groundwater Treatment System* was submitted to the regulators in March 2018 for review and approval.

4a. Are Sr-90 concentrations in plume core wells above or below 8 pCi/L?
Sr-90 concentrations in 3 of 19 core wells were above 8 pCi/L in 2017 with a maximum of 40 pCi/L.

4b. Is there a significant concentration rebound in core wells and/or extraction wells following shutdown?
The system was placed in a pulsed pumping mode (one month on and one month off) in October 2014. In the first quarter of 2015, Sr-90 was detected at 178 pCi/L in well 106-95 (immediately upgradient of EW-1). Since then, the Sr-90 concentrations have dropped off to less than 10 pCi/L since the third quarter of 2016.

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 the projected attenuation of the remaining Sr-90 concentrations, the DWS is expected to be achieved by 2040. Comparison of the current plume with a series of plume snapshots dating back to 2002 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:

- Until regulatory approval of the Petition for Shutdown is approved by the regulators (submitted in March 2018), continue to operate extraction well EW-1 in pulsed pumping mode (one month on and one month off) and maintain EW-2 and EW-3 in standby. If significant rebound is identified, these extraction wells may be restarted.
- Following system shutdown, change the sampling frequency for the monitoring wells to the standby phase, and maintain quarterly sampling of the extraction wells.
- Due to Sr-90 concentrations remaining less than DWS for several years, discontinue monitoring the following monitoring wells:
    - 106-22 - downgradient sentinel well currently sampled semi-annually that has never exceeded the DWS since it was installed in 1997.
    - 106-23 – downgradient sentinel well currently sampled semi-annually that has never exceeded the DWS and has and has not detected Sr-90 since 2006.
    - 106-62 - downgradient sentinel well currently sampled semi-annually that has never exceeded the DWS and has and has been less than 3.0 pCi/L since it was installed in 1998.
    - 106-63 - downgradient sentinel well currently sampled semi-annually that has never exceeded the DWS and has and has not detected Sr-90 since 2004.

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3.2.17 HFBR Tritium Pump and Recharge System

In late 1996, tritium was detected in monitoring wells near the HFBR. The source of the release was traced to the HFBR spent fuel pool. In response, the fuel rods were removed and the spent fuel pool was drained. In May 1997, a three-well groundwater pump and recharge system was constructed on the Princeton Avenue firebreak road, approximately 3,700 feet downgradient of the HFBR to capture the leading edge of the tritium plume should it be necessary to 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 2013d) 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

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 34 wells is used to monitor the source area and verify the predicted attenuation of the plume (**Figure 1-2 and 3.2.17-1**).

Sampling Frequency and Analysis

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

3.2.17.3 Monitoring Well Results

Figure 3.2.17-1 displays postings of fourth quarter 2017 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. The only tritium detections above the DWS were in well 075-42 during three sampling events in 2017, with concentrations ranging from 22,400 pCi/L to 23,200 pCi/L. **Appendix C** contains the complete set of monitoring well data.

Following shutdown of the system in May 2013, groundwater monitoring data indicate that tritium concentrations in the monitoring wells have not rebounded above 20,000 pCi/L at Weaver Drive. In addition, the maximum tritium concentration identified in the 11 temporary wells installed in 2013 and 2014 between Weaver Drive and EW-16 was 9,050 pCi/L. These data are consistent with the closure criteria. A summary of tritium sampling results from the permanent monitoring wells since 2013 is provided as in the *HFBR Tritium Plume Pump and Recharge System Petition for Closure* (BNL 2018b).

Comprehensive annual summaries of monitoring well data for this plume since the pump and recharge system was placed in standby in 2013 can be found in the annual BNL Groundwater Status Reports. The most recent detection of tritium in the plume above the DWS was 57,300 pCi/L in well 075-44 in March 2018. This well is located on the lawn of the HFBR. This is also the maximum tritium concentration identified in the monitoring wells since 2013.

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 remaining tritium inventory in 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 March 2018 detection of 57,300 pCi/L in well 075-44 appears to be in response to the two foot increase in water table elevation that occurred slightly less than a year prior. The figure also demonstrates how the magnitude and frequency of these events has decreased over the 20 years of monitoring. Based on the decreasing concentration trend, the inventory of tritium beneath the HFBR that is affected by the water-table flushing has significantly decreased over the years.

The lowering of the water table over most of the past eight years has had an impact on the flushing of tritium from the vadose zone under the HFBR. This has probably affected tritium concentrations in the monitoring wells downgradient of the HFBR. From 2013 through 2016, the water table elevation immediately downgradient of the HFBR was lowered from approximately 43 feet above mean sea level (MSL) to 37 feet above MSL. There was an approximately three foot rise in the water table elevation in 2017 to 40 feet MSL. This correlates with the spike to 57,300 pCi/L in well 75-44 from the March 2018 sample round. A similar water table increase has been observed at the site during the February-March 2018 time-frame. The wells downgradient of the HFBR will be monitored for a tritium concentration increase in response to the latest water table changes.

All data from permanent and temporary wells indicate that the downgradient tritium plume segment attenuated to less than the DWS in 2010 and 2011, prior to system shutdown. The *HFBR Tritium Pump and Recharge System Petition for Closure* includes additional analyses which demonstrate the attenuation of the HFBR tritium plume.

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 2017. The treatment system was in standby mode throughout 2017. All extraction well tritium concentrations in 2017 were below 750 pCi/L.

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 is decreasing based on the documented decreases in tritium concentrations in groundwater immediately downgradient of the building. The site water table elevation has been consistently low over the past several years as compared to historical values. This could be minimizing any flushing effect on the remaining inventory beneath the HFBR. The highest concentration observed in the source area during 2017 was 23,200 pCi/L in monitoring well 075-42. 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**. A water table increase has been observed at the site during the February-March 2018 time-frame. The wells downgradient of the HFBR will be monitored for a tritium concentration increase in response to the latest water table changes.

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 2017.

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. A Petition for Closure was submitted to the regulatory agencies in June 2018.

5a. Are tritium concentrations in extraction wells above or below the 20,000 pCi/L DWS?
There have been no tritium detections in an extraction well above 1,000 pCi/L since 2014. The highest tritium detection in an extraction well dating back to the beginning of operations was 7,350 pCi/L in EW-9 during 2006.

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 Tritium Pump and Recharge System and monitoring program:

- Based on the attenuation of the downgradient portion of the plume to barely detectable levels over the past several years, a petition for closure was submitted to the regulators in May 2018. Any periodic increases in tritium concentration immediately downgradient of the source area resulting from the flushing of the vadose zone will continue to be monitored.
- Source area monitoring of the plume will be the most effective means of tracking any future tritium releases to groundwater given the attenuation of the downgradient segment. Seven new permanent monitoring wells will be installed on the lawn of the HFBR at approximate 30-foot intervals to continue to assess the decreasing levels and inventory of tritium beneath the HFBR that is affected by the water table flushing. The wells will be positioned in an east-west line perpendicular to groundwater flow immediately south of the HFBR. This array will account for expected fluctuations in groundwater flow directions that we observe in this area. See **Figure 3.2.17-4** for the proposed location of these wells. These four-inch diameter wells will be constructed with a 20 foot screen to account for the historical high (approximately 49 feet above mean sea level) and low (approximately 33 feet above mean sea level) water table elevation variation. The monitoring data will continue to be documented in the Groundwater Status Reports.
- Tritium monitoring for wells in the current sampling program will be discontinued once the new monitoring wells are installed.
- 55 monitoring and four extraction wells are proposed for abandonment/decommissioning in the Petition for Closure as summarized in **Table 3.2.17-1** and **Figure 3.2.17-3**.

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**).

Building 650 is included on the BNL Environmental Liabilities list of buildings that have contamination associated with them and will be addressed as funding becomes 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 (**Figure 1-2 and 3.3.1-1**).

Sampling Frequency and Analysis

During 2017, 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 away from the former Building 650 sump outfall area as it attenuates. 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 in the area immediately north of the NSLS II Facility. based on the results from monitoring wells 076-181 and 076-182 and the three temporary wells installed in 2015.

Sr-90 concentrations in source area wells 076-13 and 076-168 have fluctuated from just below to just above the DWS over the past year (**Figure 3.3.1-2**). There has been a shift in the groundwater flow direction to the southeast in this area over the past several years as shown on **Figure 2-2**. This shift could be contributing to the decrease in concentrations in some of the plume core wells (076-24, 076-415, 076-182, and 076-416) over the past several years. Well 076-184, located to the east of wells 076-182 and 076-416, increased to 7 pCi/L in 2017 after remaining just above detectable levels during the ten previous years. A recommendation will be made to install temporary wells to the east of these locations to verify any plume shift to the southeast. The highest concentration observed in the plume during 2017 was in monitoring well 076-24 (10 pCi/L in March).

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.

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

The source area was remediated in 2002 yet there are still persistent detections of Sr-90 in the source area at levels near or 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 water table has remained at low elevations over the past several years due to drought conditions. The groundwater flow has shifted in this area to the southeast over the past several years due to changes in pumping and recharge in the vicinity.

Characterization work will be recommended in this report to verify whether there has been any shift of the plume resulting from these changes.

2. Were unexpected levels or types of contamination detected?
All Sr-90 detections in 2017 were within the expected concentration range.

3. Is the plume naturally attenuating as expected?
Decrease of concentrations in the plume core have been faster than expected. A shift in the plume due to changing groundwater flow conditions could be at least partially responsible for this. 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 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 only two wells exceeding this limit in 2017 (076-13 and 076-24) 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. Increase the sampling frequency of well 076-184 to semi-annual.
- Install up to eight temporary wells to verify whether there has been any southeast shift of the plume due to changes in groundwater flow direction in the area. Temporary wells will be located southeast of monitoring wells 076-168, 076-24, 076-415, and south of Brookhaven Avenue (leading edge of plume).

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.

Based on a request from the SCDHS, four wells from the former OU V sampling program were sampled during 2017 for 1,4-dioxane. The results are discussed in **Section 3.2.13.1**.

3.5 OPERABLE UNIT VI EDB TREATMENT SYSTEM

The OU VI EDB Treatment System addresses an 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 17 wells monitor the EDB plume from the BNL south boundary to locations on private property south of North Street (**Figure 3.5-1**). As recommended in the *2016 Groundwater Status Report*, due to EDB concentrations remaining less than DWS for several years, monitoring of six wells were discontinued in the fourth quarter of 2017. The federal DWS for EDB is 0.05 µg/L.

Sampling Frequency and Analysis

The OU VI EDB plume monitoring program is in the O&M phase (**Table 1-8**). The sampling frequency for the plume core and perimeter wells is semiannual (**Table 1-5**). However, five wells were sampled at a quarterly frequency for the year. To maintain consistency with the remaining core and perimeter monitoring wells, the sampling frequency for wells 000-178, 000-520, and 000-524 was changed from quarterly to semi-annual in the fourth quarter 2017. The wells are analyzed for EDB according to EPA Method 504. Sampling for VOCs using Method 524.2 was discontinued in all wells since there have been no detections exceeding AWQS since 2004.

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 2017 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 2017 follows:

- Core wells 000-283 and 000-284, located approximately 1,700 feet upgradient of the extraction wells, detected the maximum historical EDB concentrations in the plume of 7.6 µg/L and 6.8 µg/L in 2001 and 2003, respectively. These wells have seen a steady drop in EDB concentrations since 2005. However, they continue to detect values above the DWS with up to 0.26 µg/L in well 000-283 in 2017.
- EDB concentrations in all core wells upgradient of well 000-178 have declined significantly over the past several years. EDB in well 000-178 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 decreased to 0.19 µg/L in 2017. This well is approximately 1,000 feet upgradient of EW-2E.

- Core well 000-500, located downgradient of well 000-178 and approximately 250 feet upgradient of EW-2E, has detected gradually increasing levels of EDB above the DWS since 2007. The maximum 2017 EDB concentration was 0.46 µg/L in the second quarter, which is also the high for all plume wells this year.
- In 2012, EDB concentrations in core well 000-507 reached an historical high of 1.67 µg/L. Since 2013, concentrations have dropped with a maximum EDB value of 0.03 µg/L in the second quarter 2017. This well is approximately 250 feet upgradient of extraction well EW-1E. This decline is consistent with the reduced EDB concentrations observed in upgradient core well 000-283 starting in 2007.
- EDB in the eastern perimeter monitoring well 000-524 remained below the DWS since it was installed in 2012. This indicates that the lateral extent of the plume continues to be captured.
- The bypass monitoring wells have not detected EDB since 2005, except for one estimated value of 0.008 µg/L in well 000-527 in the first quarter 2015. EDB was not detected in subsequent sampling events.

The southern migration of the plume is observed by analyzing the trends on **Figure 3.5-3**. The core of the plume identified as greater than 1.0 µg/L is located between the extraction wells and just downgradient of well 000-178. Comparing the plume's distribution from 1999 to 2017 (**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 has been below the DWS in well 000-173, located south of North Street since 2015. This indicates that the trailing edge of the plume is moving slowly south. Overall, peak EDB concentrations declined from 7.6 µg/L in 2001 (in well 000-283) to 0.46 µg/L in 2017 (in monitoring well 000-500).

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
2017 SPDES Equivalency Permit Levels

Parameters	Permit Limit (µg/L)	Max. Measured Value (µg/L)
pH (range)	5.0 – 8.5 SU	5.2 – 6.7 SU
ethylene dibromide	0.03	<0.02
chloroform	7.0	1.0
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	<0.50

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

January – September 2017
The system was off from January 5th to 10th for a carbon change-out. The system ran normally for the remainder of this time. The system treated approximately 132 million gallons of water during this period.

October – December 2017
The system operated normally for this period. The system treated approximately 38 million gallons of water.

Extraction Wells
During 2017, the system treated approximately 170 million gallons of water, with an average flow rate of approximately 328 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 2017, the extraction wells had a maximum EDB detection of 0.033 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 remained relatively stable from 2008 through 2013, bordering the DWS. Since then, concentrations began to diminish to a low of 0.02 µg/L since 2017. 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 system influent throughout 2017, except for December. The maximum influent concentration was 0.02 µg/L. During 2017, the system effluent was below the regulatory limits specified in the SPDES equivalency permit of 0.03 µg/L (**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. The last detection exceeding the DWS was 0.06 µg/L in 2014. EDB was detected in all four quarterly samples in both extraction wells. However, EDB was not detected above the standard in 2017. Low-level chloroform was also detected below the AWQS.

3.5.5 System Evaluation

No operating difficulties were experienced beyond normal maintenance in 2017, and the equivalency permit was not 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?

There were no unexpected levels or types of contamination detected.

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 eastern perimeter well 000-524, and the lack of detections in the western perimeter wells 000-497 and 000-498, the extent of the plume is defined. EDB was not detected in bypass monitoring well 000-527 in 2017 which ensures that the deeper portion of the plume is being captured by the extraction wells. 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 in the core monitoring wells. Although EDB concentrations in EW-2E are below the DWS, the higher concentration portion of the plume is still evident near well 000-178.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. The system is operating longer because the plume is migrating slower than anticipated. In June 2015, the groundwater model was updated using more recent data to better refine the remaining time required to remediate the EDB plume to below the DWS. The model projected the system will need to operate to 2020.

4a. Are EDB concentrations in plume core wells above or below 0.05 μg/L?

In 2017, four 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?

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 MCL 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 2020. The *2016 Five Year Review* (BNL 2016b) evaluated two treatment options, enhanced in-situ biodegradation or adding new treatment wells, that could reduce the time required to meet the DWS for EDB in the aquifer. However, considering the cost of implementing these options and the significant decline in EDB concentrations over the last few years, continued operation of the existing two extraction wells appears to be the most cost-effective solution to meet the cleanup goal at this time.

3.5.6 Recommendations

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

- Maintain full time operation of the treatment system and continue quarterly sampling of the extraction wells.
- To enhance the monitoring of EDB concentrations upgradient of well 000-507, install two vertical profiles and a monitoring well to the west of well 000-178. Update the groundwater model based on the analytical results.
- Discontinue sampling upgradient core well 000-110 (currently sampled semi-annually) since EDB concentrations have remained less than DWS since 2012. Reduce the sampling frequency of wells 000-173, 000-175, and 000-209 from semi-annual to annual since EDB concentrations have remained less than DWS since 2015.

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 2017 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 scheduled to be collected annually and analyzed for VOCs (**Table 1-5**). During 2016, the wells were inadvertently not sampled due to a scheduling mistake. Samples were collected in April 2017 and reported in the *2016 Annual Groundwater Status Report*. Samples were again collected in July 2017 for the *2017 Annual Groundwater Status Report.*

3.6.2 Monitoring Well Results

The complete groundwater analytical data 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 0.49 µg/L of methylene chloride in well 063-09 (AWQS of 5 µg/L) during the April sampling event. The highest concentration of a volatile organic compound during the July event was a detection of methyl tert-butyl ether of 0.16 µg/L reported in well 034-03.

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

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

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 2017. 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 annual monitoring program are warranted at this time.

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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 2017 Environmental Monitoring Report, Current and Former Landfill Areas* (BNL 2018a). 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 2017, the landfill had been capped for 22 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 2017:

- Benzene was detected in downgradient well 087-11 at concentrations slightly above the AWQS with a maximum concentration of 2.1 μg/L. The other VOCs detected above the AWQS were chloroethane and DCA during 2017. DCA was detected in two monitoring wells above the standard of 5 μg/L, 088-108 and OUI-MW01-2017. The maximum concentration of 1,1-dichloroethane during 2017 was 32 μg/L. During 2017, chloroethane concentrations ranged up to 49 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 drinking water standard.
- 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. Ammonia was detected above the AWQS of 2 mg/L in downgradient well 088-109 at a high of 3.3 mg/L.
- During 2017, iron, and sodium in the background well, and aluminum, antimony, arsenic, iron, manganese, and sodium in several downgradient wells were detected above their respective AWQS.
- Strontium-90 was detected in well 088-21 downgradient of the Current Landfill, but at concentrations well below AWQS. 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.

3.7.1.1 Current Landfill Recommendations

The monitoring well network for the Current Landfill is sufficient. No changes to the network or the sampling frequency are warranted at this time.

3.7.2 Former Landfill Summary

Monitoring 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. All Former Landfill Area wells are scheduled to be sampled every two years. The *2016 Environmental Monitoring Report, Current and Former Landfill Areas*, recommended increasing the Sr-90 sampling frequency from bi-annual to annual for wells 097-64, 106-02, 106-43, 106-44, and 106-45 to monitor for any increasing concentration trends. All other wells and parameters, which include VOCs, pesticides/PCBs, general chemistry, metals and radionuclides are scheduled to be sampled in 2018. Groundwater monitoring wells for the Former Landfill are shown on **Figure 3.7-2**. The following is a summary of the results from the samples collected during 2017:

- The trend of increasing strontium-90 concentrations which was observed in well 097-64 over the past several years was not observed in 2017. The data from well 097-64 indicated a decreased strontium-90 concentration from 6.6 pCi/L in 2016 to 1.4 pCi/L in 2017. The strontium-90 concentrations for this monitoring well have remained below the DWS of 8 pCi/L since 2000.

3.7.2.1 Former Landfill Recommendations

The monitoring well network and sampling schedule for the Former Landfill are sufficient. No changes are warranted at this time. A full round of monitoring will be conducted in 2018.

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 leach 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, and groundwater monitoring of the source area to verify the continued effectiveness of the stormwater controls. Monitoring of the source area will continue for as long as the activated soils have the potential to impact groundwater quality. Contingency actions would be developed if tritium levels in groundwater monitoring wells exceed 1,000,000 pCi/L.

3.8.1 g-2 Tritium Source Area and Plume Groundwater Monitoring

Well Network

The g-2 tritium source area is monitored using two upgradient wells, five downgradient wells approximately 200 feet downgradient of the source area near Building 912A, and 10 wells located approximately 600 feet downgradient of the source area near Building 912 (**Figure 3.8-1**).

Sampling Frequency and Analysis

During 2017, the source area wells were monitored two times, and the samples were analyzed for tritium (**Table 1-6**). The wells located near Building 912 were sampled once during the year, and the samples were analyzed for tritium. The wells are monitored for tritium because it is more leachable than sodium-22, migrates at the same rate as groundwater, and is therefore a better indicator of the effectiveness of the cap.

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 2017 is depicted on **Figure 3.8-1**.

Source Area Monitoring Results

The maximum tritium concentration in source area wells was 33,200 pCi/L in well 054-07 during the fourth 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 of Building 912. The maximum tritium concentration in this area was 18,800 pCi/L in a sample from well 065-122 collected during the fourth quarter.

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

The 2017 monitoring data were evaluated using the following DQO statements.

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

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** and **Figure 3.8-4**). 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 a 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 will decrease by means of the natural water table flushing mechanism and by natural radioactive decay.

3. Is the plume naturally attenuating as expected?
Yes. With the effectiveness of the source area controls, the plume segment immediately downgradient of the source area is attenuating as expected.

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.

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:

- Continue routine inspections of the g-2 cap.
- Continue semiannual monitoring of source area wells near Building 912A, and annual monitoring of wells located downgradient of Building 912.

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 rainwater infiltration into the activated soil below the building. In 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 this beam line 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**).

Sampling Frequency and Analysis

During 2017, the three wells located immediately downgradient of the BLIP facility (064-47, 064-48, 064-67) were monitored twice, and the upgradient well (064-46) was sampled once. The groundwater samples were analyzed for tritium (**Table 1-6**). Because tritium is more leachable than sodium-22, and it migrates at the same rate as groundwater, it is the best early indicator of a possible release.

3.9.2 BLIP Monitoring Well Results

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

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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).

remained below the 20,000 pCi/L DWS (**Figure 3.9-1**). During 2017, the maximum tritium concentration was 923 pCi/L in the fourth quarter sampling of well 064-48.

3.9.3 BLIP Groundwater Monitoring Program Evaluation

The 2017 monitoring data were evaluated using the following DQO 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.
- No changes to the groundwater monitoring program are recommended.

4.0 FACILITY MONITORING PROGRAM SUMMARY

During 2017, 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 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 2017, 116 groundwater monitoring wells were sampled during 180 sampling events. **Table 1-6** summarizes the Facility Monitoring Program by project. Complete analytical results from groundwater samples collected in 2017 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 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 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 because 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

[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 the leading edge of the g-2 tritium plume that has migrated underneath Building 912 (**Section 3.8**).

Sampling Frequency and Analysis

During 2017, 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, tritium 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 2017, tritium from the g-2 plume was detected in three wells (065-122, 065-323 and 065-324), with a maximum concentration of 18,800 pCi/L detected in a sample collected from well 065-122. A trace level of tritium was detected in Building 912 monitoring well 065-126 at a concentration of 395 pCi/L (with an MDL of 327 pCi/L). 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 2017 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. Other than tritium associated with the g-2 tritium plume, only a trace level of tritium was detected in one well. This indicate 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 2018, 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 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. 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 2017, 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 these 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, it is apparent that 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 2018, 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 2017, 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 2017, tritium was not detected in the NSRL monitoring wells.

[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 2018, 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.

Following the installation of monitoring wells in late 1999 and early 2000, tritium and sodium-22 were detected at levels greater than their applicable 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 2017, 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. During 2017, tritium was detected in one well, at a concentration of 919 pCi/L in well 064-80 (**Figure 4.1-3**).

4.1.4.3 Former AGS E-20 Catcher Groundwater Monitoring Program Evaluation

The 2017 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 2018, 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 2017, 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 2017, 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 2017 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 2018, 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. 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 200 feet downgradient of the g-2 beam stop area (see **Section 3.8**). An investigation into the source of the contamination revealed that the tritium originated from activated soil shielding adjacent to the g-2 beam stop. This section of the beam line was not a designed beam loss area, and therefore was not protected by the gunite cap installed over the beam stop. In December 1999, an impermeable cap was installed over the activated soil shielding, and joined to the beam stop cap. 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 g-2 tritium source area monitoring wells described in **Section 3.8**.

Sampling Frequency and Analysis

During 2017, 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 2017, tritium was not detected in any of the wells.

4.1.6.3 Former g-2 Beam Stop Groundwater Monitoring Program Evaluation

The 2017 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?

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 2018, 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 continue to 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 2017, 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 2017 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 2018, 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.

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 2017, 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

During 2017, tritium was detected in the former U-Line Target area well 054-130 at a concentration of 535 pCi/L (**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 2017 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.

4.1.8.4 Former AGS U-Line Recommendation

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

- For 2018, 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 can result in the production of tritium and sodium-22 in the nearby soil shielding, 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 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 2017, 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 annually, and were analyzed for tritium and gamma emitting radionuclides (such as sodium-22).

4.2.2 RHIC Monitoring Well Results

During 2017, 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 2017 monitoring data were evaluated using the following Data Quality Objective statement.

1. Has the source of potential contamination been controlled?

Groundwater and surface water monitoring data continue to demonstrate that the impermeable caps installed over the RHIC beam stop and collimator areas are effectively preventing rainwater infiltration into the activated soil shielding.

4.2.4 RHIC Recommendation

The following is recommended for the RHIC groundwater monitoring program:

- During 2018, 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 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 did 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 groundwater directly downgradient (within 30 feet) of the BMRR. The maximum tritium concentration observed during 1997 was 11,800 pCi/L, almost one-half of the 20,000 pCi/L DWS. The highest observed tritium concentration since the start of groundwater monitoring was 17,100 pCi/L in October 1999. The tritium 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 sampled once every two years. The last samples were collected in 2016. The groundwater samples were analyzed for tritium, gamma emitting radionuclides, gross alpha, and gross beta. No samples were collected during 2017.

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 last sample round in 2016, tritium was not detected in any of the samples. Furthermore, gamma, gross alpha, and gross beta analyses did 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, 2014 and 2016 sample periods. Groundwater monitoring results 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 2018.

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 recharge basins, the sanitary waste stream is 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. 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 former sand filter beds. 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 2017. As required by the permit, the samples are analyzed for the following metals: copper, iron, lead, nickel, silver, zinc and mercury (**Table 1-6**).

4.4.2 STP Monitoring Well Results

All metals concentrations, tracked under the SPDES permit were below the applicable AWQS. As in previous years, sodium was detected at concentrations above the 20 mg/L AWQS in five of the STP recharge basin wells, with a maximum concentration of 75 mg/L in well 039-115.

4.4.3 STP Groundwater Monitoring Program Evaluation

The 2017 monitoring data were evaluated using the following Data Quality Objective statement.

1. Are STP operations impacting groundwater quality?

Monitoring results for 2017 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

For 2018, the following is recommended for the STP groundwater monitoring program:

- In accordance with the SPDES permit, the STP groundwater monitoring wells will be sampled annually, and the samples will be analyzed for the metals specified in the permit.

4.5 MOTOR POOL AREA

The Motor Pool (Building 423) consists of a five-bay automotive repair shop, which includes office and storage spaces (**Figure 4.5-1**). The facility has 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. 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.

4.5.1 Motor Pool 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. 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**). As needed, groundwater quality downgradient of Building 423 can also be monitored using four wells (102-10, 102-11, 102-12, and 102-13).

Sampling Frequency and Analysis

During 2017, the two UST area wells were monitored annually, and the samples were analyzed for VOCs (**Table 1-6**). The remaining wells were not sampled during 2017. The wells were also checked for the presence of floating petroleum hydrocarbons.

4.5.2 Motor Pool Monitoring Well Results

Underground Storage Tank Area

During 2017, a trace level of chloroform (0.22 µg/L) was detected in well 102-06. As in previous years, no floating product was detected in the wells.

4.5.3 Motor Pool Groundwater Monitoring Program Evaluation

The 2017 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 2017, there were no reported gasoline or motor oil losses or spills that could 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 2018:

- The sampling frequency for the UST area wells 102-05 and 102-06 will continue to be annually.

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4.6 ON-SITE SERVICE STATION

Building 630 was a commercial automobile service station, privately operated under a contract with BNL. The station was built in 1966 and was used for automobile repair and gasoline sales until January 2018. Potential environmental concerns at the Service Station included 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. 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. The 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. In early 2018, the underground storage tanks were emptied of their contents, and hydraulic oils were draining from the lift stations. Plans are currently being prepared to decommission the facility.

4.6.1 Service Station Groundwater Monitoring

Well Network

Groundwater quality in the service station area is monitoring using four shallow Upper Glacial wells. The monitoring program is used to confirm that the engineered and institutional controls in place are effective in preventing contamination of the aquifer and to evaluate continued impacts from historical spills (**Figure 4.6-1**).

Sampling Frequency and Analysis

During 2017, the service station facility wells were monitored one time, and the samples were analyzed for VOCs (**Table 1-6**). Two 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 groundwater water quality at the Service Station had been impacted by a variety of VOCs that were related to historical vehicle maintenance and refueling operations, monitoring conducted during 2015 through 2017 indicates a significant drop in VOC concentrations. During 2017, the highest VOC concentration was detected in well 085-17, with tetrachloroethylene at 3.7 μg/L, slightly below the NYS AWQS of 5 μg/L. **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 2017 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>

VOC concentrations for individual compounds have declined to less than applicable AWQS. During 2017, there were no reported gasoline or motor oil losses or spills that could affect groundwater quality, and all waste oils and used solvents were properly stored and recycled. The gasoline USTs have electronic leak detection systems, and while the Station was in operation, there was 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

The following are recommendations for 2018:

- Continue sampling UST area wells 085-17, 085-236, and 085-237 annually for VOCs and floating product, until the UTSs have been formally decommissioned.

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; 3) historical solvent spills near the CSF; and 4) solvent spills that occurred in the Building 650 area.

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 2017, 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 (e.g., chloroform, tetrachloroethylene and acetone) not associated with fuel storage activities continued to be detected in some of the downgradient wells, all VOC concentrations were less than the applicable AWQS (**Figure 4.7-1**). Tetrachloroethylene was detected in upgradient well 076-25 at a concentration up to 2.1 µg/L. The tetrachloroethylene is likely to have originated from the Building 650 area located immediately upgradient of the MPF.

4.7.3 MPF Groundwater Monitoring Program Evaluation

The 2017 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) and the Building 650 area to the north. 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 2018, monitoring will continue as required by the NYS operating permit, with semiannual monitoring for VOCs and SVOCs, and monthly testing for floating product.

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 2017, the WMF wells were sampled in March 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 *2017 Groundwater Monitoring Report for the Waste Management Facility* (BNL 2017b).

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. During 2017, low levels of cobalt-60 (Co-60) and sodium-22 (Na-22) were detected for the first time in several of the WMF monitoring wells. During the March sample period, Co-60 was detected in well 056-21 at a concentration of 6.6+/-4.8 pCi/L (method detection limit [MDL] = 5.0 pCi/L) and in well 066-222 at a concentration of 6.3+/-3.5 pCi/L (MDL = 3.2 pCi/L). Both Co-60 concentrations were less than 4% of the 200 pCi/L DWS. Co-60 was not detected in any of the WMF wells during the August sample period. Furthermore, during the August sample round, Na-22 was detected in well 066-221 at a concentration of 7.8+/-4.2 pCi/L (MDL = 4.1 pCi/L), which is less than 2% of the 400 pCi/L DWS. Na-22 was not detected in any of the WMF wells during the March sample period or in previous years. Based upon documented waste management operations and results of groundwater monitoring over the past 20 years, the WMF is not a likely source for either Co-60 or Na-22, and additional monitoring is required to verify these detections.

As reported for the 2016 monitoring period, low levels of Sr-90 continued to be detected in a number of the downgradient monitoring wells. The maximum Sr-90 concentration was detected in well 066-221 at 0.95+/-0.2 pCi/L (MDL = 0.2 pCi/L), which is approximately 12% of the 8 pCi/L DWS. This is slightly higher than the maximum Sr-90 concentration for 2016 of 0.7+/-0.2 pCi/L that was also detected in well 066-221. The likely source of the Sr-90 is historical leakage of wastewater from the sanitary line that ran through the current WMF area before it was re-routed south of the facility. During construction of the WMF, portions of the old sanitary line were abandoned in place. Low levels of Sr-90 were also detected in pre-operation (baseline) samples collected in May 1997 in both upgradient and downgradient wells at concentrations up to 5.4 pCi/L. The only operation at the WMF that could potentially contribute Sr-90 to the environment is the BGRR/WCF groundwater treatment system located in Building 855. However, the pipeline in the WMF area is double lined, and is monitored by a leak detector. There are no indications that this piping system has leaked.

Non-Radiological Analyses

All anions (chlorides, sulfates, and nitrates) and most metals concentrations were below applicable ambient NYS AWQS or DWS. As in previous years, sodium was detected at concentrations above the 20 mg/L AWQS. Sodium was detected at concentrations above the standard in both upgradient wells (055-03 and 055-10) at concentrations up to 81 mg/L, and in three downgradient wells (066-220, 066-221, and 066-222) at concentrations up to 120 mg/L. The elevated sodium concentrations are likely the result of road salting operations. Although trace levels of several VOCs (primarily chloroform) continue to be detected in a number of the WMF's upgradient and downgradient wells, all concentrations were below the AWQS

4.8.3 WMF Groundwater Monitoring Program Evaluation

The 2017 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 2017 continued to show that WMF operations are not affecting groundwater quality. Furthermore, there were no outdoor or indoor spills at the facility during 2017 that could have affected soil or groundwater quality.

4.8.4 WMF Recommendation

The following are recommended for 2018:

- 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 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 MPF monitoring wells (076-18 and 076-19) are used as upgradient/background wells for the NSLS-II facility.

Sampling Frequency and Analysis

During 2017, the four NSLS-II monitoring wells and the two MPF wells were sampled one time, and the samples were analyzed for tritium (**Table 1-6**).

4.9.2 NSLS-II Monitoring Well Results

No tritium was detected in the groundwater samples collected during 2017.

4.9.3 NSLS-II Groundwater Monitoring Program Evaluation

The 2017 monitoring data were evaluated using the following Data Quality Objective statement.

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

Monitoring results for 2017 indicate that NSLS-II beam line operations conducted to date have not affected groundwater quality.

4.9.4 NSLS-II Recommendations

For 2018, 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:

- Based on the lack of significant rebound in VOC concentrations since system shutdown in 2013 and very low remaining VOC concentrations in area monitoring wells, submit a petition to decommission the OU I South Boundary Treatment System in 2018.
- Complete the 2017 annual characterization (delayed by weather conditions) of the former HWMF Sr-90 plume by installing temporary wells downgradient of this area.
- Maintain the VOC groundwater monitoring program of an annual sample collection from plume core wells: 107-40, 107-41, 115-13, 115-16, and 115-51. Maintain quarterly sampling of OUI-MW01-2017.
- Install several temporary wells as necessary in the vicinity of Sr-90 sentinel monitoring wells 107-35 and 108-45 to evaluate the resulting eastward shift in the Sr-90 migration path. Install permanent monitoring wells, as needed.
- Discontinue Sr-90 sampling from monitoring wells 099-04, 107-10, 107-24, 107-26, 107-40, 115-03, 115-13, 115-14, 115-15, 115-16, 115-28, 115-29, 115-30, and 115-31. Sr-90 concentrations have been either non-detect or barely detectable for at least five years in these wells. In addition, several of the wells are located significantly to the west of the established plume pathway or are significantly deeper than the observed plume depth.

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.
- Modify the pumping rate to expand the capture zone of RTW-1 to ensure that VOCs in well 095-159 are being fully captured. May need to submit modified SPDES Equivalency Permit request to NYSDEC for an increase in the maximum flow rate.
- Maintain treatment wells RTW-2, RTW-3, and RTW-4 in standby mode, and restart the wells if extraction or monitoring well data indicate that TVOC concentrations exceed 50 µg/L.
- Since elevated PCE concentrations were identified in soil gas monitoring well 085-359 in 2017, perform a soil vapor extraction pilot study to evaluate the effectiveness of reducing the persistent contamination in the former source area.
- Install a temporary well at the location of B96-GP02-2018 to determine the vertical extent of the VOCs observed in the deepest samples in this temporary well.
- Decommission the hexavalent chromium ion-exchange treatment system in the spring of 2018.

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:

- Maintain the Building 452 Treatment System in standby mode for one more year. If there isn't a rebound in Freon-11 concentrations, with concentrations exceeding 50 μg/L, prepare a Petition for Closure by 2019. It is anticipated that the Building 96 treatment well RTW-1 will remain in full-time operation for several more years.
- Maintain the semiannual sampling frequency for the groundwater monitoring wells and quarterly sampling frequency for EW-18 for the remainder of the standby period.

5.4 Middle Road Treatment System

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.
- Install vertical profiles as necessary upgradient of well 104-37 to determine the cause for the persistently elevated VOC concentrations observed in this well.

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 well EW-17 on a full time basis. Continue pulsed pumping of well EW-4 one month on and one month off.
- Maintain the routine O&M monitoring frequency implemented last year.
- Install a vertical profile between RW-7 and well 121-54 to evaluate persistently high TVOC concentrations in this area.

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 elevated concentrations persisting at well 126-14.
- Based on the low TVOC concentrations below the capture goal of 20 µg/L, maintain extraction well WSB-2 in standby mode. 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 per the groundwater modeling report install four new groundwater extraction wells in 2018. The addition of these wells are projected to meet the groundwater cleanup goal of meeting MCLs by 2030.

- Submit a modification request to the regulators documenting the design details for the four new extraction wells recommended in the groundwater modeling report.
- Move to startup monitoring frequency (quarterly) for all wells associated with WSB-1 and the new extraction wells. For wells to the east monitoring WSB-2 continue the O&M phase (127-04, 127-06, and 121-42).

5.7 Industrial Park Treatment System

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

- Continue pulsed operation of the deeper extraction wells IP-EW-8 and IP-EW-9.
- Maintain the seven UVB wells in standby. If TVOC concentrations exceed the 50 µg/L capture goal near any of the wells they may be restarted.
- Install a vertical profile well between wells 000-529 and 000-541 to address a potential data gap west of well 000-529. If concentrations are low, evaluate shutdown of extraction wells EW-8 and EW-9 in 2019.

5.8 Industrial Park East Treatment System

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

- In accordance with the 2013 Petition for Closure of the Industrial Park East Groundwater Treatment System and the 2016 Groundwater Status Report, since monitoring wells 000-494, 000-526, 000-427, and 000-429 have been below the AWQS for a minimum of four consecutive sampling events, further monitoring will be discontinued.

5.9 North Street Treatment System

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

- If TVOC concentrations in any core monitoring wells increase to over the 50 µg/L capture goal, the extraction well(s) may be restarted.
- Change the groundwater monitoring well schedule for the North Street system to standby.
- NS-1 and NS-2 will remain in standby. If TVOC concentrations remain below the capture goal through 2018, a Petition for Closure will be submitted in 2019.

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, or if EDB is detected in NSE-1. Continue quarterly sampling of NSE-1 for EDB and analyze using Method 504.
- Continue characterization of EDB around well 000-394 with vertical profiles, and install additional permanent monitoring wells, as appropriate.
- Update the groundwater model based on the EDB characterization data.

- Since VOCs have not been detected above AWQS in wells downgradient of extraction NSE-1 since 2005, further monitoring of these wells will be discontinued. These wells include 000-482, 000-483, 000-484, 000-485, and 000-486. Well 000-481 will continue to be sampled as a bypass monitoring well for NSE-1.
- Since VOCs have not been detected above AWQS in shallow perimeter well 000-137 since 2000, further monitoring of this well will be discontinued.

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 for wells RTW-2A and RTW-3A and continue full time operation of wells RTW-1A, RTW-4A and RW-6A. Keep well RTW-5A in shutdown mode. 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 wells that are not operating, the well(s) will be put back into full-time operation.
- Maintain LIPA wells EW-1L, EW-2L, EW-3L and EW-4L in standby mode. These extraction wells may be restarted if TVOC concentrations rebound above the 50 µg/L capture goal in either the plume core monitoring wells or the extraction wells.
- The Airport monitoring wells changed to the O&M phase monitoring frequency. Change the LIPA monitoring wells to the standby monitoring frequency.

5.12 Magothy Monitoring

The following are recommendations for the Magothy groundwater monitoring program:

- Continue the current monitoring schedule for the Magothy monitoring program. See **Table 1-5**.
- Continue pumping the Magothy extraction wells at Middle Road, South Boundary, Airport and the new IP wells. The North Street, North Street East and LIPA Magothy extraction wells are currently in standby as they have reached the OU III capture goals identified for shutdown of these wells. The IPE extraction well was abandoned as it had reached its cleanup goal.

5.13 Central Monitoring

No changes are recommended for the OU III Central Monitoring Program.

5.14 South Boundary Radionuclide Monitoring Program

No changes are recommended for South Boundary Radionuclide Groundwater Monitoring Program

5.15 BGRR/WCF Strontium-90 Treatment System

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

- Place extraction wells SR-3 and SR-7 in standby mode based on low Sr-90 concentrations. Place SR-8 in pulsed pumping mode (one month on and one month off) based on low Sr-90 concentrations.
- Maintain source area monitoring frequency of monthly for BGRR source area well 075-701.
- Continue operating wells SR-1, SR-2, and SR-9 in full time mode. Maintain wells SR-4, SR-5, and SR-6 in standby mode.
- Change SPDES sampling frequency from bi-monthly to monthly.

- Maintain the semi-annual sampling frequency of WCF well 065-160 to due to increased concentrations in 2016-17. Maintain semi-annual sampling frequency of 085-398 and 085-403 based on the advance of the leading edge of plume into this area.
- Supplement the current monitoring network with temporary well data in order to get a comprehensive status of the plumes and account for well network gaps and groundwater flow related plume shifts. Areas of focus will include:
  - Immediately south of Building 701/BGDs and cap.
  - Areas in between Buildings 535 and 725 in line with BGRR/BGDs and PFS plumes.
  - Center line of BGRR/BGD plume south of Brookhaven Avenue.
  - Approximately 150 feet south of PFS and Building 801 source area.
  - Southeastern edge of former WCF yard.
  - Areas just north and south of HFBR and south of Temple Place in high concentration and leading-edge portions of the WCF plume.
- Maintain well 065-175 semi-annual sampling frequency to monitor for Sr-90 migrating south from the WCF yard.

5.16 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:

- Until regulatory approval of the Petition for Shutdown is approved by the regulators (submitted in March 2018), continue to operate extraction well EW-1 in pulsed pumping mode (one month on and one month off) and maintain EW-2 and EW-3 in standby. If significant rebound is identified, these extraction wells may be restarted.
- Following system shutdown, change the sampling frequency for the monitoring wells to the standby phase, and maintain quarterly sampling of the extraction wells.
- Due to Sr-90 concentrations remaining less than DWS for several years, discontinue monitoring the following monitoring wells:
  - 106-22 - downgradient sentinel well currently sampled semi-annually that has never exceeded the DWS since it was installed in 1997.
  - 106-23 – downgradient sentinel well currently sampled semi-annually that has never exceeded the DWS and has and has not detected Sr-90 since 2006.
  - 106-62 - downgradient sentinel well currently sampled semi-annually that has never exceeded the DWS and has and has been less than 3.0 pCi/L since it was installed in 1998.
  - 106-63 - downgradient sentinel well currently sampled semi-annually that has never exceeded the DWS and has and has not detected Sr-90 since 2004.

5.17 HFBR Tritium Pump and Recharge System

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

- Based on the attenuation of the downgradient portion of the plume to barely detectable levels over the past several years, a petition for closure was submitted to the regulators in May 2018. Any periodic increases in tritium concentration immediately downgradient of the source area resulting from the flushing of the vadose zone will continue to be monitored.

- Source area monitoring of the plume will be the most effective means of tracking any future tritium releases to groundwater given the attenuation of the downgradient segment. Seven new permanent monitoring wells will be installed on the lawn of the HFBR at approximate 30-foot intervals to continue to assess the decreasing levels and inventory of tritium beneath the HFBR that is affected by the water table flushing. The wells will be positioned in an east-west line perpendicular to groundwater flow immediately south of the HFBR. This array will account for expected fluctuations in groundwater flow directions that we observe in this area. See **Figure 3.2.17-4** for the proposed location of these wells. These four-inch diameter wells will be constructed with a 20 foot screen to account for the historical high (approximately 49 feet above mean sea level) and low (approximately 33 feet above mean sea level) water table elevation variation. The monitoring data will continue to be documented in the Groundwater Status Reports.
- Tritium monitoring for wells in the current sampling program will be discontinued once the new monitoring wells are installed.
- 55 monitoring and four extraction wells are proposed for abandonment/decommissioning in the Petition for Closure as summarized in **Table 3.2.17-3** and **Figure 3.2.17-3**.

5.18 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. Increase the sampling frequency of well 076-184 to semi-annual.
- Install up to eight temporary wells to verify whether there has been any southeast shift of the plume due to changes in groundwater flow direction in the area. Temporary wells will be located southeast of monitoring wells 076-168, 076-24, 076-415, and south of Brookhaven Avenue (leading edge of plume).

5.19 Operable Unit V

Based on the recommendations in the 2013 and 2014 groundwater status report the groundwater sampling requirements for OU V were completed.

5.20 Operable Unit VI EDB Treatment System

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

- Maintain full time operation of the treatment system and continue quarterly sampling of the extraction wells.
- To enhance the monitoring of EDB concentrations upgradient of well 000-507, install two vertical profiles and a monitoring well to the west of well 000-178. Update the groundwater model based on the analytical results.
- Discontinue sampling upgradient core well 000-110 (currently sampled semi-annually) since EDB concentrations have remained less than DWS since 2012. Reduce the sampling frequency of wells 000-173, 000-175, and 000-209 from semi-annual to annual since EDB concentrations have remained less than DWS since 2015.

5.21 Site Background Monitoring

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

5.22 Current Landfill Groundwater Monitoring

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

5.23 Former Landfill Groundwater Monitoring

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

5.24 g-2 Tritium Source Area and Groundwater Plume

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

- Continue routine inspections of the g-2 cap.
- Continue semiannual monitoring of source area wells near Building 912A, and annual monitoring of wells located downgradient of Building 912.

5.25 Brookhaven Linac Isotope Producer (BLIP) Facility

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.
- No changes to the groundwater monitoring program are recommended.

5.26 Alternating Gradient Synchrotron (AGS) Complex

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

5.27 Relativistic Heavy Ion Collider (RHIC) Facility

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

5.28 Brookhaven Medical Research Reactor (BMRR) Facility

The following is recommended for the BMRR groundwater monitoring program:

- The monitoring frequency for the BMRR wells will continue to be once every two years, with the next set of samples being collected in 2018.

5.29 Sewage Treatment Plant (STP) Facility

The following is recommended for the STP groundwater monitoring program:

- In accordance with the SPDES permit, the STP groundwater monitoring wells will be sampled annually, and the samples will be analyzed for the metals specified in the permit.

5.30 Motor Pool Area

The following is recommended for the Motor Pool monitoring program:

- The sampling frequency for the UST area wells 102-05 and 102-06 will continue to be annually.

5.31 On-Site Service Station

The following is recommended for the on-site service station groundwater monitoring program:

- Continue sampling UST area wells 085-17, 085-236, and 085-237 annually for VOCs and floating product, until the UTSs have been formally decommissioned.

5.32 Major Petroleum Facility (MPF) Area

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

5.33 Waste Management Facility (WMF)

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

5.34 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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