Five-Year Review Report

for

Brookhaven National Laboratory Superfund Site (NY7890008975)

Town of Brookhaven, Hamlet of Upton
Suffolk County, New York

June 1, 2021

PREPARED FOR:
The United States Department of Energy
Office of Science

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Executive Summary

The U.S. Department of Energy (DOE) owns the Brookhaven National Laboratory (BNL) site in Upton, New York, and is the lead agency for the Five-Year Review. DOE entered into a Federal Facilities Agreement (also referred to as the Interagency Agreement, or IAG) for the BNL site, along with the U.S. Environmental Protection Agency (EPA) and the New York State Department of Environmental Conservation (NYSDEC). Brookhaven Science Associates (BSA), under contract with the DOE, manages and operates BNL.

The purpose of this Five-Year Review is to determine whether the remedies implemented at BNL continue to be protective of human health and the environment. The methods, findings, and conclusions of reviews leading to such determinations are documented in *Five-Year Review Reports*. In addition, *Five-Year Review Reports* identify potential problems with the ability of the current remedial actions to meet the cleanup objectives, if any, and provide recommendations to address them.

The remedies for the BNL Superfund site in Upton include excavation and off-site disposal of contaminated soil, sediment, tanks, and structures, capping of landfills and other contaminated soil areas, installation and operation of groundwater treatment systems, groundwater monitoring, and implementation of institutional controls. DOE has invested approximately $620 million to date to implement the groundwater, soil, Peconic River, and reactor remedies. All of the remedies for the nine signed Records of Decision (RODs) and four Explanations of Significant Differences (ESDs) have been fully implemented except for remaining remedial actions at the High Flux Beam Reactor (HFBR).

The first comprehensive *Five-Year Review Report* was submitted to the regulatory agencies in July 2005, and issued as a final document in August 2006. The second *Five-Year Review Report* was submitted to the regulatory agencies in March 2011, and the Addendum addressing regulator comments was issued as final in November 2011. The third *Five-Year Review Report* was submitted to the regulatory agencies in June 2016, and the Addendum addressing regulator comments was issued as final in February 2017. The 2021 *Five-Year Review Report* also covers all of the operable units (OUs) and reactor-related *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) actions.

According to data reviewed from the closeout reports, the annual *BNL Groundwater Status Reports*, site inspections, and regulatory interviews, the remedies were implemented in accordance with the RODs and four OU III ESDs. The soil cleanup levels have been met and the groundwater remediation systems continue to meet the remedial action objectives identified in each ROD.

Since the last Five-Year Review, two additional remedy optimizations were accomplished. The first was the addition and start-up in March 2019 of four new extraction wells to capture and treat deeper VOCs for the Western South Boundary groundwater treatment system. This deeper contamination was detected through routine groundwater monitoring and resulted in a characterization effort to define the extent. The North Street East groundwater treatment system was also modified in 2020 with the addition of two new extraction wells to remediate an ethylene dibromide (EDB) plume that had not been previously observed in this area. In 2018, an area of radiologically contaminated soil along the former Waste Concentration Facility's northern fence line to the adjacent metal storage yard was identified and excavated. This was the final phase of soil cleanup in this area.

In 2018, supplemental sediment remediation of a small on-site area of the Peconic River (Area PR-WC-06) was completed. Post-excavation sediment sampling confirmed that the excavation was effective in meeting the cleanup goals. All other areas have met their long-term cleanup objectives identified in the ROD. Long-term protectiveness of the Peconic River remedy has been verified and post-cleanup

monitoring of the sediment, surface water, and fish is complete. BNL will continue to annually assess the Peconic River water levels and perform population surveys to determine if fish sampling can be performed. BNL would then recommend sampling of fish for mercury and PCBs in on-site portions of the Peconic River as part of the site environmental surveillance monitoring program.

In early 2021, the HFBR stack was demolished in accordance with the HFBR ROD. The closeout report will be submitted to the regulators in the fall of 2021. Although not part of the CERCLA remedial action scope, demolition of Building 650 (formerly known as the Reclamation and Hot Laundry Facility) was demolished in early 2021.

In February 2021, BNL identified two new areas of concern (AOCs 33 and 34) for PFOS/PFOA and 1,4-dioxane as well as a new operable unit (OU VIII). Characterization work performed to date and the planned implementation of a Time Critical Removal Action for two PFAS plumes are summarized in this review.

A comprehensive sitewide protectiveness determination covering all the OUs and the reactors (BGRR and HFBR) must be reserved at this time because work is not complete for the HFBR reactor vessel removal.

The fifth comprehensive Five-Year Review in 2026 will include all OUs, the BGRR, HFBR, and the g-2/Brookhaven Linac Isotope Producer (BLIP) tritium plume remedy. The table below provides a summary of each OU's issues and recommendations from the 2021 Five-Year Review. The recommendations are subject to regulatory review, and implementation timing will be based on the availability of funding.

Table E-1: Recommendations and Follow-up Actions

Issue	Recommendations/ Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Y/N)	
					Current	Future
Sr-90 in OU I Former HWMF Groundwater	Continue to track Sr-90 plume attenuation. Enhance monitoring network with temporary and/or permanent wells as necessary. Monitor plume attenuation progress with 2021 groundwater model predictions and report in annual Groundwater Status Report.	BNL	DOE, EPA, NYSDEC, SCDHS	June 2026	N	N
OU III Building 96 Source Removal Effectiveness	Monitor plume and source area. Evaluate and/or implement a liquid carbon in-situ treatment for the source area soils if groundwater concentrations do not decline to below the system capture goal.	BNL	DOE, EPA, NYSDEC, SCDHS	October 2023	N	N

Issue	Recommendations/ Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Y/N)	
					Current	Future
OU III Middle Road VOC Contamination	Conduct a pre-design characterization of VOCs in groundwater between monitoring well 104-37 and the site boundary by installing several temporary vertical profile wells. Install new extraction well(s) based on data and groundwater modeling.	BNL	DOE, EPA, NYSDEC, SCDHS	October 2024	N	N
OU III South Boundary VOC Contamination	Conduct a pre-design characterization of VOCs in groundwater upgradient and downgradient of monitoring well 121-54 and the site boundary by installing temporary vertical profile wells. Install new extraction well(s) based on data and groundwater modeling.	BNL	DOE, EPA, NYSDEC, SCDHS	October 2024	N	N
Continuing Sr-90 sources at BGRR, WCF, and Building 801	Monitor plume segments and source areas. Perform intermittent pulsed pumping of extraction wells SR-1, SR-2, and SR-3. Evaluate effectiveness during next Five-Year Review.	BNL	DOE, EPA, NYSDEC, SCDHS	June 2026	N	N
OU VI EDB Contamination	Update the groundwater model framework based on latest geologic and groundwater quality data. Modify the system to meet ROD cleanup goals and ensure capture of deeper EDB..	BNL	DOE, EPA, NYSDEC, SCDHS	October 2024	N	N
OU VIII PFAS	Begin operation of the TCRA groundwater treatment systems for current and former firehouses' PFAS plumes..	BNL	DOE, EPA, NYSDEC, SCDHS	2022	Y	Y
Peconic River	Complete federal-required vegetation monitoring at Area PR-WC-06.	BNL	DOE, EPA, NYSDEC, SCDHS	September 2022	N	N
HFBR	Issue final stack demolition closeout report	BNL	DOE, EPA, NYSDEC, SCDHS	Fall 2021	N	N
HFBR	Explore the feasibility of reducing the 65-year safe storage (decay) period and completing the removal of large sized activated components earlier.	BNL	DOE, EPA, NYSDEC, SCDHS	Recurring	N	N

Issue	Recommendations/ Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Y/N)	
					Current	Future
OUs III & VI – Maintain terms of groundwater treatment system property access agreements	Record property access agreements with County Clerk, continue to manage existing access agreements.	BNL	DOE, EPA, NYSDEC, SCDHS	Ongoing	N	Y
Building 650	Update Building 650 LUIC fact sheet based on as left conditions documented in final D&D closeout report.	BNL	DOE, EPA, NYSDEC, SCDHS	Fall 2021	N	N

Notes:
Recommendations are subject to regulatory review; implementation will be based on the availability of funding
BGRR = Brookhaven Graphite Research Reactor
DOE = U.S. Department of Energy
EPA = U.S. Environmental Protection Agency
HFBR = High Flux Beam Reactor
NYSDEC = New York State Department of Environmental Conservation
SCDHS = Suffolk County Department of Health Services
VOC = Volatile Organic Compound

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site name *(from WasteLAN)*: Brookhaven National Laboratory Superfund Site		
EPA ID *(from WasteLAN)*: NY7890008975		
Region: 2	**State:** NY	**City/County:** Upton, Suffolk

SITE STATUS	
NPL status: ☒ Final ☐ Deleted ☐ Other (specify)	
Remediation status (choose all that apply): ☒ Under Construction ☒ Operating ☒ Complete	
Multiple OUs?* ☒ YES ☐ NO	**Construction completion date:** ___ / ___ / _____
Are the properties associated with this site in use or are they suitable for reuse? ☒ YES ☐ NO	

REVIEW STATUS	
Lead agency: ☐ EPA ☐ State ☐ Tribe ☒ Other Federal Agency (DOE)	
Author name: Robert Gordon	
Author title: DOE Site Manager	**Author affiliation:** U.S. DOE, Upton, NY
Review period:** 4/1/2016 to 12/31/2020	
Date(s) of site inspection: 8/17/20 through 9/2/20	
Type of review: ☒Post-SARA ☐ Pre-SARA ☐ NPL-Removal only ☐Non-NPL Remedial Action-site ☐ NPL State/Tribe-lead ☐Regional Discretion	
Review number: ☐ 1 (first) ☐ 2 (second) ☐ 3 (third) ☒ Other (specify) 4 (fourth)_____	
Triggering action: ☐ Actual RA Onsite Construction at OU I ☐ Construction Completion ☐ Other (specify)	☐ Actual RA Start at OU#____ ☒ Previous Five-Year Review Report
Triggering action date *(from WasteLAN)*: 8/9/2016	
Due date *(five years after triggering action date)*: 8/9/2021	

* ["OU" refers to operable unit.]
** [Review period should correspond to the actual start and end dates of the Five-Year Review in WasteLAN]

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List of Acronyms

µg/dL	Micrograms per decaliter
µg/L	Micrograms per liter
1,1-DCA	1,1-Dichloroethane
ALARA	As Low As Reasonably Achievable
AOC	Area of Concern
AGS	Alternating Gradient Synchrotron
AS	Air Stripping
AS/SVE	Air Sparging/Soil Vapor Extraction
AWQS	Ambient Water Quality Standards
BER	Brookhaven Executive Roundtable
BGD	below-ground duct
BGRR	Brookhaven Graphite Research Reactor
BHSO	U.S. Department of Energy-Brookhaven Site Office
BLIP	Brookhaven Linac Isotope Producer
BNL	Brookhaven National Laboratory
BSA	Brookhaven Science Associates
CAC	Community Advisory Council
CAMP	Community Air Monitoring Plan
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
CFR	*Code of Federal Regulations*
Cs-137	Cesium-137
DOE	U.S. Department of Energy
DQO	Data Quality Objective
EA	Environmental Assessment
EDB	ethylene dibromide
EM	Office of Environmental Management
EPA	U.S. Environmental Protection Agency
EPD	Environmental Protection Division
ES&H	Environmental Safety and Health
ESD	Explanation of Significant Differences
FFA	Federal Facilities Agreement
FS	Feasibility Study

FSP	Field Sampling Plan
GIS	Geographic Information System
gpm	gallons per minute
HFBR	High Flux Beam Reactor
HWMF	Hazardous Waste Management Facility
IAG	Interagency Agreement
IC	Institutional Control
IP	Industrial Park
IRIS	Integrated Risk Information System
ISB	Interdisciplinary Science Building
Linac	Linear Accelerator
LIPA	Long Island Power Authority
LUCMP	Land Use Controls Management Plan
LUIC	Land Use Institutional Controls
mCi	milliCuries
MCL	maximum contaminant level
mg/kg	milligrams per kilogram
MOC	Method of Characteristics
mRem	milliRem
MTBE	methyl tertiary-butyl ether
MW	Megawatt
NCP	*National Contingency Plan*
NEPA	*National Environmental Policy Act*
ng/L	nanograms per liter
NPL	*National Priorities List*
NRMP	Natural Resource Management Plan
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
O&M	operation and maintenance
ORISE	Oak Ridge Institute for Science and Education
OSWER	EPA Office of Solid Waste and Emergency Response
OU	Operable Unit
pCi/L	picocurie(s) per liter
pCi/g	picocurie(s) per gram

PCBs	polychlorinated biphenyls
PCE	tetrachloroethylene
PFAS	per- and polyfluoroalkyl substances
PFOS	perfluorooctane sulfonate
PFOA	perfluorooctanoic acid
ppm	part(s) per million
QAPP	Quality Assurance Project Plan
RA	Removal Action
RAO	Remedial Action Objective
RD	Remedial Design
RDIP	Remedial Design Implementation Plan
RI	Remedial Investigation
ROD	Record of Decision
SCDHS	Suffolk County Department of Health Services
SCGs	Standards, Criteria, and Guidance Values
SCWA	Suffolk County Water Authority
SDWA	Safe Drinking Water Act
SPDES	State Pollutant Discharge Elimination System
Sr-90	strontium-90
STP	Sewage Treatment Plant
SUSC	Science and User Support Center
SVE	Soil Vapor Extraction
SVOC	semi-volatile organic compound
TAGM	Technical and Administrative Guidance Memorandum
TBC	Items “to be considered”
TCA	1,1,1-trichloroethane
TCRA	Time Critical Removal Action
TCE	trichloroethene
TSS	total suspended solids
TVOC	total volatile organic compound
UCMR	Unregulated Contaminant Monitoring rule
USACE	U.S. Army Corps of Engineers
UST	underground storage tank
VISL	Vapor Intrusion Screening Level

VOC	volatile organic compound
VPB	Vertical Profile Boring
WCF	Waste Concentration Facility
WLA	Waste Loading Area
WSB	Western South Boundary

Glossary

Administrative Record: A file that contains the documents, including technical reports, which forms the basis for selection of a final remedy and acts as a vehicle for public participation.

Area of Concern: A geographic area of BNL where there has been a release or the potential for a release of a hazardous substance, pollutant, or other contaminant. There are 34 areas of concern at BNL.

Closeout Report: A report that documents the completion of construction of the remedy and how it complies with the requirements of the remedial design plans, specifications, and the ROD. The report includes post-excavation confirmatory sampling results.

Institutional Controls: Measures or restrictions established to prevent exposure of workers or the public to hazards. These may include the establishment of fencing, posting of signs, prevention of unplanned alteration of contaminant plume flow pathways, etc.

Interagency Agreement: A legal binding document established under the *Comprehensive Environmental Response, Compensation, and Liability Act,* that presents the framework for implementing the cleanup activities at a particular site. At BNL, the IAG, also known as a Federal Facilities Agreement (EPA 1992), was signed in 1992 by the U.S. Department of Energy, the U.S. Environmental Protection Agency, and the New York State Department of Environmental Conservation.

Maximum Contaminant Level: A standard set by the U.S. Environmental Protection Agency and the New York State Department of Environmental Conservation for contaminants in drinking water. These contaminants represent levels that the regulatory agencies believe are safe for people to drink. NYSDEC standards often apply a safety factor and are more stringent than the Federal standards.

Operable Unit: Groups of areas within a site containing the same or similar contamination. The areas within one operable unit are not necessarily adjacent. BNL has six operable units.

Picocurie Per Liter: A unit of measure of radioactivity per liter of water.

Record of Decision: Documents the decision by DOE and the regulators on a selected remedial action. It includes the responsiveness summary and a bibliography of documents that were used to reach the remedial decision. When the record of decision is finalized, the remedial design and construction can begin.

Time Critical Removal Action (TCRA): This type of interim cleanup action was developed by EPA for initiating early cleanup action or accelerating ongoing cleanup action to abate, mitigate, or reduce risk to human health or the environment at a contaminated waste site. Section 415 of the NCP lists the factors to be considered in determining the appropriateness of a TCRA, including actual or potential contamination of drinking water supplies or sensitive ecosystems. Under the BNL Federal Facilities Agreement, DOE is authorized to perform removal actions in accordance with CERCLA and the NCP. The TCRA will ultimately be evaluated for inclusion as a final action in the subsequent ROD.

Brookhaven National Laboratory
Five-Year Review Report

1.0 Introduction

The purpose of this Five-Year Review is to determine whether the remedies implemented at Brookhaven National Laboratory (BNL) continue to be protective of human health and the environment. The methods, findings, and conclusions of reviews leading to such determinations are documented in Five-Year Review Reports. In addition, Five-Year Review Reports identify potential problems, if any, with the ability of the current remedial actions to meet the cleanup objectives and provide recommendations to address them.

The U.S. Department of Energy (DOE) prepared this Five-Year Review Report pursuant to the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA) §121 and the *National Contingency Plan* (NCP). CERCLA §121 states:

> *If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented. In addition, if upon such review it is the judgment of the President that action is appropriate at such site in accordance with section [104] or [106], the President shall take or require such action. The President shall report to the Congress a list of facilities for which such review is required, the results of all such reviews, and any actions taken as a result of such reviews.*

DOE interpreted this requirement further in the NCP; *40 Code of Federal Regulations* (CFR) §300.430(f)(4)(ii) states:

> *If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action.*

Brookhaven Science Associates (BSA), under contract with the DOE, manages and operates BNL. BSA's Environmental Protection Division (EPD) conducted this Five-Year Review of the remedial actions implemented at the BNL site under the direction of the DOE Brookhaven Site Office. This report documents the results of the review.

This is the fourth sitewide Five-Year Review for the BNL site and includes all the Operable Units (OUs), the Brookhaven Graphite Research Reactor (BGRR), the High Flux Beam Reactor (HFBR), and the g-2 Tritium Plume and Brookhaven Linac Isotope Producer (BLIP) Areas of Concern (AOCs). The triggering action for this 2021 sitewide statutory Five-Year Review is the completion of the third sitewide review in June 2016. This review is required because hazardous substances, pollutants, or contaminants at the site are above levels that allow for unlimited use and unrestricted exposure. This fourth sitewide Five-Year Review includes an evaluation of all the AOCs at BNL. Previous Five-Year Reviews were:

- Five-Year Evaluation Reports prepared for the Current and Former Landfills in 2001 and 2002 in accordance with New York State Part 360 requirements (BNL 2001a and 2002).
- A Five-Year Review focused specifically on the OU IV remedy in September 2003 (BNL 2003a).
- The first sitewide Five-Year Review submitted as draft to the regulators in July 2005, with the final Report issued in August 2006 (BNL 2006). The triggering action for this review was initiation of the remedial action for OU I contaminated landscape soils in July 2000. This Review did not include the g-2/BLIP or HFBR Records of Decision (RODs).
- The second sitewide Five-Year Review was submitted to the regulators in March 2011 (BNL 2011a), and the Addendum addressing regulator comments was issued as final in November 2011 (BNL 2011b). The triggering action for this review was the completion of the last review.

- The third sitewide Five-Year Review was submitted to the regulators in June 2016 (BNL 2016b), and the Addendum addressing regulator comments was issued as final in February 2017 (BNL 2017a). The triggering action for this review was the completion of the last review and EPA's August 2016 concurrence letter.

2.0 Site Chronology

Remedial actions at the BNL site are currently being addressed under RODs for six OUs, the BGRR, the HFBR, and g-2/BLIP, covering 32 AOCs. In February 2021, DOE identified two new AOCs for perfluorooctane sulfonate (PFOS)/perfluorooctanoic acid (PFOA) (which are per- and polyfluoroalkyl substances [PFAS]) and 1,4-dioxane as well as a new OU (OU VIII), bringing the number of AOCs to 34. The chronology in **Table 2-1** first identifies general site information, and then breaks down each OU by major event. **Table 2-2** presents each OU and Removal Action AOC.

Table 2-1: Chronology of Site Events

General Site Information	
Site of future BNL serves as Army Camp Upton for World Wars I and II, operated by the Civilian Conservation Corps between wars	1917 – 1940s
Site transferred to the Atomic Energy Commission, BNL developed	1947
BNL transferred to the Energy Research and Development Administration	1975
BNL transferred to the DOE	1977
BNL added to NYSDEC list of Inactive Hazardous Waste Sites	1980
BNL listed on EPA National Priorities ("Superfund") List	1989
DOE entered into Interagency Agreement with EPA and NYSDEC under CERCLA	1992
Operable Unit I	
RA for "D-waste" tanks removal	1994
RA for Landfill capping	1995–1997
RA for South Boundary groundwater treatment system construction and public water hookups	1996
RA for Chemical/Animal Pits and Glass Holes excavation	1997
ROD signed	1999
Completed excavating landscape soil; Closeout Report issued	2000/2001
Completed excavating sludge from Building 811 USTs; Closeout Report issued	2001
Completed excavating soil and pipeline associated with Building 650; Closeout Report issued	2002
Completed capping Ash Pit; Closeout Report issued	2003/2004
Completed excavating soil and reconstructed Upland Recharge and Meadow Marsh; Closeout Report issued	2003/2004
Completed excavating former HWMF soil; Closeout Report issued	2005
Completed excavating Building 811 USTs/soils; Closeout Report issued	2005
Completed excavating former Chemical Holes residual surface soils; Addendum to Closeout Report issued	2005
Completed decontamination of the Merrimack Hole at the former HWMF	2006
RA completed for excavating the former HWMF Phase I Perimeter Soils; Completion Report issued	2009
Completed excavating the former HWMF Phase II Perimeter Soils; Completion Report Addendum issued	2010
Former HWMF Perimeter Soils designated as Sub-Area of Concern 1J	2013
Petition approved for shutdown of the South Boundary groundwater treatment system	2013
Completed excavating the former HWMF Phase III Perimeter Soils; Completion Report Addendum issued	2014
Completed demolition of former WCF and soil removal; Closeout Report issued	2017
Completed excavating soil north of former WCF; Addendum Closeout Report issued	2019
Petition approved for closure of the South Boundary groundwater treatment system	2019
Operable Unit II/VII	
RA for BLIP Facility (AOC 16K) cap, drainage control, grout injection; Closeout Report issued	1998/2002
Remedial Investigation performed; RI Report issued	1999
Evaluation of alternatives included under OU I Feasibility Study	1999
Operable Unit III	
RA for Building 479 PCB-contaminated soil excavation	1992
RA for Building 464 mercury-contaminated soil excavation	1993
RA for cesspools/septic tanks completed; Closeout Report issued	1994–1999
RA for USTs completed; Closeout Report issued	1994–1999
RA for public water hookups	1996–1998
RA for South Boundary groundwater treatment system construction	1997

Continued…

Table 2-1: Chronology of Site Events *(continued)*

RA for HFBR tritium plume groundwater treatment system	1997
RA for Carbon Tetrachloride groundwater treatment system construction	1999
RA for Industrial Park groundwater treatment system construction	1999
ROD signed	2000
Completed constructing Building 96 groundwater treatment system	2000
Completed constructing Middle Road groundwater treatment system	2001
Completed constructing low-flow pumping system for HFBR tritium plume	2001
Completed constructing Western South Boundary groundwater treatment system	2002
Completed constructing Chemical Holes Sr-90 groundwater treatment system (Pilot Study)	2003
Petition approved for shutdown of the Carbon Tetrachloride treatment system	2004
Completed constructing four remaining off-site groundwater treatment systems: Industrial Park East, North Street, North Street East, LIPA/Airport	2004
Completed constructing BGRR/WCF Sr-90 groundwater treatment system	2004
Completed excavating and off-site disposal of Building 96 PCB-contaminated soil; Closeout Report issued	2005
ESD issued for Magothy, Sr-90, Building 96 geophysical anomalies	2005
Building 96 Groundwater Treatment System Shutdown Petition Issued	2005
Completed construction of additional extraction wells for the HFBR, Chemical Holes, and Airport groundwater treatment systems	2007
ESD issued for Building 96 VOC soil excavation	2009
Petition approved for shutdown of the Industrial Park East groundwater treatment system	2009
Petition approved for closure of the Carbon Tetrachloride groundwater treatment system; system dismantled	2009-2010
Completed excavating and off-site disposal of Building 96 VOC-contaminated soil	2010
Completed construction of additional extraction wells for the WCF Sr-90 groundwater treatment system	2011
Building 452 Freon-11 Source Area and Groundwater Plume designated as Area of Concern 32	2011
Issued ESD; completed construction of Building 452 Freon-11 groundwater treatment system	2012
Completed construction of additional deeper extraction wells for the OU III South Boundary and Middle Road groundwater treatment systems	2012-2013
Petition approved for shutdown of the Industrial Park groundwater treatment system	2013
Petition approved for closure of the Industrial Park East groundwater treatment system	2013
Petition approved for shutdown of the North Street groundwater treatment system	2013
Petition approved for shutdown of the HFBR Pump and Recharge groundwater system	2013
Petition approved for shutdown of the North Street East groundwater treatment system	2014
Completed construction of additional deeper extraction wells for the Industrial Park groundwater treatment system	2015
Petition approved for shutdown of the Building 452 Freon-11 groundwater treatment system	2016
Petition approved for shutdown of the Sr-90 Chemical Holes groundwater treatment system	2018
Completed construction of additional deeper extraction wells for the Western South Boundary treatmentsystem	2019
Petition approved for closure of the Building 452 Freon-11 groundwater treatment system	2019
Petition approved for closure of the HFBR Tritium Pump and Recharge groundwater system	2019
Petition approved for closure of the North Street groundwater treatment system	2020
Completed construction of additional extraction wells for the North Street East groundwater treatment system to address an EDB plume (North Street East EDB is considered a separate treatment system)	2020
Completed administrative closeout of the North Street East original VOC groundwater treatment system	2020
Operable Unit IV	
RA for fence around Building 650 Sump Outfall area soil	1995
ROD signed	1996
Completed constructing AS/SVE remediation system	1997
Petition approved for shutdown of AS/SVE remediation system	2000
Five-Year Review submitted to EPA and NYSDEC	2002
Petition for closure of AS/SVE Remediation System approved by EPA and NYSDEC; system dismantled	2003
Final Five-Year Review Report issued	2003

Continued….

Table 2-1: Chronology of Site Events *(continued)*

Operable Unit V	
RA for Imhoff Tanks	1995
ROD signed for STP	2002
Completed excavation of STP soils; Completion Report issued	2003/2004
RA for Peconic River sediment excavation on site (Phase 1); Completion Report issued	2004/2005
RA for Peconic River sediment excavation off site (Phase 2); Completion Report issued	2004/2005
ROD signed for Peconic River	2005
Closeout Report for Peconic River Phase 1 and 2 Remediation issued	2005
Initiated post-cleanup Peconic River monitoring program to demonstrate the effectiveness of the cleanup	2006
Completed sediment trap removal and Peconic River Supplemental Remediation: Closeout Report issued	2011/2012
Completed supplemental sediment remediation at Peconic River Area PR-WC-06: Closeout Report issued	2017
Operable Unit VI	
RA for public water hookups	1996-1997
ROD signed	2001
Completed constructing EDB groundwater treatment system off site	2004
Operable Unit VIII	
TCRA for PFAS Groundwater Systems at Current and Former Firehouses	In progress
Brookhaven Graphite Research Reactor	
RA for BGRR primary cooling fans and equipment	1999
RA for pile fan sump	1999–2000
RA for above-grade ducts	2000–2002
RA for canal house and water treatment house	2001–2002
RA for coolers and filters	2002–2003
RA for BGD primary liner	2004
RA for fuel canal and subsurface soils	2005
ROD signed	2005
Graphite pile removal; Closeout Report issued	2009-2010
Engineered cap installed; Closeout Report issued	2011
Issued ESD; Biological shield removed; Closeout Report issued	2012
Began Long-Term Surveillance and Maintenance	2012
g-2/BLIP/USTs	
Impermeable caps placed over BLIP and g-2 source areas	1997 and 1999
Groundwater monitoring, cap inspections and maintenance	1999-2010
ROD signed	2007
ROD contingency triggered; additional groundwater monitoring initiated in downgradient plume segment	2011
Downgradient plume monitoring complete	2015
High Flux Beam Reactor	
Dismantlement and removal of several ancillary buildings	2006
RA completed for excavating former HWMF Waste Loading Area soils; Completion Report issued	2007-2009
ROD signed	2009
Removal of Bldgs. 801-811 underground waste transfer lines (A/B waste lines with co-located piping) and associated soil; Closeout Report issued.	2009
RA for removal/disposal of control rod blades and beam plugs; Completion Report issued	2009-2010
Began Long-Term Surveillance and Maintenance for Confinement Building and Stack	2010 and 2012
Fan houses (Bldgs. 704 and 802), above- and below-ground structures, soil removal; Closeout Report issued	2011
Confinement Building stabilization; Closeout Report issued	2011
Underground utilities and associated soil removal; Closeout Report issued	2011
Stack Silencer Baffles and survey of outside areas; Closeout Report issued	2012
Stack demolition complete (Draft Closeout Report to be issued in fall 2021)	2021

Notes:
AOC = Area of Concern
AS/SVE = Air Sparging/Soil Vapor Extraction

BLIP = Brookhaven Linac Isotope Producer
BGD = below-ground duct
BNL = Brookhaven National Laboratory
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act*
DOE = Department of Energy
EPA = U.S. Environmental Protection Agency
EDB = ethylene dibromide
ESD = Explanation of Significant Differences
FS = Feasibility Study
HFBR = High Flux Beam Reactor
HWMF = Hazardous Waste Management Facility
IAG = Interagency Agreement
LIPA = Long Island Power Authority
NYSDEC = New York State Department of Environmental Conservation
PCB = Polychlorinated Biphenyl
PFAS = Per- and Polyfluoroalkyl substances
RA = Removal Action
RI = Remedial Investigation
ROD = Record of Decision
Sr-90 = Strontium-90
STP = Sewage Treatment Plant
TCRA = Time Critical Removal Action
USTs = underground storage tanks
VOC = volatile organic compound
WCF = Waste Concentration Facility

Table 2-2: Operable Unit (OU) AOCs

Category	AOC #	Description and Status
OU I (ROD approved)	AOC 1 (A,C,D,E,F,G,H,I,J)	Hazardous Waste Management Facility – complete
	AOC 1B	Spray Aeration site – removal action complete
	AOC 2 (A,B,C,D,E,F)	Former Landfill Area – complete
	AOC 3	Current Landfill – complete
	AOC 2 and 3	Former and Current Landfill Closures – removal actions complete
	AOC 6	Building 650 Sump and Sump Outfall – complete; Sr-90 groundwater monitoring ongoing
	AOC 8	Upland Recharge/Meadow Marsh Area– complete
	AOC 10A	Waste Concentration Facility – Tanks D-1, D-2, and D-3 – complete
	AOC 10B,C	Waste Concentration Facility – Underground pipelines and Six A/B USTs - complete
	AOC 12	USTs at Building 445 – removal action complete
	AOC 23	Off-Site Tritium Plume (southern component) – complete
	Sub AOC 24E	Recharge Basin HS, Outfall 005 – complete
	Sub AOC 24F	New Stormwater Runoff Recharge Basin – complete
OUs II/VII (addressed in OU I ROD; approved)	AOC 10A,B,C	Waste Concentration Facility (Building 811) – complete (building removed 2015; supplemental soil removal completed in 2018)
	AOC 16 (A,B,C,D,E,F,G, H,I,J,L,M,N,O,P,Q,S)	Aerial Radioactive Monitoring System Results – complete
	AOC 17	Area Adjacent to Former Low-Mass Criticality Facility – complete
	AOC 18	AGS Scrapyard ("Boneyard") – complete
	AOC 20	Particle Beam Dump, north end of Linac – complete
OU III (ROD approved)	AOC 7	Paint Shop – groundwater monitoring ongoing
	AOC 9	BGRR (groundwater) – treatment system operating
	AOC 10	Waste Concentration Facility (groundwater) – treatment system operating
	AOC 11	Building 830 Pipe Leak – complete; groundwater monitoring complete
	AOC 12	USTs at Building 830 – removal action complete
	AOC 13	Cesspools – removal action complete
	AOC 14	Bubble Chamber Spill Areas – groundwater monitoring complete
	Sub AOC 15A	Supply/Potable Wells 1, 2, 3, 4, 6, 7, 10, 11, 12; groundwater monitoring ongoing
	Sub AOC 15B	Monitoring Well 130-02 – treatment system operating
	AOC 16R	Aerial Radioactive Monitoring System results – Nuclear Waste Management Facility, Building 830 – complete (covered under AOCs 11 and 12)
	AOC 18	AGS Scrapyard (groundwater) – groundwater monitoring complete
	AOC 19	TCE Spill Area, Building T-111 – groundwater monitoring complete
	AOC 20	Particle Beam Dump, north end of Linac (includes Basin HT) – monitor and maintain per SPDES permit/NRMP
	AOC 21	Leaking sewer pipes (sitewide, not investigated under other OU study areas) – groundwater monitoring complete
	AOC 22	Old Firehouse – no further action per ROD
	Sub AOC 24A	Process Supply Wells 104 and 105 – treatment systems operating, groundwater monitoring ongoing
	Sub AOC 24B	Recharge Basin HP, Outfall 004 – monitor and maintain per SPDES permit & NRMP
	Sub AOC 24C	Recharge Basin HN, Outfall 002 – monitor and maintain per SPDES permit and NRMP
	AOC 25	Building 479 PCB soil removal complete; groundwater monitoring complete

Continued…

Table 2-2: Operable Unit (OU) AOCs *(continued)*

Category	AOC #	Description and Status
	AOC 26	Building 208 – removal action complete
	AOC 26A	Building 208 (groundwater) - groundwater monitoring complete
	AOC 26B	Former Scrapyard/Storage Area south of Building 96 – treatment system operating; soil removal complete
	AOC 27	Building 464 mercury soil removal complete; groundwater monitoring complete
	AOC 29	Spent fuel pool in HFBR and associated groundwater plume of tritium – pump and recharge system closure approved; groundwater monitoring ongoing
	AOC 32	Building 452 Freon-11 Source Area and Groundwater Plume – treatment system closure approved
OU IV (ROD approved)	AOC 5 (A,B,C,D)	Central Steam Facility – treatment system decommissioned
	AOC 6	Reclamation Facility Interim Action – complete
	AOC 12	USTs at Building 650 – removal action complete
	AOC 21	Leaking Sewer Pipes (in study area) – complete
	Sub AOC 24D	Recharge Basin HO, Outfall 003 – complete
OU V – STP (ROD Approved)	AOC 4 (A,B,C,D,E)	Sewage Treatment Plant – complete
	AOC 21	Leaking sewer pipes (in the study area) – complete
	AOC 23	Off-site tritium plume (eastern component) – groundwater monitoring complete
OU V – Peconic River (ROD Approved)	AOC 30	Peconic River – cleanup on and off of BNL property complete; additional sediment removed in 2010/2011 and 2017
OU VI (ROD approved)	AOC 28	EDB groundwater contamination – treatment system operating
OU VIII	AOC 33	PFOS and PFOA – TCRA in Remedial Design
	AOC 33A	Former Bubble Chamber Experiment and Blockhouse Area – monitoring underway
	AOC 33B	Building 924 Area - monitoring underway
	AOC 33C	East of Building 902 - monitoring underway
	AOC 33D	Current Firehouse - TCRA in Remedial Design
	AOC 33E	Former Firehouse - TCRA in Remedial Design
	AOC 33F	Major Petroleum Facility - monitoring underway
	AOC 33G	Building 526 Area - monitoring underway
	AOC 33H	Recreation Center Area - monitoring underway
	AOC 33I	Sewage Treatment Plant - monitoring underway
	AOC 34	1,4-Dioxane - monitoring underway
BGRR (ROD Approved)	AOC 9	Graphite Pile – complete Biological Shield/Engineered Cap – complete
	AOC 9A	Fuel Canal – complete
	AOC 9B	Below-ground ducts – complete
	AOC 9C	Spill sites – complete
	AOC 9D	Pile Fan Sump – complete
g-2 and BLIP (ROD Approved)	AOC 12	USTs, Buildings 462, 463, 527, 703, 927, 931B – complete
	AOC 16K	Aerial Radioactive Monitoring System results – BLIP, Building 931B – Source area protection and groundwater monitoring ongoing
	AOC 16T	Aerial Radioactive Monitoring System results - g-2 Source Area and Tritium Groundwater Plume – source area protection and groundwater monitoring ongoing

Continued…

Table 2-2: Operable Unit (OU) AOCs *(continued)*

Category	AOC #	Description and Status
HFBR (ROD Approved)	AOC 31	Waste Loading Area – complete Control Rod Blades and Beam Plugs – complete Buildings 801-811 Waste Transfer Lines – complete HFBR Stabilization – complete Fan Houses (Buildings 704 and 802) – complete Underground Utilities – complete Stack – complete (Closeout Report to be prepared)
Other Removal Action	Not applicable	Former HWMF Perimeter Soils – Phases I, II, and III – complete
	Not applicable	Central Steam Facility Lead-Contaminated Soil – complete
	Not applicable	Shotgun Range Lead-Contaminated Soil - complete

Notes:
AGS = Alternating Gradient Synchrotron
AOC = Area of Concern
BGRR = Brookhaven Graphite Research Reactor
BLIP = Brookhaven Linac Isotope Producer
EDB = ethylene dibromide
HFBR = High Flux Beam Reactor
NRMP = *Natural Resources Management Plan*
ROD = Record of Decision
SPDES = State Pollutant Discharge Elimination System
STP = Sewage Treatment Plant
TCE = trichloroethene
TCRA = Time critical removal action
USTs = Underground Storage Tanks
VOC = volatile organic compound

3.0 Facility-Wide Background

3.1 Physical Characteristics

The BNL site is located in Upton, Suffolk County, New York, near the geographic center of Long Island. The BNL property approximates a square, 3 miles on each side, comprising an area of approximately 5,265 acres (about 8 square miles). The boundaries of BNL are either near or adjacent to neighboring communities. The site's terrain is gently rolling, with elevations varying between 40 and 120 feet above mean sea level. The land lies on the western rim of the Peconic River watershed, with a tributary of the river rising in marshy areas west of the William Floyd Parkway and in the northern part of the site.

3.2 Geology/Hydrogeology

BNL is underlain by unconsolidated glacial and deltaic deposits that overlie gently southward sloping, relatively impermeable, crystalline bedrock. The deposits are about 2,000 feet thick in central Suffolk County. The aquifer system beneath BNL is comprised of three water-bearing units: the Upper Glacial, the Magothy, and the Lloyd aquifers. These units are hydraulically connected and make up a single zone of saturation with varying physical properties extending from a depth of 45 to 1,500 feet below the land surface. The Long Island Aquifer System is designated as a "sole-source aquifer" by the EPA and serves as the primary source of drinking water for Nassau and Suffolk Counties.

3.3 Land and Resource Use and Institutional Controls

The site where BNL is located was formerly occupied by the U.S. Army as Camp Upton during World Wars I and II. Between the wars, the Civilian Conservation Corps operated the site. In 1947, the Atomic Energy Commission established BNL. The Laboratory was transferred to the Energy Research and Development Administration in 1975 and to the DOE in 1977. BNL is a federal facility that conducts basic and applied research in high-energy nuclear physics and solid-state physics; fundamental material and structure properties and the interaction of matter; biomedical and environmental sciences; as well as in energy technologies and national security.

The developed region of the site includes the principal BNL facilities which are near the center of the site on relatively high ground. These facilities comprise an area of approximately 1,800 acres, of which 500 acres were originally developed for Army use. Outlying facilities occupy approximately 550 acres and include an apartment area, Sewage Treatment Plant (STP), firebreaks, and former landfill areas. 530 acres of land on the eastern portion of the site has been designated as the Upton Ecological Research Reserve. DOE has granted an easement on approximately 200 acres of land on the east and southeast portion of the site for the operation of the Long Island Solar Farm. This 32 megawatt (MW) solar photovoltaic power plant was constructed in 2011.

The current land-use designations for the BNL site includes industrial use in the central portion of the site, with open space borders. Discovery Park, a new gateway to BNL is currently under construction at the location of the previously developed 40-acre apartment area. Further detail of the land-use designations for specific remediation areas is identified in the *BNL Land Use and Institutional Controls* (LUIC) website (https://luic.bnl.gov/LUIC/).

These land-use settings are projected to remain the same. These include:

- Soil Remediation Complete - Unrestricted Land Use (A)
- Soil Remediation Complete - Restricted Land Use (B)
- Capped/Controlled Contaminated Soils - Restricted Land Use (C)
- Known or Potentially Contaminated Soils, Remediation Pending - Restricted Land Use (D)
- Groundwater Contamination Areas - Restricted Groundwater Use (E)
- Radiological Facility, Decontamination & Demolition Pending - Restricted Land Use (F)
- Sensitive Areas, Biologically/Culturally Sensitive - Restricted Land Use (G)

Institutional controls are administered as per the *BNL Land Use Controls Management Plan* (LUCMP) (BNL 2018c). LUICs will be maintained for as long as necessary in order to ensure performance of the completed remedies as described and documented in the BNL RODs. The AOC-specific institutional controls are documented on fact sheets stored on the BNL LUIC website (https://luic.bnl.gov/LUIC/). This is a secure website and is not open to the general public. The website is BNL's tool for internally managing Institutional Controls (ICs) and consists of an interactive Geographic Information System (GIS) base map that is linked to the AOC-specific fact sheets. Planning for any work at the site that may potentially disturb a remediated area requires a review of the website. ICs are deployed at BNL to prevent exposure to residual environmental contamination and to ensure the long-term effectiveness of the remedies.

The LUCMP is periodically updated by BNL and reviewed by the regulators in an effort to stay current with evolving management techniques. The LUCMP has been updated five times since its initial issue in 2003, with the latest update published in April 2018 (BNL 2003b, 2005d, 2007a, 2009d, 2013a, and 2018c). LUICs are evaluated from a sitewide standpoint on an annual basis and issues from the previous year are summarized in a letter report to the regulatory agencies. A summary of findings from the required annual inspections of AOCs is included in this report. The LUCMP also details notification criteria in the event of a LUIC breach or unauthorized change in land use. Specific ICs for each area are detailed in the fact sheets and are summarized by OU in **Section 7.0** of this Report.

Because of chemical contamination in the Upper Glacial aquifer, DOE provided public water hookups for homes in the area south of BNL. Ten homeowners within the designated public water hookup area declined the free DOE hookup offer in 1996-1997 and continued to use their private wells for drinking purposes. That number was reduced to seven homeowners in 2005 and six in early 2006. In 2006, two additional homes and in 2011 one additional business were identified that were previously thought to be connected to public water. In 2012, two of the homeowners hooked-up to public water and one of the homeowners' well is no longer being used. In 2017 and 2019, two additional homeowners hooked-up to public water. This brings the number of homes not connected to public water to four (one in OU III, one in OU V, and two in OU VI). Annually, DOE formally offers those homeowners free testing of their private drinking water wells. The samples are collected and analyzed by the Suffolk County Department of Health Services (SCDHS).

3.4 History of Contamination

Much of the environmental contamination at BNL is associated with past accidental spills and historical storage and disposal of chemical and radiological materials. These past operations, some of which may date back to when the site was an Army training camp, have caused soil and groundwater contamination that can be categorized into four main areas. These areas are 1) the groundwater contamination (primarily volatile organic compounds [VOCs], PFOS/PFOA, ethylene dibromide [EDB], strontium-90 [Sr-90], and tritium), 2) soils contamination (primarily polychlorinated biphenyls [PCBs], tetrachloroethylene [PCE], PFOS/PFOA, metals, cesium-137 [Cs-137], and Sr-90) and landfills, 3) the Peconic River sediment contamination (primarily metals and PCBs), and 4) the BGRR and HFBR facilities (primarily Sr-90 and tritium, respectively). Contamination in the Peconic River and VOC groundwater contamination have extended off the BNL property. The most significant environmental concern is that BNL lies above a sole-source aquifer that is used for drinking water purposes both on and off site. Brief descriptions of the nature of contamination associated with each OU, the BGRR, g-2/BLIP/underground storage tanks (USTs), and the HFBR covered under this Five-Year Review are as follow:

- OU I – Former landfills, disposal pits, and soils contaminated with metals such as mercury and lead, and radionuclides including Cs-137 and Sr-90; above- and below-ground leaking storage tanks; and Sr-90 and VOC-contaminated groundwater such as chloroethane and 1,1-dichloroethane on BNL property.

- OU II/VII – Radiologically contaminated soils on BNL property such as Cs-137 identified as part of aerial radiological surveys. The AOCs in this OU were documented under the OU I and III RODs (except for BLIP [AOC 16K], which was documented in the g-2/BLIP/USTs ROD (BNL 2007b).
- OU III – Groundwater contaminated with VOCs such as carbon tetrachloride, 1,1,1-trichloroethane (TCA), and PCE, and radionuclides such as tritium and Sr-90 on BNL property; VOC-contaminated groundwater off of BNL property including PCE, carbon tetrachloride and EDB; and residual PCE soil contamination at one location on BNL property.
- OU IV – Soil and groundwater contaminated with VOCs such as toluene and ethylbenzene, and semi-volatile organic compounds (SVOCs) from a former oil/solvent tank spill on BNL property. Groundwater contaminated with Sr-90 located in central portion of BNL property.
- OU V – Radiological- and metal-contaminated soil at the STP such as Cs-137, mercury, and silver; metal- (mercury, silver, copper) and PCB-contaminated sediment in the Peconic River; and VOC-contaminated groundwater, including trichloroethene (TCE) on and off of BNL property.
- OU VI – EDB-contaminated groundwater off of BNL property.
- OU VIII - PFOS and PFOA in groundwater downgradient of the current and former firehouse facilities have been identified significantly above the drinking water standards recently established by the State of New York. 1,4-Dioxane has also been identified in groundwater on and off of BNL property above the new standard. Residual PFOS and PFOA in on-site soil is also a concern.
- BGRR – Activated components including the graphite pile and biological shield, radiologically contaminated soils, sumps, ducts, piping, and standing water, including Cs-137 and Sr-90; and Sr-90 in groundwater on the BNL site.
- g-2/BLIP/USTs – Radioactive soil shielding and contaminated groundwater at the former g-2 experiment and BLIP facility areas, and removal of USTs.
- HFBR – Activated components, contaminated structures, systems, underground pipes/ducts, ancillary buildings, and associated soils. Tritium-contaminated groundwater on the BNL site.

3.5 Initial Response

In 1980, the BNL site was placed on the NYSDEC list of Inactive Hazardous Waste Disposal Sites. In 1989, BNL was also included on the EPA *National Priorities List* because of soil and groundwater contamination. Subsequently, EPA, NYSDEC, and DOE entered into a Federal Facilities Agreement (also referred to as the Interagency Agreement, or IAG). While not formal IAG partners, the Suffolk County Department of Health Services (SCDHS) and the New York State Department of Health (NYSDOH) are also actively involved with BNL cleanup decisions. The IAG became effective in 1992, and it identified AOCs that were grouped into OUs to be evaluated for response actions. The IAG established the framework and schedule for characterizing, assessing, and remediating the site in accordance with the requirements of CERCLA. There are currently 34 AOCs and eight OUs at the BNL site. DOE recommended the addition of AOCs 33 (PFOS and PFOA) and 34 (1,4-dioxane), and OU VIII to the regulators in February 2021.

As noted in **Table 2-1**, prior to the approval of the RODs, DOE used its removal action authority in many situations to help reduce risks to human health and the environment. In most cases, these actions were taken to address source areas of contamination. These activities include the closure/capping of landfills, fencing to restrict access, tank removals, soils remediation, groundwater treatment, public water hookups, STP remediation, Peconic River sediment remediation, and response actions at the BGRR and HFBR. In several cases, the removal action ended up being the final remedial action. These actions are documented in the RODs. A Time Critical Removal Action (TCRA) is currently underway to address groundwater contamination from the current and former firehouse facilities.

3.6 Basis for Taking Action

The nature of the contamination, as well as the risks to human health and the environment for each OU, are summarized below.

Operable Unit I. Radioactively contaminated soil is the principal issue. In addition, Removal Actions were conducted to address buried waste at several AOCs.
Soils: The former HWMF (AOC 1) contained most of the radioactively contaminated soil at BNL. The predominant radionuclide was Cs-137, which is the primary source of risk from direct exposure. Sr-90 was also present, and most of the contamination was at or near the surface, although in some locations it extended to 12 feet below grade. The former HWMF Perimeter Area (AOC 1J) soils contained primarily Cs-137. Other contaminated soil areas included the former Waste Concentration Facility (WCF, AOC 10) (which also contained leaking tanks), former Building 650 Sump and Sump Outfall (AOC 6), and several areas throughout the site that were the result of contaminated soils that were unknowingly used for landscaping purposes. The Former (AOC 2), Interim (AOC 2D), and Current (AOC 3) Landfills, as well as the Chemical/Animal Pits and Glass Holes (AOC 2B and 2C), received waste generated at the BNL site from 1918 through 1990. These disposal areas were unlined and had a direct impact on groundwater quality prior to being capped or excavated in the mid-1990s. Contaminants at the Former Landfill Area included VOCs, metals such as mercury, and Sr-90.

The ash pits (AOC 2F), which once received ash and slag from a solid-waste incinerator located on the BNL site, have lead concentrations above cleanup goals. The Upland Recharge/Meadow Marsh Area (AOC 8) contained sediment with levels of pesticides and metals that were below cleanup standards for human health; however, these levels presented an exposure risk to eastern tiger salamanders, an endangered species in New York State.

Groundwater: The groundwater beneath the Former Landfill Area contained VOCs and Sr-90, while groundwater beneath the Current Landfill contains VOCs and metals. Sr-90 and VOCs have also entered the groundwater from the former HWMF. VOC contamination from these areas has migrated beyond the site's boundary.

Operable Unit II/VII. The principal threat is from radioactively contaminated soils.

Soils: Cs-137 is the major radiological contaminant of concern in soil where it can exceed specified risk or radiation dose limits. Cs-137 was found in the WCF soils as well as several areas identified from the aerial radioactive monitoring system results (i.e., landscaping soils [AOC 16S]). During the remedial investigation, no Cs-137 soil contamination in the landscape soils was found greater than two feet below grade. This soil contamination was included under the OU I project. Sr-90 soil contamination was found deeper than two feet at the WCF, as was tritium contamination in soil at the BLIP.

Groundwater: The BLIP (AOC 16K) contains an area of soil and groundwater contamination. (See discussion on g-2 and BLIP areas below).

Operable Unit III. Groundwater contamination is the most significant concern; however, there are several soil AOCs.

Groundwater: VOC-contaminated groundwater extends south from the central portion of BNL off site to the Brookhaven Airport area, a distance of approximately three miles. The VOC plumes originated from a variety of sources including various small spill areas in the central industrial/research areas of the site, former Building 96 area, the Former Landfill, the Central Steam Facility (OU IV), Former Building 208 warehouse area, the former Carbon Tetrachloride UST, and maintenance Building 452. The primary

contaminants are TCA, PCE, Freon-11, and carbon tetrachloride. Tritium and Sr-90 are also present above the maximum contaminant levels (MCLs) on the BNL site. There is no radiological contamination off of BNL property that exceeds MCLs. The potable drinking water wells off of the BNL site are currently not impacted by VOCs or radioactivity, nor are they expected to be impacted from the contamination. Although these plumes were not found to have impacted any off-site private drinking water supply wells, in the 1990s DOE provided public water connections to most of the homes in the designated hook-up area downgradient of the site. Although one homeowner continues to use their private well for drinking water purposes within the OU III area, DOE offers free annual testing of their well water, which is conducted by the SCDHS.

Soils: PCB-contaminated soils above the New York State Technical and Administrative Guidance Memorandum (TAGM) cleanup levels, as well as high concentrations of PCE in soil, were found at the former Building 96 Scrapyard (AOC 26B). Other smaller contaminated soil areas included mercury at Building 464 (AOC 27) and PCBs at Building 479 (AOC 25).

Operable Unit IV. Soil and groundwater are the concerns.

Groundwater: VOCs and SVOCs, such as benzene, toluene, and ethylbenzene from an historical oil/solvent spill, contaminated the groundwater at this OU. Strontium-90 was released to groundwater at the Building 650 Sump Outfall and the plume is located in the central portion of the site.

Soil: VOCs and SVOCs were also present in the soils from the historical oil/solvent spill. Radiological contamination of soils was identified at the Building 650 Sump Outfall. This soil contamination was included under the OU I project.

Operable Unit V. Radioactively and metal-contaminated soil, and metal and PCB-contaminated river sediment are the principal threats.

Soil/Sediment: The STP berms soil (AOC 4) presented concern due to potential impacts to future on-site residents from Cs-137 and mercury. In addition, concentrations of mercury and PCBs in fish may have posed a health hazard to people consuming fish taken from certain locations on the Peconic River (AOC 30). Sediment within certain depositional areas of the Peconic River was contaminated with mercury, silver, and copper, and posed a potential ecological concern. Surface sediment in depositional areas up to 1.5 miles downstream of the STP contained the PCB Aroclor-1254. Trace amounts of cesium-137 were co-located in the sediment, but did not pose a risk to people or aquatic organisms.

Groundwater: VOCs (primarily TCE and TCA) were the primary contaminants in the groundwater on and off of the BNL site. Low levels of tritium were also found, but at concentrations below the 20,000 picocuries per liter (pCi/L) MCL. In the 1980s, one private well was impacted by site-related VOCs at concentrations exceeding drinking water standards. DOE provided a carbon filtration system to this home, and subsequently connected it to the public water supply. Although this action was not performed as part of a CERCLA remedy under the BNL Federal Facilities Agreement, it did help support the basis for investigation of the groundwater in OU V. DOE currently offers free annual testing to one other homeowner that continues to use their private well for drinking water purposes.

Operable Unit VI. Groundwater contamination is the primary threat.

Groundwater: The pesticide EDB is the contaminant of concern (AOC 28). It has been found in groundwater on and off of BNL property significantly above the MCL of 0.05 micrograms per liter (µg/L). The EDB originated from application in the Biology Fields in the 1970s. DOE offers free annual testing to one business and one homeowner that continue to use their private wells for drinking water purposes.

Operable Unit VIII

Groundwater: Past use of firefighting foam for training purposes has resulted in PFAS groundwater contamination downgradient of the current and former firehouse facilities (AOCs 33D and E) significantly above the State MCLs of 10 nanograms per liter (ng/L) for PFOS and 10 ng/L for PFOA. Lower levels of PFOS and PFOA exceeding the standards have also been identified on BNL property (AOCs 33A,B, C and F through I) and in several off site areas. Low levels of 1,4-dioxane exceeding the 1.0 µg/L MCL have been identified in several on site and off site areas (AOC 34). PFOS has been detected in three of BNL's potable drinking water supply wells at concentrations exceeding the 10 ng/L MCL. As a precaution, well 4 and well 6 were removed from service and carbon treatment was added to wells 10 and 11. Carbon treatment for well 12 will be complete in the fall 2021.

Soil: To date, only limited sampling of soils for PFAS has been performed. Sampling conducted at BNL's Recreation Center in the southwest part of the site identified low levels of PFOS and PFOA in the shallow soils where firefighting foam had been released. Additional soil sampling at other identified foam release areas will be performed during the RI.

BGRR

Structures and Soils: There were several radiologically contaminated and activated structures and components at various locations within the BGRR complex (AOC 9). These include the graphite pile and surrounding biological shield, contaminated concrete within the fuel-handling system's deep pit and fuel canal (AOC 9A), and contaminated steel, concrete, air coolers, and filters within the below-ground ducts (BGD, AOC 9B). Additionally there are isolated pockets of contaminated soils (primarily Sr-90) adjacent to the BGD secondary cooling air bustle and expansion joints, fuel canal outer walls and construction joint, the reactor building pipe trench, and the reactor building drains. Concerns also include rainwater infiltration and subsequent leaching of Sr-90 into the soil/groundwater, as well as the continued release of residual Sr-90 that had previously leached into the deep vadose zone soils beneath the building and underground structures during periods of high water-table levels. To reduce the ability of rainwater to infiltrate the contaminated below ground structures and soil, a number of stormwater management controls have been implemented. Most non-radiological hazardous materials associated with the BGRR were removed through previous interim stabilization measures. Isolated pockets of non-radiological hazardous material contamination are present within the reactor building pipe trench, and within embedded drain lines. Hazardous materials intrinsic to construction materials, such as floor tiles, paint, and insulating materials, remain within the reactor building.

Groundwater: Groundwater contaminated with Sr-90, included under OU III, is present beneath the BGRR complex at concentrations significantly above the 8 pCi/L MCL. The Sr-90 contamination in groundwater extends from the BGRR to 1,500 feet south.

g-2/BLIP/USTs

Structures and Soils: Particle accelerator operations at the former g-2 experiment area (AOC 16T) and BLIP facility (AOC 16K) have resulted in the activation of soil used for shielding. The primary contaminants of concern in the activated soils are tritium and sodium-22. The infiltration of rainwater through the activated soils can leach tritium and sodium-22 from the soils and carry them into the groundwater. To reduce the ability of rainwater to infiltrate the activated soils, a number of stormwater management controls have been implemented. In addition, eight USTs from several locations across the site were removed between 1988 and 1996, and confirmatory soil sampling following the tank removals indicated no environmental impacts.

Groundwater: Groundwater in the vicinity of the former g-2 experiment area (AOC 16T) and BLIP facility (AOC 16K) had been contaminated with tritium at concentrations that exceeded the 20,000 pCi/L MCL.

Although sodium-22 concentrations had occasionally exceeded the 400 pCi/L MCL, it was found to naturally attenuate (via decay and dispersion) to nearly non-detectable levels within a short distance from the source areas. There were no groundwater impacts associated with the former USTs.

HFBR

Activated Components, Contaminated Structures and Soils: Past operations resulted in the formation of radioactive material (i.e., activation products) within the metal and concrete of the large reactor components (reactor vessel/internals, thermal shield and biological shield). Smaller quantities of radioactive material were also found in ancillary structures (fan houses and stack), underground pipes/ducts, and associated soils.

Groundwater: Groundwater contaminated with tritium, including under OU III, was present beneath the HFBR and had extended several thousand feet to the south at concentrations exceeding the 20,000 pCi/L MCL. The downgradient portion of the plume has attenuated to below the MCL, and currently tritium is only periodically detected above the MCL in monitoring wells immediately downgradient of the HFBR. Tritium from the HFBR was never detected above the MCL beyond the BNL property boundary.

4.0 Remedial Actions

4.1 Remedy Selection

To date, nine Records of Decision and four Explanations of Significant Differences have been signed at BNL. The first was signed in 1996 (OU IV ROD) and the last in 2012 (OU III ESD). The nine RODs are:

1. OU I – Radiologically contaminated soils on the BNL site (incorporates OU II/VII AOCs) (BNL 1999)
2. OU III – Groundwater on and off of the BNL site (BNL 2000a)
3. OU IV – Soil and groundwater on site (BNL 1996a)
4. OU V – STP (BNL 2001b)
5. OU V – Peconic River (BNL 2004a)
6. OU VI – EDB in groundwater off of the BNL site (BNL 2000b)
7. BGRR – Radiologically contaminated structures and soil on site (BNL 2005b)
8. g-2/BLIP/USTs – Radiologically contaminated soil shielding and groundwater (BNL 2007b)
9. HFBR – Radiologically contaminated structures and soil (BNL 2009b)

The four ESDs are:

1. OU III – Magothy and Sr-90 groundwater cleanup, institutional controls (BNL 2005a)
2. OU III – Building 96 soil and groundwater remedy optimization (BNL 2009a)
3. OU III – BGRR Biological shield removal changes (BNL 2012b)
4. OU III – Building 452 Freon-11 groundwater remedy (BNL 2012a)

Individual site locations are shown on **Figure 4-1**. Brief descriptions of the ROD remedial action objectives and the major remedy components are described below.

<u>Operable Unit I ROD, signed August 1999 (BNL 1999)</u>

- Objectives are to:
  - Prevent or minimize leaching of contaminants (radiological and chemical) from soil into the groundwater.
  - Prevent or minimize migration of contaminants present in surface soil via surface runoff and windblown dust.
  - Prevent or minimize human exposure including direct external exposure, ingestion, inhalation, and dermal contact, and environmental exposure to contaminants in the surface and subsurface soils.
  - Prevent or minimize the uptake of contaminants present in the soil by ecological receptors.
  - For radionuclides in soil, the cleanup goal is based on a total dose of 15 milliRem per year (mRem/yr) above background.
  - The NYSDEC guidance of 10 mRem/yr above background has been adopted as an As Low As Reasonably Achievable (ALARA) goal which will be considered during the design and construction phase.

- OU I Remedy Components:
  - Excavate soils that are radiologically and chemically contaminated above the selected cleanup goals at the former HWMF, WCF, Building 650 Sump and Sump Outfall, and the Chemical/Animal Pits and Glass Holes, and dispose of soil at an approved off-site facility. Reconstruct wetlands at the former HWMF.
  - Remove out-of-service facilities, tanks, piping, and equipment at the former HWMF and WCF.
  - Install soil caps to address metal contamination at ash pits.

- Excavate chemically contaminated sediment from the Upland Recharge/Meadow Marsh Area and dispose of sediment at an approved facility off the BNL site. Reconstruct wetlands and monitor. Note: The cleanup values for the primary contaminants of concern were mercury 1.84 mg/kg, lead 15.8 mg/kg, thallium 0.35 mg/kg, zinc 22.4 mg/kg, and copper 25 mg/kg.
- Implement long-term institutional controls and monitoring to ensure that planned uses are protective of public health.
- All of the previous removal actions that were implemented, such as landfill capping, waste and soil excavation, groundwater pump and treat systems, and groundwater monitoring, were selected as final remedies under the ROD.

Groundwater contamination associated with the Former Landfill Area and off-site groundwater associated with other Operable Unit I AOCs were addressed in the OU III ROD (BNL 2000a). An evaluation of remedial alternatives for contaminated soil and groundwater associated with the BLIP facility (AOC 16K) was completed. The final remedy for contaminated soils and groundwater at BLIP is documented in the g-2/BLIP/USTs ROD (BNL 2007b).

Operable Unit II/VII Decisions

Remedial actions for the OU II and VII AOCs are documented in the OU I ROD (BNL 1999), the OU III ROD (BNL 2000a), and the g-2/BLIP/USTs ROD (BNL 2007b).

Operable Unit III ROD, signed June 2000 (BNL 2000a)

- Objectives are to:
  - Meet drinking water standards (i.e., MCLs) for VOCs (5.0 µg/L for most VOCs), Sr-90 (8.0 pCi/L), and tritium (20,000 pCi/L) in groundwater.
  - Complete cleanup of the groundwater in the Upper Glacial aquifer within 30 years (by 2030) or less. [Note: the updated timeframe for Sr-90 is addressed in the 2005 ESD].
  - Prevent or minimize further migration of VOCs, Sr-90, and tritium in groundwater.
- OU III Remedy Components:
  - For VOCs – Install treatment systems at the Long Island Power Authority (LIPA) right-of-way, North Street, Airport, North Street East, Industrial Park East, Middle Road, and Western South Boundary. All of the previously implemented VOC removal actions (including treatment systems at the South Boundary and Industrial Park) were selected as final remedies under the OU III ROD.
  - For tritium (AOC 29) – Institute contingency plans to reactivate the Princeton Avenue pump and recharge system, and low-flow groundwater extraction of high tritium concentrations at the HFBR with approved off-site disposal of the water.
  - For Sr-90 – Install treatment systems using ion exchange at the Chemical Holes and the BGRR/WCF plumes. Prior to implementation, perform a pilot treatability study to evaluate the effectiveness of extraction and treatment, and modify the remedy, if needed.
  - Magothy aquifer – Perform additional characterization and determine the need for a remedy. If a remedy for the Magothy is necessary, either the OU III ROD would be modified or another decision document would establish the selected action (see OU III ESD below).
  - The previous removal action that was implemented for public water hookups was selected as a final remedy under the ROD.
  - Groundwater monitoring program to monitor and verify the cleanup over time.
  - Source Areas – Source removal system at Building 96 for VOCs in groundwater and PCBs in soil, remediation of groundwater at the former Carbon Tetrachloride UST spill area, and removal of Building 830 USTs (AOC 12).
  - Deferred Decisions – The final remedy for potential source areas such as the Building 96 geophysical anomalies (AOC 26B) was documented in a subsequent ROD (see OU III ESD

below). The final remedy for AOC 9D, the Pile Fan Sump, was documented in the BGRR ROD.

Operable Unit III Explanation of Significant Differences, signed May 2005 (BNL 2005a)

- OU III Remedy Components:
  - Magothy aquifer – Add two Magothy aquifer extraction wells off of BNL property in addition to the three wells already installed. Meet drinking water standards within 65 years of the signing of the OU III ROD (by 2065).
  - Sr-90 – Continue to operate the "pilot study" remediation facility treatment system at the Chemical Holes and meet the drinking water standards within 40 years (by 2040). Install an ion exchange treatment system for the BGRR/WCF plume, and meet the drinking water standards within 70 years (by 2070).
  - Building 96 Scrapyard – No further action for the geophysical anomalies.
  - Implement long-term institutional controls and monitoring to ensure that planned uses are protective of public health.

Operable Unit III Explanation of Significant Differences, signed August 2009 (BNL 2009a)

- OU III Remedy Components:
  - Building 96 Scrapyard – Changes to the Building 96 groundwater remedy to include excavation and off-site disposal of PCE-contaminated soils. This will optimize the remedy by reducing the number of years of active treatment and enable BNL to achieve the ROD cleanup goal for this groundwater plume (by meeting drinking water standards for VOCs by 2030).

Operable Unit III Explanation of Significant Differences, signed May 2012 (BNL 2012a)

- OU III Remedy Components:
  - Building 452 Freon-11 Source Area and Groundwater Plume – Following the 2011 discovery of a Freon-11 plume near site maintenance Building 452, a new groundwater treatment system was installed in early 2012. This remedy will enable BNL to achieve the ROD cleanup goal for this groundwater plume (by meeting drinking water standards for VOCs by 2030).

Operable Unit IV ROD, signed March 1996 (BNL 1996a)

- Objectives are to restore the groundwater quality of the most contaminated portion of the AOC 5 plume to MCLs or background levels, and prevent or minimize:
  - Leaching of contaminants (radiological and chemical) from the soils into the groundwater.
  - Volatilization of contaminants from surface soils into the ambient air.
  - Migration of contaminants present in surface soil via surface runoff and windblown dust.
  - Human exposure including ingestion, inhalation, and dermal contact, and environmental exposure to contaminants in surface soil.
  - Uptake of contaminants present in the soil and/or groundwater by plants and animals.
- OU IV Remedy Components:
  - Treat chemically contaminated soil in the vadose zone of the spill area (AOC 5A) and the fuel unloading area (AOC 5D) using soil vapor extraction (SVE).
  - Treat groundwater at the most contaminated portion of the spill area using SVE and air sparging (AS).
  - Use an engineering enhancement option for the groundwater if AS/SVE alone will not achieve the desired performance levels.
  - As an Interim Action, install a fence around the radiologically contaminated soil at Building 650 Sump and Sump Outfall area with institutional controls and monitoring. The final remedy for these soils is documented in the OU I ROD as discussed above.

- Monitor the natural attenuation of Sr-90 contamination in groundwater originating from the former Sump Outfall area.

Operable Unit V Sewage Treatment Plant ROD, signed January 2002 (BNL 2001b)

- Objectives are to:
  - Protect public health and the sole-source aquifer, continue to monitor the groundwater, and to prevent or minimize:
    - Migration of contaminants present in surface soil via surface runoff and windblown dust.
    - Human and environmental exposure to contaminants in surface and subsurface soil.
    - Potential for uptake of contaminants present in the soil by ecological receptors.
    - Potential for migration of contaminants (radiological and chemical) from the soil to groundwater.
  - Reduce the levels of contamination in the sand filter beds (AOC 4B)/berms and adjacent areas.
- OU V STP Remedy Components:
  - Excavate radiologically and chemically contaminated soil at the sand filter beds and berms, firing range berms, and the sludge drying beds, and dispose of soil at an approved off-site facility.
  - Remove sludge from manholes along a retired section of the sanitary sewer line leading to the STP.
  - Monitor the groundwater for VOCs and tritium.
  - A previously implemented removal action for the Imhoff Tank is selected as the final remedy (AOC 4C).
  - Implement institutional controls on BNL property such as preventing the installation of pumping wells that may interfere with groundwater monitoring.
  - Any sale or transfer of BNL property will meet the requirements of 120(h) of CERCLA to ensure that future users are not exposed to unacceptable levels of contamination.

Operable Unit V Peconic River ROD, signed January 2005 (BNL 2004a)

- Objectives are to:
  - Reduce site-related contaminants (e.g., mercury) in sediment to levels that are protective of human health.
  - Following cleanup on Laboratory property, the average mercury concentration will be less than 1 part per million (ppm), with a goal that all mercury concentrations in the remediated areas are less than 2 ppm.
  - Following cleanup outside Laboratory property, the average mercury concentration will be less than 0.75 ppm, with a goal that all mercury concentrations in the remediated areas are less than 2 ppm.
  - Reduce or mitigate, to the extent practicable, existing and potential adverse ecological effects of contaminants in the Peconic River.
  - Prevent or reduce, to the extent practicable, the migration of contaminants off the BNL property.
- OU V Peconic River Remedy Components:
  - Removal and disposal of mercury-contaminated sediment above agreed upon cleanup levels from designated depositional areas on and off of BNL property.
  - Implement a monitoring program to demonstrate the effectiveness of the cleanup. Near-term monitoring results will establish the basis for the long-term monitoring program. The program includes monitoring for methyl mercury in the water column, sediment sampling, and fish sampling on and off of BNL property.

- Conduct an annual review for the first five years after commencement of the remedial action to ensure that the remedies continue to provide adequate protection of human health and the environment.
- Sampling results for each annual review and the formal Five-Year Review will be evaluated with the regulators and appropriate modifications will be made, as necessary, for subsequent sampling.

Operable Unit VI ROD, signed March 2001 (BNL 2000b)

- Objectives are to:
  - Meet the MCL for EDB in groundwater (0.05 µg/L).
  - Complete cleanup of the groundwater in a timely manner. For the Upper Glacial aquifer, this goal is 30 years (by 2030) or less.
  - Prevent or minimize further migration of EDB in groundwater vertically and horizontally.
- OU VI Remedy Components:
  - Install a treatment system to extract EDB from the groundwater with subsequent treatment via activated carbon filtration.
  - The previous removal action that was implemented for public water hookups was selected as a final remedy under the ROD.
  - Develop groundwater monitoring program to monitor and verify the cleanup over time.
  - Implement institutional controls on the BNL property to prevent use of contaminated groundwater in the OU VI area.

Operable Unit VIII (No ROD)

- Includes AOC 33 (PFOS and PFOA) and AOC 34 (1,4-Dioxane)
- Time Critical Removal Action (TCRA) is underway for PFOS/PFOA-contaminated groundwater downgradient of the Current and Former Firehouses.

BGRR ROD, signed March 2005 (BNL 2005b)

- Objectives are to:
  - Ensure protection of human health and the environment, without undue uncertainties, from the potential hazards posed by the radiological inventory that resides in the BGRR complex.
  - Use the ALARA principle while implementing the remedial action.
  - Following completion of the remedial activities, implement long-term monitoring, maintenance, and institutional controls to manage potential hazards to protect human health and the environment.
- BGRR Remedy Components:
  - Remove the BGD filters and primary liner.
  - Remove a portion of the fuel canal outside the structural footprint of the reactor building. Remove accessible subsurface contaminated soil in the vicinity of the fuel canal, BGD expansion joint #4, and the secondary cooling air bustle.
  - Isolate the BGD and demolish the instrument house.
  - Install water infiltration control (i.e., engineered cap) and monitoring system (including the installation of groundwater monitoring wells) for remaining structures and subsurface contaminated soil.
  - Remove the graphite pile and biological shield.
  - Complete final status surveys to document that cleanup objectives are met and to document final conditions.
  - Develop and implement land use and institutional controls that include routine inspection and surveillance of the BGRR complex, maintenance and upkeep of Building 701 and surrounding water infiltration control system, and reporting requirements to ensure that planned uses are protective of public health.

- Submit an annual certification to NYSDEC that institutional and engineering controls are in place, are unchanged from the previous certification, and nothing has occurred that would impair the ability of the control to protect public health and the environment.
- All of the previous removal actions that were implemented prior to the ROD signing, such as removal and disposition of accumulated contaminated water, Pile Fan Sump and soils, above-ground ducts, canal and water treatment house, accessible contaminated soils, and exhaust cooling coils and filters, were selected as final remedies under the ROD.

BGRR Explanation of Significant Differences, signed June 2012 (BNL 2012b)

- OU III Remedy Components:
  - Biological Shield - Changes to the scope of work for removal of the BGRR biological shield include the removal of the outer steel walls, the inner steel walls, and the concrete between the inner and outer walls down to the existing floor level, rather than removing the approximately three vertical feet of biological shield embedded below the existing floor.

g-2/BLIP/USTs ROD, signed May 2007 (BNL 2007b)

- Objective is to:
  - Prevent additional rainwater infiltration into activated soil shielding at g-2 and BLIP.
- g-2/BLIP/USTs Remedy Components:
  - Inspect and maintain the caps and other stormwater controls at the g-2 and BLIP source areas. Submit an annual certification to NYSDEC that institutional and engineering controls are in place, are unchanged from the previous certification, and nothing has occurred that would impair the ability of the control to protect public health and the environment.
  - Conduct routine groundwater monitoring to verify the effectiveness of the stormwater controls. Monitor the downgradient portion of the g-2 plume until tritium concentrations decrease to below the 20,000 pCi/L MCL.
  - For the former UST areas, no additional remedial actions are required.

High Flux Beam Reactor ROD, signed April 2009 (BNL 2009b)

- Objectives are to control, minimize, or eliminate:
  - All routes of future human and/or environmental exposure to radiologically contaminated facilities or materials.
  - The potential for future release of non-fixed radiological or chemical contamination to the environment.
  - All routes of future human and/or environmental exposure to contaminated soils.
  - The future potential for contaminated soils to impact groundwater.
- HFBR Remedy Components:

  The HFBR remedy incorporates many completed interim actions, several near-term actions, and the segmentation, removal, and disposal of the remaining HFBR structures, systems, and components following a safe storage decay period (not to exceed 65 years).

  Completed interim actions:
  - The HFBR fuel was removed and sent to an off-site facility.
  - The primary coolant was drained and sent to an off-site facility.
  - Scientific equipment was removed and is being reused.
  - Shielding and chemicals were removed and are being reused at BNL and other facilities.
  - The cooling tower superstructure was dismantled and disposed of.
  - The confinement structure and spent fuel canal were modified to meet Suffolk County Article 12 requirements.
  - The Stack Monitoring Facility (Building 715) was dismantled and disposed of.

- The Cooling Tower Basin and Pump/Switchgear House (Building 707/707A) was dismantled and disposed of.
- The Water Treatment House (Building 707B) was dismantled and disposed of.
- The Cold Neutron Facility (Building 751) contaminated systems were removed and the clean building has been transferred to another organization for re-use.
- The Guard house (Building 753) was dismantled and disposed of.
- Soil excavation and disposal of the former HWMF Waste Loading Area (WLA) was performed.
- Control rod blades and beam plugs were removed and disposed of.

Near-term Actions:

- Removal of ancillary buildings and associated soils.
  - Stack (Building 705) by 2020 – Stack Demo Complete February 2021 (Closeout Report to be issued fall 2021)
  - Fan houses (Buildings 704 and 802) - Complete
- Removal of contaminated underground pipes and ducts - Complete
- Preparation of Reactor Confinement Building (Building 750) for safe storage - Complete.

Removal after Safe Storage Decay Period:

- Large activated components (reactor vessel and internals, thermal shield and biological shield).
- Reactor Confinement Building structures, systems and components.
- Cleanup of associated soils.

In addition, the final remedy specifies the requirements for surveillance and maintenance to manage the inventory of radioactive material during the safe storage period. Land use and institutional controls, including periodic certification to EPA and NYSDEC, are also specified.

4.2 Remedy Implementation

With the exception of the decommissioning and decontamination of the remaining HFBR structures (e.g., large activated components including reactor vessel, systems, and confinement building), all soil, groundwater, and decommissioning and decontamination remedies for the nine signed RODs at the site have been implemented. This includes the excavation and approved off-site disposal of all contaminated soil, sediment, and tanks, the installation and operation of all groundwater treatment systems, and Long-Term Surveillance and Maintenance of the BGRR and HFBR. As noted above, a TCRA for the construction of PFOS/PFOA groundwater treatment systems downgradient of the current and former firehouse facilities is underway and will ultimately be documented in an OU VIII ROD. A chronology of the previous removal actions undertaken for each OU, and post-ROD remedial actions, is presented in **Table 2-1** (see **Section 2.0**). A brief summary of the status of remedy implementation since the signing of each ROD is identified below.

Operable Unit I: Excavation and off-site disposal of radiologically contaminated soil was initiated in 2000 with the landscape soil (approximately 2,800 cubic yards), followed by the Building 650 Sump and Sump Outfall (approximately 1,800 cubic yards), and Upland Recharge/Meadow Marsh Area (approximately 500 cubic yards). In 2005, removal of the former HWMF (approximately 13,000 cubic yards), Building 811 soil (approximately 4,000 cubic yards), and former Chemical Holes residual surface soil (approximately 4,000 cubic yards) was completed. Of the total contaminated soil volume, approximately 23,600 cubic yards were disposed of at Envirocare of Utah, and 2,500 cubic yards were disposed of at Niagara Falls Landfill Facility. (Furthermore, approximately 11,000 cubic yards of soil were excavated from the Chemical/Animal Pits and Glass Holes during 1997 as part of a Removal Action that was conducted prior to the ROD being signed.) In 2003, the ash pits were capped with a soil cover to prevent direct contact

risks, and removal and disposal of the Building 811 USTs was completed in 2005. The Oak Ridge Institute for Science and Education (ORISE), an independent contractor to DOE, verified that the cleanup effort at these radiologically contaminated soils areas attained the cleanup goals defined in the ROD (ORISE 2008). Closeout reports were issued for the landscape soil, Building 650 Sump and Sump Outfall, Upland Recharge/Meadow Marsh Area, the former HWMF, and Building 811 soil, and an addendum to the existing Chemical Holes Closeout Report was issued. In March 2007, the decontamination of the Merrimack Holes at the former HWMF was completed. Between 2009 and 2014, three phases of cleanup of the former HWMF Perimeter Soils were performed (approximately 407 cubic yards were excavated). Closeout reports for each phase of the cleanup were issued (BNL 2010a, 2010b, 2015a). Starting in 2014 and continuing into 2018, the former Waste Concentration Facility Buildings 810 and 811 were demolished, waste transfer lines were removed, and excavation of radiologically-contaminated soil was completed (approximately 1,822 cubic yards of waste).

As noted in the *Final Closeout Report for Area of Concern 16 Landscape Soils* (BNL 2001c), monitoring conducted after calendar year 2000 and the excavation of the landscape soil indicates that the potential exposure to workers and future site residents is less than the 15 mRem/yr above background criteria. This cleanup also met the NYSDEC ALARA goal of less than 10 mRem/yr above background. Landscape soil from the Building 355 area was excavated again in March 2010 as part of construction activities for the new Interdisciplinary Science Building (ISB) 734. The soil was transferred to the former HWMF to be used as fill. Three confirmatory soil samples identified remaining Cs-137 concentrations below 0.5 picocuries per gram (pCi/g). The regulators were briefed on this work.

The OU I South Boundary Treatment System, installed under a Removal Action, began operation in 1997 and was approved for shutdown in 2013 and closure in 2019.

Operable Unit III: Fifteen of BNL's 18 groundwater treatment systems are included under OU III. Following the signing of the OU III ROD in June 2000, the groundwater treatment systems were installed between 2000 and 2012 both on and off of the BNL property. Twelve of the treatment systems were installed to address VOC groundwater contamination and two systems were installed to address Sr-90 groundwater contamination. The performance of these systems in meeting the overall groundwater cleanup goals is evaluated in the annual *BNL Groundwater Status Reports.* Through 2020, the OU III treatment systems are responsible for 95 percent of the 7,700 pounds of VOCs removed by all of the BNL groundwater treatment systems.

In accordance with the ROD, several low-flow extraction events were performed between 2000 and 2001 for the high-concentration segments of the HFBR tritium plume. Approximately 100,000 gallons of tritium-contaminated water were pumped from the aquifer and disposed of at an approved off-site facility. Contingency remedies continue to remain in place for the HFBR tritium plume. In response to the November 2006 triggering of the OU III ROD contingency plan, the HFBR Pump and Recharge system was re-started in December 2007. As part of this action, a new extraction well was constructed to improve control and capture of the plume. This well began operation in November 2007. All four wells were placed in standby mode in 2013.

The Building 96 treatment system was originally approved for shutdown in 2005. In 2008, the system was turned back on and extraction well RTW-1 was modified from a recirculation well to an extraction well to improve the removal efficiency of VOCs in the source area. Subsequent investigations identified a continuing localized source of VOC contamination within the vadose zone. In accordance with the OU III ESD approved in 2009 (BNL 2009a), the VOC-contaminated soils were excavated in 2010 and disposed of at an approved off-site facility. Hexavalent chromium was also detected in Building 96 area monitoring wells in 2008 as a byproduct of earlier potassium permanganate injections in the source area that were used to remediate residual VOCs. Well RTW-1 also included treatment for hexavalent chromium from 2008

through 2018. Between 1999 and 2005, approximately 2,200 cubic yards of PCB-contaminated soil from the former Building 96 Scrapyard area were excavated and disposed of offsite. This was accomplished in accordance with the ROD to reduce the risk of direct contact with contaminated soils in this area.

In accordance with the OU III ESD approved in 2005 (BNL 2005a), two additional Magothy aquifer groundwater extraction wells were installed to address VOC contamination at the LIPA and Industrial Park East treatment system areas. Between 2007 and 2020, additional extraction wells were installed at the LIPA/Airport, Chemical Holes Sr-90, HFBR Tritium Pump and Recharge, BGRR/WCF Sr-90, South Boundary, Middle Road, Industrial Park, Western South Boundary, and the North Street East systems. These additional extraction wells were necessary to address changing plume conditions identified as part of the long-term groundwater monitoring program.

In accordance with the OU III ESD approved in 2012 (BNL2012a), one Upper Glacial aquifer groundwater extraction well was installed to address Freon-11 contamination detected near site maintenance Building 452. This well began operation in 2012 and was shut down in 2016.

The status of the *Petitions for Shutdown* and *Petitions for Closure* of the OU III groundwater treatment systems are as follow:

- Carbon Tetrachloride: Approved for shutdown in 2004. Approved for closure in 2009-2010.
- Industrial Park East: Approved for shutdown in 2009. Approved for closure in 2013. Infrastructure repurposed in 2014 to support deeper Industrial Park extraction wells.
- North Street: Approved for shutdown in 2013; however, it was restarted in 2014 due to rebound of VOCs. Approved for closure in 2020.
- HFBR Tritium Pump and Recharge: Approved for shutdown in 2013. Approved for closure in 2019.
- Industrial Park: Approved for shutdown in 2013, however, it was restarted in 2014 due to rebound of VOCs. Shut down again in 2017. Two additional extraction wells became operational in 2015 to address the deep VOCs and were placed in standby mode in 2019.
- North Street East: The original VOC treatment system was approved for shutdown in 2014 and administratively closed in 2020. Two additional extraction wells were installed and became operational in 2020 to address a newly identified EDB plume.
- Building 452 Freon-11: Approved for shutdown in 2016. Approved for closure in 2019.
- Chemical Holes Sr-90: Approved for shutdown in 2018.

Operable Unit IV: In accordance with the March 1996 OU IV ROD (BNL 1996a), a groundwater treatment system was installed in 1997 to remediate VOC and SVOC soil and groundwater contamination at a former oil/solvent spill area. A CERCLA Five-Year Review performed for OU IV in 2003 (BNL 2003a) found that the remedy was highly effective in remediating soil and groundwater contamination. The system met its cleanup objectives and the regulatory agencies approved its decommissioning in 2003.

Operable Unit V: Following issuance of the OU V STP ROD (BNL 2001b), the contaminated soil at the plant was excavated and disposed of offsite in 2003. A completion report for this effort was issued in 2004 (BNL 2004b). Following the 2012 regulatory approval of a *Final Petition to Discontinue Operable Unit V Groundwater Monitoring* (BNL 2012d), natural attenuation monitoring of the low-level VOC groundwater plume that originated from the STP area was completed in 2014.

Prior to issuance of the OU V Peconic River ROD (BNL 2004a), on- and off-site contaminated sediments were excavated from the river (approximately 21,000 cubic yards) during 2004 and 2005 under the authority of a Removal Action (BNL 2004c). The closeout report for the Peconic River Phases 1 and 2 was issued in 2005 (BNL 2005c). Based on Peconic River monitoring data (for approximately 1,700 sediment,

surface water, and fish samples collected between 2006 and 2010 [BNL 2007f, 2008a, 2009e, 2010f, 2011i, 2012g]), DOE and the regulatory agencies determined that supplemental sediment removal in the river was necessary. In late 2010 through early 2011, an additional 800 cubic yards of contaminated sediment were excavated. The final completion report was issued in 2012 (BNL 2012h). Based on Peconic River annual sediment monitoring data collected between 2011 and 2015 at the three supplemental remediation areas, a small segment of the river was identified as requiring additional sediment remediation (BNL 2013c). In 2016, DOE submitted a plan to the regulators for supplemental sediment removal at on-site Area WC-06 (BNL 2016d). Supplemental sediment removal of 108 cubic yards was performed in 2017 in Area WC-06. The final completion report was issued in December 2017 (BNL 2017b).

Operable Unit VI: In 2004, a groundwater treatment system was installed in accordance with the OU VI ROD and began operations to remediate the plume of EDB located beyond the site boundary. Per the OU III and VI RODs (BNL 2000a, b), DOE continues to offer homeowners not connected to public water free annual testing of their private wells.

Operable Unit VIII: In 2021, the installation of two groundwater treatment systems are planned downgradient of the Current and Former Firehouses where high levels of PFOS and PFOA have been identified. The work is being performed under the authority of a TCRA. A draft Action Memo was submitted to the regulators in June 2021 for review.

BGRR: All of the cleanup actions performed at the BGRR prior to the ROD approval in 2005 were conducted through removal actions or *National Environmental Policy Act* (NEPA) categorically excluded actions. Since ROD approval, the cleanup actions at the BGRR (e.g., removal of the graphite pile) were performed as remedial actions under the ROD (BNL 2005b). Remedial activities associated with the Graphite Pile Removal Project commenced in December 2009 and were completed in May 2010. The scope of these activities included removal and disposal of control rods, removal and disposal of boron shot, removal and disposal of shield plugs, removal and disposal of the upper portion of the air tight membrane, removal and disposal of Invar rods, and removal and disposal of the Graphite Pile. Installation of the final engineered cap adjacent to Building 701 was completed in 2011 and a final closeout report issued (BNL 2011c). In 2012, the biological shield was removed in accordance with the ESD (BNL 2012b) and a final closeout report issued (BNL 2012c).

g-2/BLIP/USTs: BNL routinely inspects and maintains the caps and other stormwater controls at the g-2 and BLIP source areas. Routine groundwater monitoring at the source areas is conducted to verify the effectiveness of the stormwater controls. Following the detection of tritium in groundwater south of Brookhaven Avenue above the 20,000 pCi/L ROD (BNL 2007b) contingency trigger level, BNL initiated additional monitoring in this area. During 2015, the tritium levels were found to have attenuated to below the 20,000 pCi/L MCL in the downgradient portion of the plume. Monitoring of the downgradient plume segment was subsequently discontinued. Monitoring is currently limited to areas directly downgradient of the g-2 and BLIP source areas. No additional remedial actions are required for the former UST areas.

HFBR: Prior to the ROD approval in 2009, all of the cleanup actions at the HFBR were performed through removal actions or NEPA categorically excluded actions. Since ROD approval, stabilization of the reactor confinement building for safe storage and the cleanup actions at the HFBR, such as the removal of Buildings 801-811 waste transfer lines (A/B waste lines with co-located piping) and associated soil, were performed as remedial actions under the ROD (BNL 2009b). Other remedial actions associated with the removal of ancillary structures were also performed and closeout reports issued (BNL 2011d, e, f and 2012f): Fan houses, confinement building stabilization, underground utilities, soil (2011) and stack silencer baffles (2012). Surveillance and maintenance of the HFBR is performed in accordance with the *Long-Term Surveillance and Maintenance Plans* and *Long-Term Surveillance and Maintenance Manuals* for the HFBR (2011g, 2018d,e).The stack Closeout Report will be submitted to the regulators in the fall of 2021.

The Waste Loading Area (WLA) was part of the former HWMF, AOC 1. It is an area (of about two acres in size) along the eastern boundary of the former HWMF that was left in place so that it could be used as a waste staging and railcar loading area for the BGRR, HFBR and other decommissioning projects. The WLA was transferred to the HFBR scope of work in September 2005 through a modification to the *Remedial Design Implementation Plan* (RDIP) for the former HWMF. In February 2009, AOC 31, comprising the HFBR complex and the WLA, was established. The cleanup of the WLA was performed as a non-time-critical removal action (BNL 2007d). The cleanup of this area used the same cleanup goals and methodology required for AOC 1 in the OU I ROD. Soil remediation was performed from November 2007 to May 2008, and the cleanup goals for both chemicals and radionuclides were achieved. This work is summarized in the document *High Flux Beam Reactor, Area of Concern 31, Final Completion Report for Waste Loading Area Soil Remediation* (BNL 2009c). The WLA continues to be used for waste rail car loading.

Physical demolition of the stack was completed in February 2021 and structures/soil remediation was completed in May 2021. A Closeout Report will be submitted to the regulators for review in the fall of 2021.

The reactor vessel is scheduled for removal by 2072.

Groundwater Monitoring: An essential component of the groundwater remediation program is continued monitoring of the groundwater to ensure the cleanup is progressing as planned and that source controls continue to be effective. An average of 1,500 groundwater samples were collected and analyzed annually between 2016 and 2020. The effectiveness of the groundwater remediation systems' performance is evaluated monthly, quarterly, and annually. Comprehensive summaries of the annual monitoring and evaluations of the systems and plumes are documented in quarterly progress reports and in the annual *BNL Groundwater Status Reports* (Volume II of the *BNL Site Environmental Report*). Recommendations are made on an annual basis for modifications to groundwater monitoring programs and treatment system operations in response to changing plume conditions. These recommendations are developed with regulatory agency input. The treatment systems and monitoring programs are optimized with the goal of meeting drinking water standards within 70 years (2070) for the BGRR/WCF Sr-90 plume, within 65 years (2065) for the Magothy aquifer, within 40 (2040) for the Chemical Holes Sr-90 plume, and within 30 years (2030) for VOCs in the Upper Glacial aquifer.

Property Access: Seven access agreements are currently in place with the county, town, local utility, and private landowners. Six of these agreements enable BSA to perform groundwater remediation activities for contamination that has migrated beyond the property boundary of BNL. The seventh agreement is with Suffolk County and allowed for the supplemental remediation of the Peconic River sediment in 2017. One of the land parcels changed property ownership in 2020 and a new access agreement is being prepared. BNL is currently working to renew one agreement that expired in 2018 and one that needs to be modified. The terms of these agreements must be adhered to, such as maintaining adequate liability insurance, and in some cases, making annual monetary payments.

4.3 System Operations/Operation and Maintenance

To date, 18 of the planned groundwater treatment systems have been constructed. The first system became operational in January 1997, and the last system was placed in service in 2020 for the treatment of EDB. The location of each of the treatment systems, the systems'operational status, and the operational status of each of the extraction wells is shown on **Figure 4-1**. (Note that Brookhaven Airport and LIPA are one treatment system, and North Street East and North Street East EDB are considered two treatment systems.) The Industrial Park East, OU IV AOC 5, and Carbon Tetrachloride systems met their cleanup

goals and were decommissioned, and the OU I South Boundary, North Street, HFBR Tritium Pump and Recharge, and Building 452 Freon-11 systems were recently approved for closure. The original North Street East system was administratively closed in 2020. The Industrial Park and Chemical Holes Sr-90 systems are currently in standby mode. The remaining eight systems (BGRR WCF Sr-90, Building 96, Middle Road, Western South Boundary, OU III South Boundary, North Street East EDB, OU VI EDB, and Brookhaven Airport) are in active operation. New extraction wells were installed in 2019 and 2020 to address VOC contamination that was detected in the deep portion of the Upper Glacial aquifer at the Western South Boundary and EDB contamination at North Street East. As part of a TCRA, two groundwater treatment systems will be installed during 2021/2022 for the high concentration PFOS/PFOA plume segments associated with the Current and Former Firehouses. The requirements for ongoing operation and maintenance (O&M), as well as performance monitoring frequencies of these systems, are identified in the O&M manuals. The O&M manuals are updated as needed to reflect changes to the treatment systems, such as the installation of additional extraction wells. BNL performs routine inspections and maintenance of these systems.

Groundwater has been extracted from the Upper Glacial and Magothy aquifers using 73 wells. Currently, 26 of these wells are in operation, 34 of these wells are in standby mode and 13 are shut down and approved for closure. Three of the 26 wells in operation were in pulsed pumping mode in 2020. Of the systems approved for closure, none of the extraction wells will be decommissioned (i.e., abandoned by sanding and grouting the well in place) until characterization for 1,4-dioxane and PFAS is complete and an assessment made of the potential future need for these wells. Average individual extraction well flow rates range from approximately 5 gallons per minute (gpm) for the Sr-90 systems to up to 200 gpm for some of the VOC systems. Groundwater treatment systems used to remediate VOCs use either air stripping methods or granular activated carbon filters. Ion exchange filters are used to treat Sr-90 contaminated groundwater. To monitor system performance, the influent, midpoint (if appropriate), and effluent are routinely sampled. Treated water from the systems is returned to the Upper Glacial aquifer via recharge basins, injection wells, or dry wells. These discharges are regulated by New York State Pollutant Discharge Elimination System (SPDES) discharge equivalency permits, and the data are reported monthly.

Table 4-1: Groundwater Treatment System O&M Costs for FY 2016 to 2020

System	($ in K) FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	Comments
OU I South Boundary	49	54	48	49	19	Air stripping. Standby since 2013. Closed 2019.
OU III South Boundary/ Middle Road	114	151	193	100	92	Air stripping. Termporary wells installed in 2018. Only 5 of 15 wells running in 2019.
OU III Industrial Park	507	391	242	94	111	In-well air stripping with vapor phase carbon treatment placed in standby 2017. New extraction wells with carbon treatment added 2015, and placed in standby mid-2019.
OU III Building 96	82	68	104	55	63	Air stripping treatment. Extraction well RTW-1 operationg full-time. RTW-2 turned back on from late 2018 through June 2020. Temporary wells amd SVE pilot study performed 2018.
OU III Western South Boundary	90	474	1059	710	154	Air stripping treatment. Additional characterization for deep VOCs in 2017 and 2018. Four new extraction wells installed in 2018/early 2019, and began operation in March 2019.
OU III North Street	221	147	145	135	129	Carbon treatment. System placed in standby in late 2016. Closed in 2020. Includes property access costs.
OU III North Street East	4	6	536	428	686	Carbon treatment. Original VOC system placed in standby 2014 and closed in 2020. Temporary well characterization performed in 2018 for EDB. Two additional extraction wells installed in 2019 and system became operational July 2020.
OU III Airport/LIPA	268	193	232	159	220	Carbon treatment. Only 5 of 10 wells running since 2019.
OU III HFBR Tritium	3	4	135	0	1	Pump and recharge system in standby since 2013 and closed in early-2019. 47 monitoring wells decommisssioned late 2018 and seven new wells installed.
OU III Sr-90 Chemical Holes	64	50	41	28	26	Ion-exchange treatment. System placed in standby mode mid-2018.
OU III Sr-90 BGRR/WCF	246	260	194	152	128	Ion-exchange treatment. Only five of nine wells running since late 2018. Resin change-outs reduced to one annually starting in 2018.
OU VI EDB	244	212	258	232	226	Carbon treatment. Temporary and permanent monitoring wells installed in 2019 and 2020. Includes property access costs.
Bldg. 452 Freon-11	40	30	25	5	0	Air stripping treatment. Standby since early 2017, closed in Sept. 2019.

The largest components of the annual O&M cost for the treatment systems are electric, system sampling and analysis, maintenance, spent carbon or ion exchange resin disposal, and property access payments (if applicable). These are direct costs of operation and do not include monitoring well sampling and analysis, and project oversight/management.

5.0 Progress Since the Last Review

This is the fourth sitewide Five-Year Review for the BNL site that covers all of the OUs. The protectiveness statement for each OU, the BGRR, the HFBR, and progress in accomplishing the cleanup goals since the previous Five-Year Review (BNL 2016b) are discussed below.

Operable Unit I: The remedy is expected to be protective of human health and the environment upon completion, and in the interim, exposure pathways that could result in unacceptable risks are being controlled.

Soil Remediation:

- In 2018, an area of surficial radiologically contaminated soil identified along the former Waste Concentration Facility north fence line to the adjacent metal storage yard was excavated. This was the final phase of soil cleanup in this area. This, along with previous cleanup actions in this area, is expected to further reduce Sr-90 contamination in the soil, thus helping to meet the groundwater cleanup objective.

Groundwater Remediation:

- The capture goal for the VOC plume was accomplished by operations of the OU I South Boundary treatment system. The off-site segment of the plume is being controlled by the North Street East system (discussed under OU III). The South Boundary treatment system, capping of the Current Landfill, remediation of the former HWMF, and natural attenuation have all contributed to a significant reduction in the overall extent and concentrations of the VOC plume, as shown on **Figure 5-1**. As a result, the regulators approved the Petition for Closure of the treatment system in 2019 (BNL 2019a). Post-closure monitoring indicates that total VOC (TVOC) concentrations in groundwater have remained less than the system capture goal of 50 µg/L TVOCs since 2013. As a result, the ROD cleanup goals of meeting MCLs by 2030 are expected to be achieved.
- Since 2015, the annual installation of temporary wells has been used to track the movement of higher concentration Sr-90 plume segments downgradient of the Former HWMF. During 2019-2020, three new monitoring wells were installed for improved monitoring of the high concentration plume segments and three additional wells were installed near the leading edge of the plume. Groundwater modeling results suggest that Sr-90 will attenuate to MCLs by the time the plume segments reach the site boundary in 2058. In 2016, a comparison of the monitoring data to natural attenuation model simulations was performed to verify the accuracy of these simulations. Updated natural attenuation simulations were performed in 2020 using the latest monitoring data, and the results are discussed in **Section 7.1**.
- The groundwater quality downgradient of the capped landfills continues to improve. VOCs were not detected above MCLs at the Former Landfill over the previous five years and have not had VOC detections above groundwater standards since 1998. VOCs continue to be periodically detected at levels above MCLs at the Current Landfill. During 2016, temporary wells were installed to supplement the network of permanent wells. The monitoring results and groundwater modeling indicate that the VOCs will not migrate beyond the site boundary at concentrations above drinking water standards. A downgradient well was added to the Current Landfill monitoring well network to monitor the attenuation of the VOCs.

Operable Unit III: The remedy is expected to be protective of human health and the environment upon meeting groundwater cleanup goals. In the interim, exposure pathways that could result in unacceptable risks are being controlled.

- The extent of the high-concentration segments of the OU III VOC plumes have decreased both on and off site as the result of groundwater remediation system operations and the effects of natural attenuation (see **Figure 5-1**).
- Changes to the treatment systems' status since 2016 are as follows:
  - Since there was no significant rebound in VOCs since 2016 and the system had met its cleanup goals, the North Street system was approved for closure in 2020.
  - The Industrial Park system recirculation wells were shut down and placed back in standby mode in 2017. The two additional extraction wells that became operational in 2015 to address deeper VOC contamination were placed in standby mode in 2019 due to low VOC concentrations.
  - Although the original North Street East VOC system met its cleanup goal in 2020, two additional extraction wells were installed during 2020 to address an EDB plume that was identified in this area. The new extraction wells became operational in mid-2020.
  - During 2019, four new extraction wells were added to the Western South Boundary system to address VOC contamination detected in the deep portion of the Upper Glacial aquifer. As part of this system modification, all of the water pumped from Western South Boundary extraction wells is now treated at the Middle Road/South Boundary air stripping system.
  - The Building 452 Freon-11 treatment system was approved for closure in 2019.
  - The LIPA extraction wells were shut down and placed in standby mode in 2017.
  - The Building 96 system expected operational period was extended to 2023 to address persistent elevated VOC concentrations in the source area.
  - The OU III South Boundary and Airport systems' expected operational periods were extended to 2023 and 2025, respectively to ensure capture of upgradient VOCs.

- **Figure 4-1** provides the operational status of each of the treatment systems including extraction wells that were shut down and placed in standby mode, and wells that are in pulsed pumping mode.
- In June 2019, to increase the capture zone of Building 96 extraction well RTW-1, the flow was increased to 60 gpm. The water is now being treated at the nearby Building 452 Freon-11 treatment system due to the larger capacity of that air stripping system. The RTW-1 discharge is now formally reported under the Building 452 Freon-11 system's SPDES Equivalency Permit.
- Although the BGRR building and engineered impermeable cap are effectively preventing tstormwater infiltration though the contaminated soils, elevated concentrations of Sr-90 are still periodically detected in the BGRR source area monitoring wells. Due to a rising water table during 2018, in 2019 Sr-90 concentrations in one well immediately downgradient of the BGRR increased to an historical high. Temporary wells installed near the source area in 2019 confirmed that the plume is narrow and the monitoring well network is adequate. Extraction well SR-3 is properly positioned to capture this portion of the plume. Strontium-90 contamination below the facility structures in the vadose zone is being periodically mobilized to the aquifer when the water-table rises, intersecting contaminated soil in the unsaturated zone. This water-table flushing process has been observed with periodic increases in tritium concentrations at several other BNL source areas (at the HFBR and at the former g-2 experiment).
- The 2015-2016 demolition of the former Waste Concentration Facility and removal of nearby impermeable surfaces may have allowed for the leaching of residual Sr-90 from the underlying soils to the groundwater. Sr-90 concentration increases were observed in extraction well SR-1 in 2018 and 2019. Temporary wells installed in 2019 confirmed that Sr-90 is still present at elevated concentrations in the source area. It is expected that these concentrations will attenuate over time, and the downgradient migration of Sr-90 from the source area will be controlled by extraction wells SR-1 and SR-2.
- The Chemical Holes system has effectively remediated Sr-90 contaminated groundwater downgradient of this former waste disposal area. Sr-90 has remained below 50 pCi/L since mid-2015, except for one detection of 65 pCi/L in a former source area monitoring well in January

2020. Following regulatory approval of the Petition for Shutdown, the system was placed in standby mode in July 2018.

- The HFBR tritium plume has significantly attenuated over the previous five years. As a result, the groundwater monitoring program has been reduced to sampling 10 wells located immediately downgradient of the HFBR. The areas further downgradient of the HFBR are no longer monitored because tritium concentrations in these areas have declined to below the 20,000 pCi/L MCL. Tritium exceeding the 20,000 pCi/L MCL is observed intermittently in individual wells immediately downgradient of the HFBR. The maximum tritium concentration detected over the last two years was 35,900 pCi/L in late 2019. The HFBR Tritium Pump and Recharge System was approved for closure in 2019.

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Operable Unit IV: The remedy is expected to be protective of human health and the environment upon attainment of groundwater cleanup goals. In the interim, exposure pathways that could result in unacceptable risks are being controlled.

- Post-closure groundwater monitoring was completed in 2011 for the OU IV air sparging/soil vapor extraction (AS/SVE) system.
- Monitoring continues for a plume of Sr-90 which originated from the Building 650 Sump Outfall and is entirely located within the central portion of the site. Temporary wells installed in 2019 confirmed a shift in the position of the plume to the southeast. The shift was likely due to reductions in the amount of water discharged to recharge basins HO and RA V, thereby lessening the hydraulic impact of those basins on flow directions.

Operable Unit V: The remedy currently protects human health and the environment because the contaminated soil at the STP filter beds and contaminated sediment in the Peconic River were excavated in 2004-2005, 2011, and 2017 to meet the appropriate cleanup levels. The Completion Report for the 2017 Peconic River supplemental remediation was approved by the regulators in April 2018 (BNL 2017b). Although vegetation monitoring of remediated area PR-WC-06 was completed in accordance with the State wetland equivalency permit requirements, monitoring will continue until the federal monitoring duration requirements are met.

- In 2018, supplemental sediment remediation of a small on-site area of the Peconic River (Area PR-WC-06) was completed. Post-excavation sediment sampling confirmed that the excavation was effective in meeting the cleanup goals. All other areas have met their long-term cleanup objectives identified in the ROD.
- Groundwater monitoring requirements under the ROD were met in 2014. Groundwater quality at the STP is currently monitored under the SPDES program.

Operable Unit VI: The remedy is expected to be protective of human health and the environment upon attainment of the groundwater cleanup goals. In the interim, exposure pathways that could result in unacceptable risks are being controlled.

- The EDB treatment system continues to effectively remediate the EDB plume (see **Figure 4-1**). However, the observed migration rate for EDB is significantly slower than originally predicted during treatment system design. In addition, contamination appears to be deeper than originally predicted as it approaches the extraction wells. Therefore, the system will continue to operate to ensure capture of the upgradient EDB. In 2020, the BNL groundwater model for this area was reassessed. As part of this assessment, additional field data were collected to address several data gaps, including soil borings and gamma logs to verify the local geology and groundwater samples to verify the vertical distribution of EDB. The updated data indicate that system modifications will be required to reduce the cleanup timeframe and to address newly observed deep contamination.

Operable Unit VIII: New OU VIII was recommended by DOE in February 2021 to document the two new AOCs (33 and 34) for PFOS and PFOA and 1,4-dioxane, respectively. No ROD has been signed.

BGRR: The BGRR ROD was finalized in March 2005. The removal and disposal of the Graphite Pile was completed in 2010. The remaining work required under the ROD, including installation of an engineered cap and removal of the biological shield, were completed in 2011 and 2012, respectively. Land-use and institutional controls were implemented and groundwater monitoring is underway in accordance with the Operable Unit III ROD, and as part of the final remedy. The remedy is protective of human health and the environment, and exposure pathways that could result in unacceptable risks are being controlled. Long-term surveillance and maintenance activities are conducted to ensure effectiveness of the remedy. The activities included periodic structural inspections of Building 701, water intrusion monitoring, preventive maintenance of Building 701 and the infiltration management system, groundwater monitoring, semi-annual inspections of the below-ground ducts, and periodic maintenance and repairs as identified during the inspections. Recent maintenance actions include: improvements to roof access, sealing of precipitation infiltration areas, and minor repairs to the cap. An update to the Long-Term Surveillance and Maintenance Manual for the BGRR was issued in December 2018 (BNL 2018b).

g-2/BLIP/USTs: The remedy is expected to be protective of human health and the environment upon attainment of groundwater cleanup goals. In the interim, exposure pathways that could result in unacceptable risks are being controlled.

- Groundwater monitoring has demonstrated that tritium levels in the areas downgradient of the Alternating Gradient Synchrotron facility have attenuated to below the 20,000 pCi/L MCL. Although the engineered cap over the source area is being maintained and is effectively preventing stormwater infiltration to the activated soil shielding, periodically tritium concentrations immediately downgradient of the source area continue to slightly exceed the standard. The periodic increases in tritium concentrations appear to be correlated to seasonal rises in the water table, which can release residual tritium from the deep vadose zone soils.

HFBR: The HFBR ROD was finalized in April 2009. The final remedy incorporates many completed interim actions, several near-term actions, and the long-term segmentation, removal, and disposal of the remaining HFBR structures, systems, and components, including the reactor vessel. The near-term actions included dismantling the remaining ancillary buildings, removing contaminated underground utilities, and preparing the reactor confinement building for safe storage. The ROD requires that these near-term actions be completed no later than 2020. The last near-term activity, removal of the stack, is near completion. Activities completed for the HFBR stack since 2016 include:

- An Updated Remedial Design/Remedial Action (RD/RA) Work Plan was submitted to the regulators in October 2019.
- The U.S. Army Corps of Engineers (USACE) awarded the stack demolition contract in February 2020.
- Following NYSDEC and EPA review of the draft Quality Assurance Project Plan (QAPP), Field Sampling Plan (FSP), Demolition Plan, and Community Air Monitoring Plan (CAMP) for the stack demolition, final plans were submitted to the regulators in August 2020.
- The demolition contractor collected premobilization characterization samples in June 2020.
- The demolition contractor mobilized to the site in August 2020 to begin the exterior coating abatement. The abatement was completed in early November 2020.
- Mobilization of the demolition equipment to the site was performed late November, and the contractor initiated demolition in early December 2020.
- DOE submitted a milestone extension request to EPA in August 2020 to extend the administrative closeout until July 2021 due to contractor mobilization delays associated with COVID-19.
- Physical demolition of the stack was completed in February 2021, followed by soil and structure removal in May/June 2021. A final status survey by the contractor and verification by ORISE is expected to be performed in mid-2021.

- Following completion of waste disposal, the Closeout Report will be submitted to the regulators.

Long-term surveillance and maintenance activities are conducted to ensure effectiveness of the remedy. The activities included routine environmental health and safety monitoring, secure access via locked doors, periodic structural inspections of Building 750 and the stack, water intrusion monitoring, preventive maintenance of Building 750 and the infiltration management system, and groundwater monitoring. Over the last five years, repairs were made 1) on the east exterior periphery wall to prevent water intrusion into the building, 2) to the roof over the machine shop, and 3) to the cracks and holes above the generator room door to prevent water, bird, and wildlife intrusion. An update to the long-term Surveillance and Maintenance Manuals for the HFBR and the Stack and Grounds was issued in December 2018 (BNL 2018e).

The WLA was used for the stack demolition waste rail car loading.

The ROD also lays out a plan for the long-term segmentation, removal, and disposal of the remaining HFBR structures, systems, and components (including the reactor vessel and thermal and biological shields). These long-term actions will be conducted following a safe storage period (not to exceed 65 years) to allow for the natural reduction of high radiation levels to a point where conventional demolition techniques can be used to dismantle these reactor components. Land-use and institutional controls and groundwater monitoring in accordance with the Operable Unit III ROD are also part of the final remedy. The completed remedy is expected to be protective of human health and the environment, and in the interim, exposure pathways that could result in unacceptable risks are being controlled.

Table 5-1 shows the status of the actions recommended in the 2016 Five-Year Review.

Table 5-1: Follow-Up Actions to the 2016 Five-Year Review Recommendations

Issue	Recommended Actions	Milestone Date	Current Status
Sr-90 in OU I Former HWMF Groundwater	Enhance monitoring well network with a combination of permanent and temporary wells on a recurring basis to track Sr-90 attenuation. Compare attenuation data with model projections prior to the next Five-Year Review.	July 2021	Temporary wells were installed in 2016 (11), 2017 (3), 2018 (20), and 2019 (2). Sr-90 up to 689 pCi/L was detected in 2020. In late 2019, three monitoring wells were installed at the highest Sr-90 concentration area and three sentinel wells were added farther downgradient. The natural attenuation model simulation was updated in 2020 using current data. Groundwater monitoring of the plume during the previous five years indicates that the model is accurately predicting the natural attenuation of Sr-90 in this area.

Continued…..

Issue	Recommended Actions	Milestone Date	Current Status
OU III Building 96 Source Removal Effectiveness	Monitor plume and continued degradation of source area. Continue treatment system operations and if capture goals are met, submit *Petition for Shutdown*.	July 2018	Maximum TVOC concentrations continue to decline from 620 µg/L in 2016 to 98 µg/L in April 2020. In 2017 and 2018, an SVE pilot study indicated that an SVE system would not be effective to address residual contamination in the source area. In 2019, the pumping rate of RTW-1 was increased to ensure capture of VOCs in the western portion of the plume. Based on the sharp decline in well 095-159 VOC concentrations following the increased pumping of RTW-1, it appears the expansion of the capture zone to the west has been achieved.
OU III Western South Boundary deep VOC contamination	Characterize nature and extent of deep VOCs identified in 2016-run model.	September 2017	Temporary wells (21) were installed from 2016 through September 2017 to delineate the deep VOC plume. Monitoring wells (17) were also installed. Based on groundwater modeling performed in March 2018, the treatment system was modified and operation of the four new extraction wells began in March 2019. The water is now treated at the Middle Road/South Boundary air stripping system.
Continuing Sr-90 source at BGRR	Monitor plume and continued degradation of source area. Continue pumping of extraction well SR-3. Evaluate during next Five-Year Review.	July 2021	Due to rising a water table, Sr-90 in well 075-701 increased in 2019 to an historical high of 1,170 pCi/L. Temporary wells installed in 2019 confirmed that the plume is narrow and the monitoring well network is adequate. Extraction well SR-3 captures this portion of the plume and will be operated whenever significant Sr-90 levels are detected in source area monitoring wells.
Continuing Sr-90 source at Chemical Holes	Continue attenuation monitoring of former source area. Continue pumping of extraction well EW-1. Evaluate during next Five-Year Review.	July 2021	Sr-90 has generally remained below 50 pCi/L since mid-2015. Maximum concentration in 2020 was 65 pCi/L in a well in the former source area. Following regulatory approval of the Petition for Shutdown, the system was placed in standby mode in July 2018. There has been no rebound of Sr-90 observed.
Peconic River Remedy Optimization	Complete supplemental excavation of elevated mercury at Area PR-WC-06.	September 2018	Excavation and disposal of 150 cubic yards of contaminated sediment was completed November 2017. The closeout report was issued in January 2018. Monitoring of vegetation

Issue	Recommended Actions	Milestone Date	Current Status
			recovery in the 2017 PR-WC-06 cleanup area continues.
HFBR	Remove stack by 2020 per the ROD.	September 2020	DOE Office of Environmental Management (EM) and the USACE managed the stack demolition. A demolition contractor was selected in January 2020. Demolition of the stack began November 2020 and was completed February 2021. A closeout report will be submitted in the fall of 2021.
HFBR	Explore the feasibility of reducing the 65-year safe storage (decay) period and completing the removal of large activated components earlier.	Recurring	An August 2020 review determined that based on the evaluation criteria specified in the ROD, and the match between the predicted and measured dose rates, there is no reason to alter the current remedial action plan. In addition, no new technologies have been identified to accelerate the removal timeframe.
OUs III & VI - Deeds not reflecting operating treatment systems	Record property access agreements with County Clerk	June 2017	Three access agreements were renewed/executed. Two agreements are expired. Only one agreement was recorded.
Soil contamination north of former Buildings 810/811	Add radiological soil contamination area to Building 811 Waste Concentration Facility LUIC fact sheet	January 2017	The area to the north was added to the LUIC fact sheet in November 2016. Excavation of this area was completed in 2018 and the final Closeout Report was issued September 2019.

There is one issue from the 2016 Five-Year Review identified in **Table 5-1** (above) that could affect future protectiveness. The issue was to record the license or access agreements for the six groundwater treatment systems off of BNL property with the Suffolk County Clerk's Office. All seven property license/access agreements have a requirement for recording except for LIPA, but there is a conveyance provision in that agreement. The only agreement that has been recorded to date was for the original Industrial Park system, which is now expired.

6.0 Five-Year Review Process

6.1 Administrative Components

The activities scheduled for this Five-Year Review included regulator and community stakeholder notification, site inspections, interviews with stakeholders and regulatory officials, development of the Five-Year Review Report including review by DOE, EPA, NYSDEC, NYSDOH, and SCDHS, and a briefing on the results to the Community Advisory Council (CAC) and Brookhaven Executive Round Table (BER). The review was led by BSA's Environmental Protection Division (EPD) Groundwater Protection Group. The Five-Year Review team consisted of:

- BSA staff – W. Dorsch, V. Racaniello, D. Paquette, R. Howe, J. Remien, T. Green, N. Sundin (recently retired), and A. Engel
- DOE staff – G. Granzen, J. Carter, and C. Polanish
- Regulatory staff – S. Hartzell and D. Pocze (EPA), B. Jankauskas (NYSDEC), S. Karpinski (NYSDOH), and A. Rapiejko (SCDHS)

The team included Hydrogeologists, Environmental Scientists, Engineers, Community Involvement Coordinator, and a Technical Editor.

6.2 Community Notification and Involvement

A Communications Plan for the Five-Year Review was prepared and, on January 14, 2020, was distributed to the project team. The plan identifies specific outreach activities to be conducted, such as initial notification, interviews, report updates, and report issuance/notification.

An initial notification announcement was published in *Newsday* on February 13, 2020. It informed the public of the start of the review, as well as the purpose, schedule for completion, and how to contact DOE for more information. A copy of the announcement is available at https://www.bnl.gov/gpg/5year-review.php.

The CAC was briefed on the start of the Five-Year Review on February 13, 2020. On February 20, 2020, an email was distributed to the CAC requesting them to participate in a survey to gather information that will be appended to the 2021 Five-Year Review. The BER was informed during the March 4, 2020 meeting. In addition, on February 21, 2020 an announcement was made on the BNL home page to inform the BNL employees and the community that the Five-Year Review was being conducted.

A brief summary of the CAC members' input/responses to the following four questions from the February 2020 email survey is provided below.

1. *What is your overall impression of BNL's cleanup and do you feel well informed about the cleanup activities and progress?*
   Feedback on the group's overall impression of the communication of the Laboratory's cleanup efforts was very good. Most were satisfied that the Laboratory was providing the organization with timely presentations and updates, and appreciated being kept in the loop on environmental matters.
2. *Are there any specific aspects of the cleanup that you feel should be of focus during the review? (e.g., RODs, cleanup goals, community input, etc.)*
   Several respondents to this question felt that emerging contaminants of concern – PFAS and 1, 4 Dioxane – were something that would need to be closely monitored in the future. One respondent was concerned about radionuclides that may be present in the soil beneath the BGRR. Many felt that the RODs, cleanup goals, and community input were all important and should continue to be monitored and communicated.

3. *Do you feel confident in BNL and DOE's management of the long-term cleanup operations for the site?*
   Overall feedback was positive that BNL and DOE have demonstrated a management commitment and have been openly candid regarding all aspects of the cleanup. Several are confident that BNL and DOE management will commit to funding the site cleanup for the long term. Deviating from the past performance would be significantly detrimental to the Laboratory. One member would also like to see more input from DOE and the regulators during the CAC meetings. Many members feel confident in BNL and DOE's management of the long-term cleanup operations for the site. One member commented "I believe all remediation plans are implemented better with transparency."
4. *Do you have any comments, suggestions, or recommendations regarding BNL/DOE's management and communications of the cleanup?*
   Several members wanted to see a chart/timeline summarizing the progress made over time for all cleanup projects in comparison to the ROD goals. Others requested that updates on the cleanup should also be communicated to the surrounding community/civic associations. One member also suggested that a published history of the cleanup, written in layman's terms, would be helpful and should be made available in local libraries. Most commented that they believe the Laboratory is doing a good job. One member suggested the Laboratory continue to collaborate with the local civic groups for concerns and inform them of the Laboratory's decisions and actions, and continue the partnership with other levels of government, as everyone working together serves the public well. Another expressed that they thought the Laboratory should be congratulated for responding quickly and openly to the discovery and testing of PFAS from Laboratory operations and for cooperating with the authorities.

   The CAC survey is included as **Attachment 1**.

The CAC was polled during its virtual (due to site restrictions resulting from COVID-19) June 14, 2020 meeting after the Five-Year Review presentation. Questions had to be reformatted to fit the polling style, but most answers reiterated the responses above.

Following regulator review/concurrence and EPA concurrence on the final protectiveness determination, the community will be notified that the Five-Year Review was completed, and it will be made available to the public. A public notice will be issued in *Newsday* at that time. The notice will include a brief summary of the results, the protectiveness statements, post-ROD information, repository locations where the report is available for viewing, and the timeframe of the next Five-Year Review. The repositories are:

- BNL Research Library, Upton, NY
- EPA Region II Office, New York City, NY
- Stony Brook University, Melville Library, Stony Brook, NY

The CAC and BER will be briefed on any changes to the report's conclusions and recommendations as a result of regulator review. The Report will also be added to the BNL website.

6.3 Document Review

The Five-Year Review consisted of a review of relevant documents including the following:

- Records of Decision for OUs I, III, IV, V (two), VI, BGRR, g-2/BLIP, and HFBR
- OU III ESDs (BNL 2005a, 2009a, 2012a, b)
- Annual BNL Groundwater Status Reports (e.g., BNL 2016a)
- Annual landfill reports (e.g., BNL 2016c)
- Annual Peconic River Monitoring Reports (e.g., BNL 2010f)
- *Final Five-Year Review Report* (BNL 2011a)

- Closeout/Closure reports for soil or sediment (BNL 1997, 2005c, 2005e, 2005f)
- *Final Closeout Report for the Meadow Marsh Operable Unit I Area of Concern 8* (BNL 2004d)
- *Final Closeout Report for the Ash Pit Operable Unit I Area of Concern 2F* (BNL 2004e)
- *Final Closeout Report for the Brookhaven Graphite Research Reactor, Graphite Pile Removal, Area of Concern 9* (BNL 2010c)
- *Final Closeout Report for the Brookhaven Graphite Research Reactor, Final Canal and Deep Soil Pockets Excavation and Removal* (BNL 2005h)
- *BNL High Flux Beam Reactor Characterization Summary Report, Rev 1* (BNL 2007e)
- *Final Completion Report for the Former Hazardous Waste Management Facility Perimeter Area Soil Remediation* (BNL 2010a)
- *Addendum to the Former Hazardous Waste Management Facility Perimeter Area Completion Report* (BNL 2010b)
- *Brookhaven National Laboratory, High Flux Beam Reactor, Area of Concern 31, Final Completion Report for Waste Loading Area Soil Remediation* (BNL 2009c)
- *Final Closeout Report for Removal of the Buildings 801-811 Waste Transfer Lines (A/B Waste Lines with Co-Located Piping), Area of Concern 31* (BNL 2010d)
- *Central Steam Facility Storm Water Outfall Remediation Closeout Report* (BNL 2007c)
- *Environmental Monitoring Plan,* Annual Updates (BNL 2021a)
- O&M manuals for the groundwater treatment systems (BNL 2002-2020)
- *BNL Land Use Controls Management Plan* (BNL 2018c)
- *Comprehensive Five-Year Review Guidance* (EPA 2001)
- *Five-Year Review Recommended Template* (EPA 2016)
- *Final Closeout Report for the Brookhaven Graphite Research Reactor Engineered Cap and Monitoring System Installation, Area of Concern 9* (BNL 2011c)
- *Final Closeout Report for the Brookhaven Graphite Research Reactor Biological Shield Removal, Area of Concern 9* (BNL 2012c)
- *Final Closeout Report for the High Flux Beam Reactor Underground Utilities Removal, Area of Concern 31* (BNL 2011d)
- *Final Closeout Report for the High Flux Beam Reactor Stabilization, Area of Concern 31* (BNL 2011e)
- *Final Closeout Report for the High Flux Beam Reactor Fan Houses (Building 704 and Building 802) Decontamination and Dismantlement (D&D), Area of Concern 31* (BNL 2011f)
- *Final Closeout Report for the High Flux Beam Reactor Removal of the Stack Silencer Baffles and Final Status Survey for Remaining Outside Areas, Area of Concern 31* (BNL 2012f)
- *Addendum to the Final Completion Report for the Former Hazardous Waste Management Facility Perimeter Area Soil Remediation* (BNL 2015a)
- *Field Sampling Plan/Quality Assurance Project Plan for the Waste Concentration Facility (AOC 10) and Surrounding Area* (BNL 2015b)
- *Closeout Report for Waste Concentration Facility (BLDG 811 - Area of Concern 10) and Surrounding Area - October 2016, rev 1* (BNL 2016e)
- *Completion Report Peconic River Supplemental Sediment Removal Area, PR-WC-06 Area – December 2017* (BNL 2017b)
- *Addendum to the Closeout Report Waste Concentration Facility (Bldg. 811 – Area of Concern 10) and Surrounding Area, June 2019* (BNL 2019b)
- *Updated Remedial Design/Remedial Action Work Plan for the Decontamination and Dismantlement (D&D) of Building 705 (the Stack) and Associated Structures and Utilities – October 2019* (BNL 2019c)
- *Phase 4 Characterization Report Per- and Polyfluoroalkyl Substances (PFAS) and 1,4-Dioxane in On-Site and Off-Site Monitoring Wells, Extraction Wells and Treatment Systems – February 2021* (BNL 2021b)
- *Time Critical Removal Action for Per- and Polyfluoroalkyl Substances (PFAS) in Groundwater*

Downgradient of the Current and Former Firehouse Facilities Plume Characterization Report – June 2021 (BNL 2021d)

- *Design Report for PFAS Source Area Groundwater Treatment Systems Time Critical Removal Action – May 2021* (BNL 2021e)

As noted in **Section 4.1** above, the remedial action objectives for the projects are identified in the RODs and the OU III ESDs.

6.4 Data Review

This section provides a brief summary review of analytical data and trends for each OU, the HFBR, BGRR, g-2 and BLIP areas over the previous five years (2016 through 2020). Figures are provided which display historical trends for key groundwater monitoring wells by plume over the last several years. A detailed discussion of the status of the groundwater plumes and the progress of the 18 groundwater remediation systems is provided in the *2020 BNL Groundwater Status Report* (BNL 2021g—see **Attachment 2** for the flash drive version or https://www.bnl.gov/gpg/gw-reports.php). The *Groundwater Status Reports* are published on an annual basis and are a source of comprehensive information on the groundwater remediation systems and contaminant plumes.

Since the start of active groundwater remediation in 1997, approximately 7,700 pounds of VOCs have been removed, and 29 billion gallons of treated groundwater have been returned to the aquifer. Additionally, the Chemical Holes Sr-90 treatment system and the BGRR/WCF treatment system have removed approximately 34 millicuries (mCi) of Sr-90 while returning nearly 260 million gallons of treated water to the aquifer.

Figure 4-1 shows the location of the 18 groundwater treatment systems. **Table 6-1** provides a summary of the treatment system status through December 2020.

Table 6-1: Groundwater Treatment System Status

Project	Target	Mode	Treatment Type	Expected System Shutdown	Highlights
OU I					
OU I South Boundary (RA V)	VOCs	Closed	P&T with AS	2013 (Actual)	Petition for Closure approved Sept. 2019.
Current Landfill	VOCs tritium	Long-Term Monitoring & Maintenance	Landfill capping	NA	Periodic VOC increases in monitoring well 088-10.
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 and Maintenance	Monitoring	NA	Temporary wells installed annually to track elevated Sr-90 in former source area. Maximum of 689 pCi/L Sr-90 detected in a temporary well in 2020. Installed two new permanent monitoring wells. Updated the Sr-90 natural attenuation groundwater model simulation.

Project	Target	Mode	Treatment Type	Expected System Shutdown	Highlights
OU III					
Chemical/Animal Holes	Sr-90	Standby	P&T with IE	2018 (Actual)	Petition for Shutdown approved and system shut down in July 2018. Continue to monitor Sr-90 groundwater concentrations in former source area which continue to decline.
Carbon Tetrachloride source control	VOCs (carbon tetra-chloride)	Decommis-sioned	P&T with carbon	2004 (Actual)	Decommissioned in 2010.
Building 96 source control	VOCs	Operational (RTW-2, RTW-3, and RTW-4 on standby)	Recirculation wells with AS for 3 of 4 wells. RTW-1 is P&T with AS.	2023	Monitoring persistent elevated PCE downgradient of former source area. SVE pilot study in 2018 indicates full-scale system would not be effective in addressing residual VOCs. Increased pumping rate of RTW-1 in 2019 is capturing western edge of plume. RTW-1 Cr-VI treatment system was decommissioned in 2018.
South Boundary	VOCs	Operational (EW-3, EW-5, EW-6, EW-7, EW-8 and EW-12 on standby)	P&T with AS	2023	Extraction well EW-17 is capturing and treating deep VOCs at site boundary. EW-4 is in pulsed pumping mode. Plume migration towards EW-17 slower than anticipated which could impact system shutdown timeframe.
Middle Road	VOCs	Operational (RW-1,RW-4, RW-5, and RW-6 on standby)	P&T with AS	2025	Monitoring persistent elevated deep VOCs south of Princeton Avenue. Plume migration towards extraction wells slower than anticipated which could impact system shutdown timeframe.
Western South Boundary	VOCs	Operational (WSB-2 on standby)	P&T with AS	2026	Temporary wells installed in 2017-2018 to delineate the deep VOC plume. Four new extraction wells became operational in 2019 to capture the deep VOCs. The water is now treated at the South Boundary/Middle Road air strippers.
Industrial Park	VOCs	Standby	In-well stripping. P&T with carbon for deep wells	2021	UVB wells placed in standby mode in 2017. Extraction wells –IP-EW-8 and IP-EW-9 placed in standby mode July 2019.
Industrial Park East	VOCs	Decommis-sioned	P&T with carbon	2009 (Complete)	Decommissioned in 2014.

Project	Target	Mode	Treatment Type	Expected System Shutdown	Highlights
North Street	VOCs	Closed	P&T with carbon	2016 (Actual)	Petition for Closure approved March 2020.
					Continued...
North Street East	VOCs EDB	Closed (VOCs) Operational (EDB)	P&T with carbon	2014 (Actual for VOCs) 2024 (EDB)	Original VOC system closed in 2020. Temporary well characterization for EDB performed 2018. Two new extraction wells became operational in July 2020 to remediate EDB.
LIPA Right-of-Way/ Airport	VOCs	Operational (LIPA wells on standby/ Airport wells RTW-5A on standby, RTW-2A and 3A on standby)	P&T and recirculation wells with carbon	2017 Actual (LIPA) 2025 (Airport)	Persistently elevated VOCs in upgradient monitoring wells along Crestwood Drive may impact Airport system shutdown. LIPA wells in standby.
Building 452 Freon-11	VOCs	Closed	Air stripping	2017 (Actual)	Petition for Closure approved August 2019.
HFBR Tritium	Tritium	Closed	Pump and recharge	2013 (Actual)	Petition for Closure approved March 2019. Ten wells continue to monitor the former HFBR source area.
BGRR/WCF	Sr-90	Operational (Wells SR-4, SR-5, SR-6, SR-7 on standby. Well SR-8 pulsed pumping)	P&T with IE	2026	Supplementing the current monitoring with temporary wells. Increased Sr-90 detected downgradient of BGRR, Bldg. 801 and WCF source areas.
OU IV					
OU IV AS/SVE system	VOCs	Decommis-sioned	AS/SVE	2003 (Complete)	Decommissioned in 2003.
Building 650 Sump Outfall	Sr-90	Long-Term Monitoring	MNA	NA	Plume continues to slowly attenuate. Temporary wells installed in 2019 verified a southeast shift in the plume.
OU V					
STP	VOCs, tritium	Long-Term Monitoring (Complete)	MNA	NA	Monitoring completed 2014.

Project	Target	Mode	Treatment Type	Expected System Shutdown	Highlights
OU VI					
EDB	EDB	Operational	P&T with carbon	2024	Additional lithology and groundwater data collected in 2020-2021 supported a model update to estimate the duration of system operations and modifications required to capture deeper EDB and meet cleanup goals.

Notes:
AS = Air Stripping
AS/SVE = Air Sparging/Soil Vapor Extraction
BGRR/WCF = Brookhaven Graphite Research Reactor/Waste Concentration Facility
EDB = ethylene dibromide
EW = Extraction wells
HFBR = High Flux Beam Reactor
HWMF = Hazardous Waste Management Facility
IE = Ion Exchange
In-Well = The air stripper in these wells is located in the well vault.
LIPA = Long Island Power Authority
MCLs = Maximum Contaminant Levels
MNA = Monitored Natural Attenuation
NA = Not Applicable
P&T = Pump and Treat
Recirculation = Double screened well with discharge of treated water back to the same well in a shallow recharge screen

6.4.1 Operable Unit I

Soils:
Starting in 2014 and continuing into 2016, the former WCF Buildings 810 and 811 were decommissioned and demolished, waste transfer lines were removed, and radiologically contaminated soil was excavated. The soil excavation activities were also a follow-up to the 2005 Waste Concentration Facility Closeout Report that identified two residual areas of radiological soil contamination that were left behind at that time due to the proximity of the soil to operating facilities Buildings 810 and 811 (BNL 2005i). The Closeout Report stated that these two areas would be remediated when the operating facilities are decommissioned. A final status survey and dose assessment was performed in May 2016 to ensure that the residential land-use cleanup goals have been met. Independent verification of the cleanup was performed in October 2016 by Oak Ridge Institute for Science and Education (ORISE), and the excavated area was backfilled and seeded. The *Closeout Report Waste Concentration Facility (Bldg. 811 – Area of Concern 10) and Surrounding Area* (BNL 2016e) was submitted to the regulators for review in October 2016, and subsequently approved. A revision to the Closeout Report was issued to the regulators in January 2017, updating the volume of waste shipped and disposed of. During the 2015-2016 excavation of the former WCF, an area of radiologically contaminated soil was identified along the north fence line to the adjacent storage yard. This yard contained activated steel, lead and equipment that were stored for potential reuse by the Collider-Accelerator Facility complex. Excavation of this area was completed in July 2018 and final status survey confirmation soil samples confirmed that the cleanup goals were met. The excavated soil was disposed of as low-level radioactive waste at Energy Solutions in November 2018. An Addendum to the Closeout Report was issued as final to the regulators in June 2019 (BNL 2019b). The BNL soil cleanup levels for principal radiological contaminants, based on the selected land use for each area, are provided in **Table 6-2**.

Table 6-2: BNL OU I Soil Cleanup Levels

Radionuclide	Soil Cleanup Level (pCi/g) Residential Land Use	Industrial Land Use
Cesium-137	23	67
Strontium-90	15	15
Radium-226	5	5

Note: A post-cleanup dose assessment is required to determine compliance with the 15 mRem/yr above background cleanup level with 50 years of institutional control.

Landfills: Monitoring at the Current Landfill continues to identify methane soil gas exceeding 100% of the lower explosive limit in several soil-gas monitoring wells immediately to the west and south. This indicates that decomposition of the waste is still occurring. At the request of the NYSDEC, in 2016 soil-gas samples were obtained southeast of the Current Landfill to verify that contaminant concentrations were not migrating beyond the existing well network. Soil-gas samples were collected at two depths for each of three locations using a Geoprobe®. There were no detections of soil gas in any of the samples. (See 2015 Report https://www.bnl.gov/gpg/landfills.php) (BNL 2016c). A second round of testing in July 2016 confirmed that soil gas was non-detect. In addition to the temporary well locations, samples were collected from several nearby upgradient permanent soil-gas wells for comparison purposes. Results from the permanent wells indicated concentration ranges for the soil gas parameters which were consistent with historical data. Therefore, it was concluded that soil gas is not migrating south from the Current Landfill. The four outpost monitoring wells, located immediately north of the Current Landfill along the south side of Brookhaven Avenue, showed no methane detections from 2016 through 2020. These wells monitor the migration of any soil gas towards the closest facility, the National Weather Service building. Soil-gas monitoring at the Former Landfill Area has shown no detections of methane or hydrogen sulfide from 2016 through 2020. The soil-gas monitoring well networks are sufficient to monitor both landfill areas.

Because of variability within results in the last few years for both mercury and lead at Wooded Wetland locations SD-12 and SD-2001, and in response to NYSDEC comments, BNL conducted supplemental sampling in December 2015. Samples were obtained at five-foot intervals around the two locations to characterize a roughly 100- square-foot area around each location. The results from this sampling event were within the range of mercury and lead historically detected at these locations. In addition, biological surveys have confirmed the survival of tiger salamanders in the Wooded Wetland. Based on these data, the NYSDEC agreed that surface water and sediment sampling of the Wooded Wetland would be discontinued after 2016. Every effort will be made in the future to allow the Wooded Wetlands to remain undisturbed so that layers of new organic matter can build up and separate the tiger salamanders from the pond sediments. Tiger salamander surveys will continue to be conducted by BNL and reported to the NYSDEC Special Licenses Unit.

Groundwater: The landfill areas were capped between 1995 and 1997. Monitoring data presented in the *2020 Environmental Monitoring Report, Current and Former Landfill Areas* (BNL 2021c) indicate that, in general, contaminant concentrations have decreased following the capping of the landfills and that landfill controls continue to be effective. VOCs and metals continue to be detected downgradient of the Current Landfill. The most prevalent VOCs detected above MCLs are chloroethane and 1,1-dichloroethane (1,1-DCA). In 2020 these VOCs were detected at maximum concentrations of 25 µg/L and 24 µg/L, respectively. **Figure 6-2** depicts VOC trends for individual wells near the Current Landfill. As with previous years, iron, manganese, and arsenic were detected downgradient from the Current Landfill at concentrations above applicable standards. During 2020, maximum concentrations of iron and manganese in downgradient wells were 94,600 µg/L and 4,090 µg/L, respectively. The maximum arsenic concentration detected in 2020 was 12.8 µg/L, which is slightly above the standard. An updated groundwater modeling simulation was performed in 2016 using the VOC results obtained from 12 temporary wells installed in

2016, along with data collected from well 088-109. TVOC concentrations in groundwater downgradient of the Current Landfill were predicted to attenuate to below 5 µg/L prior to reaching the site boundary. A permanent monitoring well (098-99) was installed to monitor the leading edge of the plume with concentrations above the Ambient Water Quality Standards (AWQS). Individual VOCs have remained below the AWQS since the well was installed in 2017, with the exception of a detection of 1,1-DCA at 6 µg/L in June 2020. These data have verified the modeled attenuation predictions.

VOCs were not detected in groundwater above applicable AWQS in Former Landfill area monitoring wells since 2015. Water chemistry parameters and metals concentrations were equivalent to historical background levels. Strontium-90 has not been detected above the standard of 8 pCi/L in Former Landfill monitoring wells since 2001.

TVOCs in the OU I Pump and Treat System monitoring and extraction wells have remained below the system capture goal of 50 µg/L since the system was shut down in 2013. As a result, a *Petition for Closure* (BNL 2019a) of the system was submitted to the regulators in May 2019 and subsequently approved in September 2019. The monitoring and extraction wells will be maintained until a determination is made on their potential reutilization to address PFAS and/or 1,4-dioxane contamination.

Groundwater monitoring continued for a plume of Sr-90 contamination that originated at the former HWMF. The leading edge of this plume is now located approximately 1,000 feet north of the site boundary. While concentrations of Sr-90 below 30 pCi/L had been observed in groundwater in this area since the late 1990s, this higher concentration plume was detected and characterized in 2015, as discussed in Section 3.1 of the *2015 Groundwater Status Report* (https://www.bnl.gov/gpg/gw-reports.php). It now appears that the higher concentrations may result from the source area remediation work at the former HWMF that was completed in 2005. This work included the removal of contaminated soils as well as the removal of buildings and paved areas that may have protected contaminated soils from stormwater infiltration. The maximum Sr-90 concentration observed in groundwater from the 2015 temporary wells was 302 pCi/L at 14 feet below grade from a location near the center of the former HWMF. A soil sample obtained from this source area temporary well location did not detect Sr-90. This plume has been monitored since 2015 using a combination of permanent monitoring wells supplemented annually with temporary wells at select locations. Three new temporary wells followed by permanent monitoring wells were installed in 2019-2020 at previously sampled temporary well locations within and at the southern edge of the former HWMF yard, where the highest Sr-90 concentrations were observed in 2015. The highest Sr-90 concentration observed in the temporary wells was 689 pCi/L. The permanent well installed at this location showed Sr-90 at 72 pCi/L in October 2020. Three new sentinel wells were also installed in 2019 to monitor the leading edge of the former HWMF Sr-90 plume. Natural attenuation modeling of this plume was performed in 2016 and again in 2021. The modeling results are discussed in **Section 7.1**.

6.4.2 Operable Unit II/VII

The remedial actions for the OU II/VII AOCs are documented in the OU I, OU III and the g-2/BLIP/USTs RODs (see **Sections 6.4.1**, **6.4.3**, and **6.4.9**).

6.4.3 Operable Unit III

Soil: A soil vapor extraction (SVE) pilot test was performed in 2018 immediately downgradient of the former Building 96 VOC source area. The purpose of the study was to evaluate the feasibility of constructing and operating an SVE system to treat residual VOCs in the source area soils, and further reduce persistent VOCs in the groundwater. Based upon the low calculated recovery rate, an SVE system was determined not to be a cost-effective option. The SVE Pilot Test Report is included as Appendix H of the *2018 Groundwater Status Repor*t (BNL 2019d).

Groundwater: Over the past five years, the OU III groundwater remediation systems continued to capture and treat contaminants originating from the central portion of the BNL site. Seven of these systems are currently in active operation. Since the 2016 Five-Year Review Report, the North Street, HFBR Pump and Recharge and Building 452 Freon-11 systems were approved for closure. The original North Street East VOC system was administratively closed in 2020. The Industrial Park and Chemical Holes Sr-90 systems are currently in standby mode and could be restarted if necessary. New extraction wells were installed in 2019 and 2020 to address VOC contamination that was detected in the deep portion of the Upper Glacial aquifer at the Western South Boundary and EDB contamination at North Street East, respectively. The extent of the high-concentration segments of the OU III VOC plumes have decreased as the result of active groundwater remediation and natural attenuation. Plume remediation progress on- and off-site can be seen on **Figure 5-1**. Complete breaks in the plumes, where contaminant concentrations have dropped below MCLs, are discernable near the South Boundary and the LIPA systems. The southernmost segment of the OU III plume has been hydraulically controlled by the Airport Treatment System. As the plumes continue to decrease in size, a number of the extraction wells have been placed in either a pulsed pumping mode or a standby mode (**Figure 4-1**).

A review and evaluation of the performance data for the treatment systems is conducted monthly for most of the systems and both quarterly and annually for all of the systems. An evaluation of all the groundwater monitoring data collected for the year is documented in the annual *BNL Groundwater Status Report*.

The following is a brief status summary of OU III plume data through 2020.

Carbon Tetrachloride Treatment System

The Carbon Tetrachloride treatment system was successful in remediating the source area to below MCLs and was decommissioned in 2010. Monitoring of the source area was discontinued in 2013. One monitoring well, 105-23, located approximately 2,000 feet downgradient of the former source area, has not detected carbon tetrachloride above the 5 μg/L MCL since 2015.

Building 96 Treatment System

Recirculation well RTW-2 was restarted November 2018 and placed back in standby June 2020. In June 2019, the pumping rate for extraction well RTW-1 was increased from 30 gpm to 60 gpm to expand the capture zone to the west in response to increased TVOC concentrations in monitoring well 095-159. This extraction well also continues to treat the lower downgradient portion of the Building 452 Freon-11 plume. Recirculation wells RTW-3 and RTW-4 remained in standby mode. Since the source area soil remediation in 2010, VOCs in the Building 96 plume core monitoring wells have significantly declined (See trends on **Figure 6-3**) but continue to remain above MCLs. An SVE pilot study conducted in 2018 indicates a full-scale system would not be effective in addressing residual VOCs. Contaminant concentrations in source area monitoring well 085-379 have decreased from a maximum of 2,435 μg/L TVOCs in 2011 to less than 100 μg/L during 2019. However, based on the contaminant concentration rate of decline in this well from 2014 through 2020, it is projected that the cleanup goal of meeting drinking water standards by 2030 may not be met. Extraction well RTW-1 will continue operating.

Groundwater monitoring data from 2008 through 2015 in the OU III Building 96 plume indicate that hexavalent chromium has been transformed back to the trivalent form.

Building 452 Freon-11 Treatment System

Following regulatory approval of a Petition for Shutdown, the treatment system was shut down and placed in standby mode in March 2016. The system was briefly placed back into full-time operation from November 2016 to March 2017 due to a temporary rebound of Freon-11 concentrations. A Petition for Closure of the system was submitted to the regulators in June 2019 and approved in August 2019. As noted above, Building 96 treatment well RTW-1 is still being used to remediate the remaining low-level Freon-11 contamination from Building 452. See **Figure 6-4** for historical Freon-11 trends.

Middle Road Treatment System

Four of the seven extraction wells (RW-1, RW-4, RW-5 and RW-6) remain in standby as TVOC concentrations have remained below the system capture goal of 50 µg/L over the past five years. Groundwater characterization was performed in 2018 for an area upgradient of well 104-37 to evaluate the source of the persistently elevated VOCs detected in this well. However, no significantly elevated VOC concentrations were identified. Although VOC concentrations in well 104-37 decreased significantly during 2018, the concentrations in this well and monitoring wells 105-66 and 105-68 are not declining at a rate that indicates that the drinking water standards will be achieved by 2030. See **Figure 6-5** for the monitoring well trends.

South Boundary Treatment System

The five easternmost extraction wells (EW-5, EW-6, EW-7, EW-8, and EW-12) and one westernmost well (EW-3) remain in standby as TVOC concentrations have been below the system capture goal of 50 µg/L. Deeper extraction well (EW-17) remains in full-time operation. Starting in February 2019, extraction well EW-4 was placed in a pulsed pumping mode. TVOC concentrations in monitoring well 121-49, located immediately upgradient of EW-17, exceeded 1,200 µg/L at the time EW-17 was installed in 2011 and have been below 300 µg/L since the first quarter of 2019. Monitoring well 121-54, located between the Middle Road and South Boundary treatment systems, has VOC concentrations that are not decreasing at a rate that indicates that the drinking water standards will be achieved by 2030 (**Figure 6-5**).

Western South Boundary Treatment System

Plume and extraction well data show that elevated VOC concentrations continue to be observed in the Western South Boundary area (**Figure 6-6**). Extraction well WSB-2, located in the eastern portion of this area, remains in a pulsed pumping mode due to the decreased VOC concentrations observed both in this well and area monitoring wells. TVOC concentrations continue to be detected upgradient of the extraction well just above the capture goal of 20 µg/L; therefore, WSB-1 remains in full-time operation.

During characterization efforts in 2016-2017 to define the extent of Freon-12 contamination, a zone of high VOC concentrations was encountered at slightly greater depths than previously observed. A total of 21 temporary vertical profile wells were installed from 2016 through the end of 2018 to characterize these VOCs and a total of 17 new monitoring wells were installed. It was determined that the two existing extraction wells were not positioned to capture this deeper contamination. As a result of these characterization efforts, four new extraction wells WSB-3, WSB-4, WSB-5, and WSB-6 were installed and began operation in 2019. Some improvements in groundwater quality have been observed since the new extraction wells began operation. Well 111-15, located immediately upgradient of WSB-3, has shown a significant decrease in TVOC concentrations, from over 100 µg/L to less than 5 µg/L over the past two years. It appears that the deeper VOCs in this area are migrating as discreet slugs and that the trailing edge of a slug has now migrated south of this well. TVOC concentrations in well 126-20, located 1,200 feet upgradient of extraction wells WSB-5 and WSB-6, have decreased from greater than 100 µg/L to less than 30 µg/L over the past two years. This also indicates that the trailing edge of a plume slug is migrating past this location. This same process has also been observed in well 126-14, which is located approximately 300 feet north of extraction well WSB-1 and has been in operation since 2002. The trailing edge of a contaminant slug has been migrating through this location and TVOC concentrations have declined from 170 µg/L in 2017 to 51 µg/L in November 2020. WSB-1 will be placed in standby once the TVOC concentrations in this monitoring well decrease to levels below the 20 µg/L capture goal for this system.

Industrial Park Treatment System

Following regulatory approval, this system was shut down in May 2013. In March 2014, recirculation wells UVB-4 through UVB-6 were returned to full-time operation due to a rebound in TVOC concentrations above the 50 µg/L capture goal. These wells were returned to standby mode in February

2017 as VOC concentrations declined. Deeper extraction wells IP-EW-8 and IP-EW-9 began one month on and one month off pulsed pumping in February 2018, and were then placed in standby mode in July 2019. The remaining area of elevated VOCs is located to the north of IP-EW-8 and IP-EW-9. The monitoring wells in this area have generally shown a slow decline in TVOC concentration over the previous five years, with concentrations largely remaining below the system capture goal of 50 µg/L since 2018. See **Figure 6-5** and **Figure 6-7** for the monitoring well trends in this area.

Industrial Park East Treatment System

The Industrial Park East treatment system was successful in remediating VOCs to below MCLs and was decommissioned in 2014. The post-closure groundwater monitoring program for this area was discontinued in 2018 (see **Figure 6-8**). The treatment building and related infrastructure are currently being used for the remediation of VOC-contaminated water from Industrial Park extraction wells IP-EW-8 and IP-EW-9.

North Street Treatment System

In March 2020, a *Petition for Closure OU III North Street Groundwater Treatment System* (BNL 2020a) was approved by the regulators (See **Figure 6-9** for the monitoring well VOC trends). TVOC concentrations in the extraction wells and plume monitoring wells are less than the 50 µg/L capture goal for this treatment system. The maximum individual VOC concentration in the monitoring wells during 2019-2020 was 9.8 µg/L of TCA. The monitoring and extraction wells will be retained for possible re-use until the completion of PFAS and 1,4-dioxane characterization efforts.

North Street East Treatment System

The original VOC treatment system that consisted of two extraction wells remains in standby mode. The system met its cleanup goal in 2014, and there has been no significant rebound in VOC concentrations. A formal petition for closure was not issued for this system because the infrastructure is now being used for remediation of the ethylene dibromide (EDB) plume described below. However, as documented in the *2020 Groundwater Status Report* (BNL 2021g), this system is now administratively closed for its originally designed purpose.

EDB was initially observed in deep Upper Glacial monitoring well 000-394, which showed a peak concentration of 1.06 µg/L in October 2017. From March through October 2018, 17 temporary wells were installed to characterize the extent of EDB in this area. Groundwater modeling performed in November 2018 determined that two additional extraction wells are needed to remediate the EDB and to ensure that the OU III ROD cleanup goal is achieved. Two additional extraction wells were installed and became operational in July 2020. The EDB concentration in well 000-394 declined to 0.08 µg/L by December 2020. Monitoring data collected over the last two years from the groundwater monitoring network indicates the contamination is migrating as a discreet slug bounded by well 000-551 to the north and extraction well EW-3 to the south, and that EDB concentrations in the area are steadily declining. See monitoring well trends on **Figure 6-10**.

LIPA/Airport Treatment System

All four LIPA extraction wells were shut down and placed in standby mode in 2017. TVOC concentrations in this area have generally been below the 10 µg/L capture goal over the previous five years.

TVOC concentrations in the vicinity of Airport extraction wells RTW-2A and RTW-3A have been less than the 10 µg/L capture goal; therefore, these wells were put on standby in March 2020. Airport extraction well RTW-5A remained in standby mode as individual VOCs in monitoring well 800-103 (located immediately north of the extraction well) have remained below applicable MCLs since 2004. Extraction wells RTW-1A, RTW-4A and RW-6A continued full-time operation because monitoring results from upgradient monitoring wells continue to show TVOC concentrations above 10 µg/L. Monitoring well 800-94 is located approximately 1,800 feet northeast of RW-6A. TVOC concentrations in this well over the

previous five years have ranged from 53 µg/L to 96 µg/L, showing a slight decreasing trend. Monitoring well 800-101 is located immediately north 2of extraction well RTW-4A. TVOC concentrations in this well have slowly increased over the previous five years, as expected. The contamination now detected in this well was located immediately south of the North Street System prior to its startup, and was planned to be captured and treated by RTW-4A. See monitoring trends on **Figures 6-11** and **6-12**.

HFBR Pump and Recharge System/Plume

The Petition for Closure of this system was submitted to the regulators for review and approval in July 2018. NYSDEC/NYSDOH and EPA approvals were received in August 2018 and March 2019, respectively. Starting in 2018, the groundwater monitoring program was reduced to routine surveillance of the HFBR using three existing and seven new monitoring wells positioned immediately downgradient of the facility. In October 2018, 47 downgradient monitoring wells were decommissioned. Sampling of the extraction wells for this system was discontinued in July 2019. The maximum tritium concentration in the source area monitoring wells in 2020 was 25,300 pCi/L in April. Historical peak tritium concentration trends are graphed on **Figure 6-13**. The remaining downgradient monitoring and extraction wells will be retained until a determination is made on their possible re-utilization following the full characterization of PFAS and 1,4-dioxane. The carbon vessels, treatment building, and a segment of piping will be repurposed for the Former Firehouse PFAS Source Area Groundwater Treatment System.

BGRR/WCF Treatment System

In October 2016, extraction wells SR-4 and SR-5 were shut off and placed in standby mode due to the reduction in Sr-90 concentrations. Extraction well SR-6 was placed in standby mode and SR-3 and SR-7 were placed in pulsed pumping mode (one month on and one month off) in October 2017 due to low Sr-90 concentrations. SR-3 and SR-7 were ultimately placed in standby mode in October 2018. Extraction well SR-8 was placed in a pulsed pumping mode in 2018. Due to increasing BGRR source area Sr-90 concentrations, extraction well SR-3 was placed back into full-time operation in February 2019. See Sr-90 concentration trends on **Figure 6-14**.

From 2017 through 2019, 61 temporary wells were installed to augment the permanent well network and fill in plume data gaps for the BGRR and WCF Sr-90 plumes. In September 2020, a vertical profile well was installed at the leading edge of the BGRR Sr-90 plume. A new permanent sentinel monitoring well was installed at this location in October 2020. Four temporary wells installed in 2019 confirmed that Sr-90 is still present at elevated concentrations (up to 278 pCi/L) in the former WCF source area. The 2015-2016 demolition of the former Waste Concentration Facility and removal of nearby impermeable surfaces may have allowed for the leaching of residual Sr-90 in the underlying soils to the groundwater. Sr-90 concentration increases were observed in extraction well SR-1 in 2018 and 2019. It is expected that these concentrations will attenuate over time, and the downgradient migration of Sr-90 from the source area is controlled by extraction wells SR-1 and SR-2.

Based on Sr-90 increases in monitoring well 075-701 (up to 1,170 pCi/L in 2019) and extraction well SR-3 (up to 42 pCi/L in 2020), it appears that the water-table elevation increase during 2018-2019 has resulted in the release of residual Sr-90 located in the deep vadose zone soils beneath the BGRR area. Monthly monitoring will continue in this area. The downgradient migration of the Sr-90 is controlled by extraction well SR-3.

Chemical Holes Treatment System

Sr-90 concentration trends in key core monitoring wells and the extraction wells have declined significantly over the last several years. The area of highest concentration is currently located in the former source area upgradient of extraction well EW-1. Monitoring well 097-314 detected a maximum Sr-90 concentration of 64 pCi/L in January 2020 but dropped to 38 pCi/L during the August 2020 sampling round. See trends on **Figure 6-15**. Overall plume size reduction has been demonstrated, and an evaluation

of cumulative mass removal indicates that the system is no longer removing significant Sr-90 mass to continue full-time operation. In April 2016, extraction well EW-1 was placed into pulsed pumping mode (one month on and one month off). In October 2016, EW-2 and EW-3 were placed in standby mode. Based on Sr-90 concentrations in plume monitoring wells since 2016, and the significantly reduced plume mass, the remaining concentrations are projected to attenuate to below the 8 pCi/L MCL before 2040. A *Petition for Shutdown* of the treatment system was approved by the regulators in July 2018, and the system was subsequently placed in standby mode (BNL 2018a).

6.4.4 Operable Unit IV

Soil: Remediated radiologically contaminated soil at the Building 650 Sump Outfall is included under OU I. Building 650 was formerly known as the Reclamation and Hot Laundry Facility. From the fall of 2020 to the spring of 2021, the building was decontaminated and dismantled. An as-left radiological survey of the building footprint and surrounding worksite was performed and the Building 650 LUIC fact sheet will be updated to document current status. This demolition was not included in the scope of the original OU IV remedial action. A demolition work plan and field sampling plan were submitted to the regulators for their information and they were kept informed of progress during monthly IAG teleconferences (BNL 2020c).

Groundwater: The OU IV AS/SVE treatment system was decommissioned in 2003 and post-closure groundwater monitoring was completed in 2011.

Groundwater monitoring continues to evaluate the natural attenuation of Sr-90 contamination that originated at the Building 650 Sump Outfall as the contamination slowly migrates to the south. Sr-90 concentrations for key wells are shown on **Figure 6-15**. The plume is projected to attenuate to less than the drinking water standard (8 pCi/L) by 2034. The maximum southward extent of the leading edge of this area (defined by 8 pCi/L) will be approximately 250 feet south of Brookhaven Avenue or just under the NSLS-2 Building. In 2019, five temporary wells were installed to evaluate the eastward shift and the southern portion of the plume. Two new monitoring wells were installed in 2020 and an existing monitoring well was added to the program to enhance the well network and monitoring of the plume core. Two new monitoring wells were also installed in 2020 downgradient of Building 650 to supplement the existing network and monitor for any impacts to groundwater resulting from the Building 650 demolition. Sr-90 was not detected in the samples collected in October 2020, prior to building demolition.

6.4.5 Operable Unit V

Peconic River: Based on the recommendations presented in the 2016 *Five-Year Review Report*, further post-cleanup sediment, surface-water and fish monitoring of the Peconic River was discontinued. However, in an August 2016 comment on the *Five Year Review Report*, NYSDEC stated that future monitoring activities of the Peconic River shall be determined following the "Area WC-06" removal action. The *Completion Report, Peconic River Supplemental Sediment Removal, Area PR-WC-06,* dated December 2017 was submitted to the regulators in January 2018 (BNL 2017b). The EPA, NYSDEC and SCDHS provided their concurrence on the report in March and April 2018. As documented in the report, all 27 post-excavation confirmatory samples verified that the sediment cleanup goals from the ROD were met (average mercury concentration of less than 1.0 milligrams per kilogram (mg/kg) and all individual samples are less than 2.0 mg/kg). With the completion of this supplemental cleanup at Area PR-WC-06 and the results from the post-excavation confirmation sampling, BNL proposed that no further post-cleanup monitoring of the Peconic River is warranted. However, NYSDEC believes that following a population survey, fish monitoring for mercury and PCBs should continue annually until they are reduced to "acceptable levels" as required by the ROD.

In order to determine if enough fish are present to support sampling, routine population assessments are conducted. In May 2019, a population assessment was conducted by BNL and resulted in the capture of 16

chain pickerel and one pumpkinseed from the onsite portions of the Peconic River. The largest fish had a length of 85 millimeters or a little over three inches. The number and size of fish were far below what was necessary to support sampling. Radiological sampling alone requires sufficient mass, approximately 0.5 kilograms, and enough fish to allow 5 to 10 samples per feeding guild (bottom feeders such as catfish and top predators such as bass or pickerel). Due to the lack of suitably sized fish with enough population to support sampling, no samples were taken in 2019 for surveillance monitoring of fish. This annual evaluation was documented in the *2019 BNL Site Environmental Report* (BNL 2020d).

Peconic River Sediment: Following successful completion of the supplemental sediment cleanup performed in 2017 at Area WC-06, further sediment sampling was discontinued.

Peconic River Water Column: Water column sampling was discontinued following recommendations from the 2016 Five-Year Review and concurrence by the regulators.

Peconic River Fish: Post-closure fish sampling was discontinued following recommendations from the 2016 Five-Year Review. As requested by NYSDEC in 2018, BNL conducted a fish population assessment and determined that sufficient fish were not available to support environmental surveillance sampling in 2019.

BNL's surveillance monitoring program of the onsite portions of the Peconic River documents potential environmental impacts and collects data needed to determine radiological dose assessments for individuals and biota. To accomplish this, BNL will continue to annually assess the Peconic River water levels and perform population surveys to determine if fish sampling will be performed. The decision for continued monitoring of fish is addressed in the Peconic River Fish Surveillance Monitoring data quality objective (DQO) summary presented in the annual BNL *Environmental Monitoring Plan* (BNL 2021a) (https://www.bnl.gov/esh/env/emp/). A fish population survey of the Peconic River also performed by BNL in July 2020 resulted in the capture of 27 creek chubsucker, 13 largemouth bass and 11 bluegill from the onsite portions of the Peconic River. The largest fish had a length of 80 millimeters with the remainder at 30 millimeters or less. The type and size of fish were far below what was necessary under the DQO to support sampling. Historically, BNL has used, and will continue to use only filet samples to represent the edible portion of the fish for potential human health exposure impacts.

Peconic River Vegetation: In accordance with the NYSDEC Permit Equivalency Application, following the 2017 sediment remediation of Peconic River Area WC-06, BNL completed two years of wetland monitoring in September 2019. In November 2019, a letter report was submitted to NYSDEC for concurrence (BNL 2019e). In February 2020, NYSDEC found the report acceptable and requested river flow data and fish population survey information. In May 2020, BNL provided the requested information. On August 5, 2020, the NYSDEC Region 1 Fisheries Biologist performed an inspection of the restored cleanup area as well as an assessment of the available fish habitat. NYSDEC approved closure of the permit in a January 6, 2021 letter (NYSDEC 2021). BNL will continue to monitor the vegetation and control the invasive species, as necessary (not to exceed 10 percent of cover), an additional three years (through September 2022), to meet the federal duration requirements.

Groundwater: The groundwater monitoring requirements for the OU V ROD have been satisfied. Groundwater monitoring results for PFAS and 1,4-dioxane in the this area are discussed in **Section 6.4.7** below. Groundwater quality in the vicinity of the STP is currently monitored under the SPDES program.

6.4.6 Operable Unit VI

Groundwater: As shown on trend **Figure 6-17**, monitoring over the past five years continues to show a steady decline in EDB concentrations as the plume migrates south and is captured by the EDB treatment

system. Overall, peak EDB concentrations in monitoring wells declined from 7.6 µg/L in 2001 to a maximum of 0.5 µg/L in a fourth quarter of 2020. The drinking water standard for EDB is 0.05 µg/L. Although EDB concentrations have significantly declined, the plume is moving significantly slower than originally simulated by the groundwater model used during the system design. In 2018, two temporary wells were installed in the plume core upgradient of the extraction wells. The maximum EDB concentration detected in these temporary wells was 0.57 µg/L. Two permanent monitoring wells were then installed at this location in January 2019. In 2020-2021, five vertical profile wells were installed to address data gaps in the distribution of EDB in the aquifer and to collect geologic data needed to update the groundwater model. This work resulted in the observation that the Gardiners Clay is not present in this area as was previously understood. Groundwater quality data obtained from these vertical profile wells identified the presence of EDB at greater depths than previously observed in the area. The maximum EDB concentration detected in these temporary wells was 1.4 µg/L. Two permanent monitoring wells were installed at this location in October 2020.

6.4.7 Operable Unit VIII

Soil: In 2018, soil samples were collected near the Recreation Center and a nearby stormwater drainage area to evaluate potential impacts from firefighting foam that had been released to the pavement and grass field. The soil samples were collected to support a Phase II Environmental Assessment (EA) that is required for BNL's planned construction of Discovery Park. No significant PFAS concentrations were identified. Soil samples will be collected at the other identified foam release areas during the planned RI.

Groundwater: Since 2018, several phases of groundwater characterization have been performed on the nature and extent of PFAS and 1,4-dioxane on and off of BNL property. The monitoring results for 2018 and 2019 are presented in the *2019 Groundwater Status Report* (BNL 2020b). The highest PFOS and PFOA concentrations were detected near the Laboratory's Current Firehouse, with concentrations of 12,200 ng/L and 240 ng/L, respectively. The site with the second highest PFOS and PFOA concentrations was the Former Firehouse area, with concentrations of 5,210 ng/L and 736 ng/L, respectively. In 2020, BNL conducted a comprehensive sampling of approximately 350 on-site and off-site monitoring wells and five off-site treatment systems for PFAS and 1,4-dioxane, and two onsite treatment systems for 1,4-dioxane. The results are presented in the *Phase 4 Characterization Report, Per- and Polyfluoroalkyl Substances (PFAS) and 1,4-Dioxane in On-Site and Off-Site Monitoring Wells, Extraction Wells and Treatment Systems* (BNL 2021b).

A detailed characterization effort was conducted in 2020 and early 2021 of the high concentration segments of the PFAS plumes associated with BNL's Current and Former Firehouse facilities. The data were used to delineate the plumes downgradient of these source areas and aid in the design of groundwater treatment systems. As part of this effort, samples from select wells were also tested for 1,4-dioxane. A summary report of this investigation was submitted to the regulators in April 2021 (BNL 2021d). These characterization data supported the design of two groundwater treatment systems at these areas. The design report was submitted to the regulators in June 2021 (BNL 2021e).

6.4.8 BGRR

Structures and Soil: Except for surveillance and maintenance inspections and follow-up repairs, no soil sampling was performed since the 2016 Five-Year Review. Repairs performed since 2016 include the roof drain on the west air intake to protect against rainfall intrusion, the flashing on the doghouse roof, the window gaskets, replacing the broken glass on the east bay window, trim around the entry door to the below ground ducts, repair to an atrium window on the east air intake, one of the four leak detection sensors in the below ground ducts was replaced and removal of vegetation and resealing of the engineered cap. Lighting was installed on the west stairwell and a new stairway was installed to the roof. An update to the Long-Term Surveillance and Maintenance Manual for the BGRR was issued in December 2018 (BNL 2018b).

Groundwater: See OU III Groundwater **Section 6.4.3** for groundwater data review.

6.4.9 g-2/BLIP/USTs

Groundwater: Groundwater monitoring at the g-2 and BLIP source areas has shown that the stormwater controls have been effective in preventing additional leaching of radionuclides from the activated soil shielding. At the BLIP facility, all tritium concentrations have been less than the 20,000 pCi/L MCL since early 2006. However, tritium concentrations periodically exceed the 20,000 pCi/L MCL in the g-2 source area monitoring wells. Since 2016, the maximum tritium concentration at the g-2 source area was 35,500 pCi/L. The periodic detection of tritium at concentrations above the MCL is related to water-table fluctuations and the flushing of residual tritium from the deep portion of the vadose (unsaturated) zone below the g-2 source area. The overall reductions in tritium concentrations observed in the source area wells suggest that the amount of residual tritium that is available to be flushed out of the deep vadose zone has decreased with time. See trend **Figure 6-18**. Contingency actions identified in the ROD for the g-2 tritium plume were not triggered over the last five years. Monitoring of the downgradient portion of the g-2 tritium plume was discontinued in October 2015 because tritium concentrations in the area south of the Alternating Gradient Synchrotron Facility have attenuated to below the MCL.

No groundwater monitoring is required for the former UST areas.

Structures and Soil: BNL routinely inspects and maintains the caps and other stormwater controls at the g-2 and BLIP source areas. Over the last five years, only minor repairs have been required for the BLIP and g-2 caps. For the former UST areas, no additional remedial actions were required.

6.4.10 HFBR

Groundwater: See OU III Groundwater **Section 6.4.3** for groundwater data review.

Structures and Soil: No soil or structure characterization was performed at the HFBR since the 2016 Five-Year Review except for the stack. The stack exterior coating (which contained lead and asbestos) was abated in November 2020 and the stack was demolished between December 2020 and February 2021. The final status survey (which includes soil sampling and a walkover survey) and ORISE independent verification of the cleanup will be performed in mid-2021. In August 2020, radiation measurements of the V-14 port on top of the reactor vessel were taken to confirm that radioactive decay is occurring at the modeled rate. These data are discussed in more detail in **Section 7.10.**

In 2020 and 2021, the Waste Loading Area was used as a staging area for temporary storage of waste from the HFBR stack and Building 650 demolition and for loading the waste onto rail cars for off-site disposal.

Since 2016, repairs performed at the HFBR as a result of surveillance and maintenance inspection findings included repairing the overhead piping insulation, resealing the openings on the air intakes on the exterior walls adjacent to the generator room, repairing cracked masonry on the east side exterior of the confinement dome, pump-out of the stack drain tank, and collection and disposal of stack paint chips on the grounds. In 2018, safety cable tie-offs were installed around the three stack platforms.

6.4.11 Groundwater Monitoring

Section 5.0 of the BNL Groundwater Status Reports identify changes to the well monitoring network at BNL (https://www.bnl.gov/gpg/gw-reports.php). Changes include the installation of additional temporary and permanent monitoring wells, well decommissioning, and modifications to monitoring frequency and analytical parameters. As shown in **Table 6-3**, from May 2015 through 2020, 58 permanent wells were installed to enhance the monitoring networks for the various plumes. From 2016 through 2020,

approximately 315 temporary wells were also installed to track and characterize contaminants in the Upper Glacial aquifer (e.g., EDB, VOCs, Sr-90, PFAS, and 1,4-dioxane). In addition, six new extraction wells were also installed during this time. **Table 6-4** identifies the 54 monitoring wells that were decommissioned between 2015 and 2021 in accordance with State policy.

6.5 Inspections

Between August 17th and September 2, 2020, representative site inspections took place for the landfills, soils, Peconic River, and groundwater. Only one representative from BNL attended due to COVID-19 precautions. The purpose of the inspections was to assess the protectiveness of the various sites, including operating treatment systems and controls. No significant issues were identified during the site inspections; however, minor issues observed included outdated O&M Manuals and SPDES equivalency permits posted in two buildings, hazard info placards that needed updating, vegetation clearing needed around buildings and wells, the Daily Operating Sheet needed be revised to reflect monthly instead of daily use, mold was identified in two buildings, and the LUIC point-of-contact sign needed to be rehung. The completed inspection checklists are included in **Attachment 3**. All of the groundwater systems are routinely inspected as part of the ongoing O&M. In addition, Environmental Safety and Health (ES&H) assessments (formerly called Tier 1) that evaluate primarily safety and operational concerns are performed on all of the systems annually (except for 2020 due to COVID-19 concerns).

There were no significant issues identified during the long-term surveillance and maintenance of the HFBR facility. However, routine repairs and maintenance were performed over the last five years including roof repairs, collection of paint chips on the ground, and collection and disposal of precipitation water generated from the stack. Structural inspections of the HFBR and the stack were performed annually. Overall the interior and exterior of the building and stack remained in good condition. Safety improvements to the stack platforms were performed in 2018.

The scope of routine surveillance activities at the BGRR includes radiological and environmental monitoring, house and grounds keeping, testing, inspection, and preventive maintenance and repair of required systems and equipment, removal of liquid waste, and verification of conditions throughout the BGRR complex. The surveillance frequencies are quarterly for the former offices and high bay, semi-annually for the engineered cap and below ground ducts, and annually for structural integrity. Repairs and maintenance performed over the last five years included roof repair, repair to a broken window, minor cap repair, and infiltration management.

The caps and other stormwater controls at the g-2 and BLIP source areas are inspected two times per year and inspection reports are submitted to the regulatory agencies annually. There have been no significant issues identified. Minor cap maintenance is performed on a routine basis.

6.6 Interviews

Interviews conducted in March 2020 consisted of discussions with the EPA, NYSDEC, NYSDOH, SCDHS, and DOE representatives. Questions from the list below were asked during the interview; however, each representative was not asked all of the questions on the list. Potential interview questions included:

- What is your overall impression of the cleanup at BNL?
- Are there any specific aspects of the cleanup that you feel should be of particular focus during the review?
- Do you believe the public is sufficiently informed of the cleanup progress?
- Do you believe the remedies are functioning as expected by the RODs?

- Are you aware of any particular component of the cleanup decisions that pose a higher degree of difficulty in achieving?
- Are you aware of any recent or upcoming changes to federal or New York State laws, regulations, or cleanup standards that may impact protectiveness of human health and the environment at BNL?
- Do you believe there are current opportunities to optimize operations and maintenance or sampling efforts at BNL that could result in cost savings or improved efficiency?
- What do you think are the biggest risks to achieving the soil and groundwater cleanup objectives at BNL?
- Do you feel that BNL and DOE are actively managing the long-term cleanup operations for the site and are properly maintaining appropriate institutional controls?
- Do you have any comments, suggestions, or recommendations regarding BNL/DOE's management of the cleanup?

The following individuals were specifically contacted for interviews concerning the BNL site:

- Ms. Sharon Hartzell - EPA Region 2
- Mr. Brian Jankauskas - NYSDEC
- Mr. Steve Karpinski - NYSDOH
- Mr. Andy Rapiejko - SCDHS (an Interview Summary form was not completed)
- Mr. Gerald Granzen - DOE

The regulators interviewed communicated that BNL has made significant progress with the cleanup in an effective and efficient manner and is taking the necessary steps to meet the remedial action objectives. EPA, NYSDOH and DOE believe the greatest risk in achieving cleanup goals is associated with characterization and remediation of PFAS and 1,4-dioxane, and being able to secure funding for the work. DOE feels that BNL has been very proactive in addressing these emerging contaminants and to some extent has progressed ahead of regulatory implementation. The NYSDEC Project Manager feels that significant work was performed to remediate the Peconic River sediment; however, they are concerned that fish tissue mercury concentrations do not appear to be reducing to below the EPA criteria. They would like to see more fish samples obtained, if possible, to support the Five-Year Review evaluation. The State is also concerned that the due date for demolition of the stack will not be met, and NYSDEC feels that having terminal dates for RODs for complex engineering actions seems lofty and sets up the team for possible failure. All agencies believe that the soon-to-be-promulgated State drinking water standards for PFAS and 1,4-dioxane will be significant, and NYDEC said that further investigation and remedial action at BNL are anticipated once additional PFAS and 1,4-dioxane standards, criteria, and guidance values (SCGs) for other media (e.g., soils, groundwater, wildlife) are released. The EPA Project Manager stated that some groundwater plumes at BNL continue to fluctuate, which will need to be an area of continued attention to make sure the remedies continue to function as intended. Another factor identified as a potential risk by EPA are delays with work progress related to the current global pandemic. All agencies feel that BNL does an excellent job of keeping the regulators and public informed on the cleanup progress. The interview summaries are included under **Attachment 4**.

7.0 Technical Assessment

The following subsections assess both the soil and groundwater remedies by OU and address the three EPA-designated questions. Information on the majority of the soil cleanup work was completed prior to this Five-Year Review and can be found in earlier documents (https://www.bnl.gov/gpg/5year-review.php). BNL performs a comprehensive assessment of each of the groundwater treatment systems' operation, performance, plume monitoring information and opportunities for optimization as part of the annual Groundwater Status Report. The *2020 BNL Groundwater Status Report* (BNL 2021g) and reports from prior years are available for review online and at the designated document repositories.

The only significant institutional control issues identified over the previous five years are:

- A key institutional control for the groundwater treatment systems located off of the BNL property is to ensure that the property access agreements are in place and have not been violated. To date, all requirements of the access agreements have been met, including communicating the LUICs and restrictions to the property owners. To date, the use of these properties has conformed to these controls. However, BNL has been working to renew an expired agreement, modify an existing agreement, and execute an agreement with a new property owner. These agreements will allow for BNL's continued access to operate and maintain groundwater treatment system-related infrastructure off of BNL property. In addition, the recording of the deeds for these properties with the Suffolk County Clerk's Office to reflect the controls and restrictions (i.e., easements) related to operation of the treatment systems is not complete. Of the seven property license/access agreements, each has a requirement for recording except for LIPA, but there is a conveyance provision in that agreement. The only agreement that has been recorded to date is for the original Industrial Park system. Efforts by BNL will continue to be made to resolve these issues and record the remaining agreements with the County Clerk.

7.1 Operable Unit I

OU I Question A: Is the remedy functioning as intended by the decision documents?

OU I Remedial Action Performance

- Based on a review of the closeout reports completed for the soil/disposal pit cleanups and wetland restoration, site inspections, and regulatory interviews, the remedies were implemented in accordance with the OU I ROD and the soil cleanup levels were met. This achieved the objectives of preventing human exposure including direct external exposure, ingestion, inhalation, and dermal contact, as well as environmental exposure to contaminants. Reconstruction of the Upland Recharge/Meadow Marsh Area wetlands was successfully implemented and has minimized uptake of contaminants in the soil/sediment by ecological receptors, including the eastern tiger salamander. Reconstruction activities included planting aquatic vegetation plants within the pond, planting native grasses adjacent to the pond, and adding rip-rap on the pond slopes to prevent erosion. Reconstruction of the former HWMF wetlands was performed in mid-2005. For the soil excavation remedies completed, such as the former HWMF, the former HWMF Perimeter Area, Building 811, and the former residual surface soils at the Chemical Holes, the work was performed in accordance with the ROD, applicable design documents, and Remedial Action Work Plans. The soil cleanup levels defined in the ROD have been met for these areas. Buildings 810 and 811 were demolished in 2015 following their decommissioning from active use. The removal of contaminated soils associated with these buildings was initiated in 2015 and completed in 2018. Final status surveys were performed following the completion of soil remediation and an independent verification was conducted by ORISE.
- The landfill areas were capped in accordance with the ROD and the NYS Part 360 requirements. The buried waste is contained and groundwater monitoring results indicate that the caps have achieved the objective to minimize the further leaching of contaminants from the soil into the

groundwater. Although groundwater monitoring results for the Current Landfill indicate that several VOCs (e.g., chloroethane and benzene) and metals (e.g., iron and sodium) continue to be detected at concentrations above MCLs in several downgradient wells, there has been an overall reduction in VOC concentrations since the landfill was capped in 1995. Elevated levels of VOCs continue to emanate from a location on the northeast side of the landfill. Characterization work to assess the downgradient migration of these VOCs was performed in 2016 and included the installation of several new wells to enhance the monitoring network. Groundwater monitoring results indicate that the VOC concentrations attenuate to below the MCLs before the contaminated water migrates to the southern site boundary. An updated natural attenuation simulation was performed in 2016 and the results were consistent with these observations. Sentinel well 098-99 was installed in 2016 to monitor groundwater quality approximately 1,000 feet south of the Current landfill and 2,000 feet north of the site boundary. The highest TVOC concentration observed in this well was 11 µg/L in 2017. Furthermore, although low levels of tritium and Sr-90 continue to be detected in the Current Landfill monitoring wells, all concentrations have been below the 8 pCi/L MCL since 1998. At the Former Landfill, there has been a significant reduction in contaminant concentrations since it was capped in 1996. Currently, all VOC and radionuclide (e.g., tritium and Sr-90) concentrations are below MCLs. This landfill is no longer having a significant impact on groundwater quality. The soil cover placed on the ash pit prevents direct contact with the metals in surface soils and prevents the potential migration of the metals by wind.

- The OU I groundwater pump and treat system operated from 1997 to 2019. The treatment system was placed in standby mode in July 2013 following regulatory approval of the *Petition for Shutdown of Operable Unit I Groundwater Treatment System* (BNL 2013b). Because TVOC concentrations remained below the capture goal of 50 µg/L in both the monitoring and extraction wells, the Petition for Closure was approved by the regulators in September 2019. There has been no evidence of VOC concentration rebound since the system was shut down. This pump and treat system has successfully remediated VOCs in groundwater which originated from the Current Landfill and former Hazardous Waste Management Facility (see **Figures 5-1** and **6-1**).
- In 2015 and 2016, groundwater monitoring identified Sr-90 in groundwater at the former HWMF at higher concentrations than were previously observed (See **Section 6.4.1**). It appears that this groundwater contamination is the result of the removal of structures and paved areas during the 2005 source area cleanup of the former HWMF, thereby uncapping and exposing residual soil contamination to the effects of precipitation and mobilization to groundwater. The groundwater model was updated in April 2016 to evaluate the expected attenuation of Sr-90. The model predicted that a small area of Sr-90 contaminated groundwater, at or just above the 8 pCi/L MCL, would arrive at the site boundary in approximately 42 years (by 2058). The groundwater model update is provided in Appendix I of the *2015 Groundwater Status Report* (BNL 2016a) (https://www.bnl.gov/gpg/gw-reports.php). The last five years of monitoring data supports the 2016 modeling findings of a slow migration to the south at the rate of 20 to 40 feet per year. The natural attenuation modeling was updated in 2021 based on monitoring data obtained from the fourth quarter of 2020. This groundwater modeling update is included in Appendix H of the 2020 Groundwater Status Report (BNL 2021g). Included in this report were the results of three temporary profile wells installed in areas of the plume where the highest Sr-90 concentrations had previously been observed. The peak Sr-90 concentration observed in 2020 was 689 pCi/L, which is more than double the peak concentration of 312 pCi/L that was used for the 2016 attenuation modeling. Despite this difference in peak concentrations, the model simulations were similar in showing Sr-90 concentrations at the 8 pCi/L MCL as it approaches the site boundary in 40-50 years (2060-2070) and near the Long Island Expressway in approximately 60 years (2080). The attenuation simulations were both run using the conservative Method of Characteristics (MOC) solution which eliminates the effects of dispersion. A model sensitivity analysis was also conducted varying peak plume concentrations and showed that the ultimate attenuation of the plume is primarily dependent on the overall plume mass and not a small area of higher Sr-90 concentrations.

The OU I ROD selected the 1996 interim remedy of natural attenuation, monitoring, and institutional controls as the final remedy for this area. The 1996 Action Memo (BNL 1996b) presents further details on the remedy.

OU I System Operations/O&M

- BNL performs monthly surveillance of the caps and associated drainage structures at the Current and Former Landfill areas. Although evidence of burrowing by small animals is common, the burrows do not penetrate beyond the outer soil layer, and therefore do not affect the protectiveness of the caps. As they are found, the burrows are filled in and repaired. Grass areas are typically mowed twice per year, and small pine seedlings are removed before their roots can damage the caps. The landfills are used by migratory birds but not ground nesting birds. In 2020 and 2021, respectively, a soil gas vent pipe on the top of the Former Landfill and a soil gas monitoring well located immediately north of the Current Landfill were found bent from inadvertent contact from a mower and payloader. A drilling contractor subsequently performed the repairs. Monthly inspections will continue to ensure that the caps are properly maintained and repaired.
- The OU I Treatment System remained in an operationally ready mode since it was shut down and placed in standby from 2013 through 2019. Monitoring and extraction wells will not be abandoned pending the characterization and any potential remediation of emerging contaminants in this area. Building 598 will be retained to support remediation of the PFAS plume from the Former Firehouse source area.

OU I Costs of System Operations/O&M

Since the OU I treatment system was shut down in 2013, the average annual O&M cost was approximately $45K over the last five years. This does not include project engineering, project management, or groundwater monitoring well sampling and analysis costs.

OU I Implementation of Institutional Controls and Other Measures

The land use and institutional controls that are in place and maintained for OU I include:

- Postings to communicate potential hazards and aid in controlling access at areas such as Building 650 Sump Outfall, the former Waste Concentration Facility area, Upland Recharge/Meadow Marsh Area pond, the Ash Pit, and former HWMF.
- No activities shall be permitted in the Landfills and Ash Pit areas that could compromise the integrity of the caps.
- Institutional controls for all three phases of the former HWMF Perimeter Areas are being implemented. The Phase II area was granted to the Long Island Solar Farm in 2010 via an easement from DOE. The Phase II cleanup allowed for industrial reuse of the property as a solar farm, but prohibits soil removal from this area.
- Fencing around cleanup areas such as the Current Landfill and former HWMF to aid in controlling physical access.
- Maintenance of landfill engineered caps to prevent continued groundwater contamination, and covers over residual soil contamination to aid in preventing the direct exposure of such contamination to site workers, visitors, and wildlife.
- Several wetland areas that may contain protected habitats are adjacent to the former HWMF. NYSDEC regulates all work within 100 feet of wetlands with confirmed protected species habitats. Any work activities within 100 feet of a wetland requires DOE and NYSDEC notification and approval.
- BNL limits activities within 850 feet of wetlands with confirmed protected species habitats.
- Restrictions/controls on the pumping and recharge of groundwater on the BNL site until cleanup levels are achieved. This will help maintain consistent groundwater flow directions.
- Groundwater monitoring to track contaminant plumes as well as reporting in the Annual

Groundwater Status Report.

No activities were observed at OU I that would have violated these institutional controls.

OU I Monitoring Activities

- The monitoring data obtained from the groundwater monitoring wells and the treatment system provide the basis to evaluate system performance and effectiveness. The monitoring wells for the OU I plume and treatment system are categorized as background, core, perimeter, or bypass wells. The landfill areas are monitored by upgradient and downgradient wells. Descriptions of the wells that are sampled and their monitoring frequencies are presented in the annual *BNL Environmental Monitoring Plan* (BNL 2021a). The monitoring data are reported in the annual *BNL Groundwater Status Report* (BNL 2021g) and the *BNL Environmental Monitoring Report – Current and Former Landfill Areas* (BNL 2021c).

  The Sr-90 plume from the former HWMF is characterized annually via temporary and permanent monitoring wells to monitor its movement and attenuation over time. During 2020, the maximum Sr-90 concentration detected in the plume was 689 pCi/L in a temporary well.

OU I Early Indicators of Potential Issues

- In 2015 and 2016, groundwater characterization identified Sr-90 in groundwater at the former HWMF at higher concentrations than were previously observed (See **Section 6.4.1**). The groundwater model was updated in March/April 2016, and again in February 2021 where the attenuation of the Sr-90 plume was simulated. The model predicts that a small area of Sr-90 at or just above the drinking water standard of 8 pCi/L will reach the site boundary in approximately 40-50 years (2060-2070). The 2016 groundwater model update is provided in Appendix I of the *2015 Groundwater Status Report (*https://www.bnl.gov/gpg/gw-reports.php). The 2021 Groundwater Modeling Update is provided in Appendix I of the *2020 Groundwater Status Report* (BNL 2021g). The OU I ROD selected the 1996 interim remedy of natural attenuation, monitoring, and institutional controls as the final remedy for this area. The 1996 Action Memo (BNL 1996b) presents further details on the remedy.
- Sr-90 is migrating at a slow rate (20-40 feet per year) and there is a comprehensive groundwater monitoring network in place to verify the expected attenuation of the plume. There do not appear to be any problems or issues at this time that could place protectiveness of the remedies at risk.

OU I Opportunities for Optimization

- Tracking Sr-90 contamination in groundwater migrating from the former HWMF yard requires continued monitoring using new permanent monitoring wells, the periodic installation of temporary profile wells using the Geoprobe®, or a combination of the two methods. The permanent monitoring network was improved over the past five years with the addition of monitoring wells positioned in the highest concentration segments of the plume along with several new sentinel monitoring wells that are positioned to provide early warning information on the migration of the leading edge of the plume. Plume migration will be assessed on an annual basis and reported in the Groundwater Status Report.
- Former Landfill groundwater monitoring data collected over the last 20 years indicate that the current impact to groundwater quality is very low. Based upon these results, it is recommended that groundwater monitoring of the Former Landfill be discontinued. See the *2020 Environmental Monitoring Report – Current And Former Landfill Areas* (BNL 2021c) for further detail.

OU I Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of remedy selection still valid?

OU I Changes in Standards and items To Be Considered (TBCs)

- As identified in **Attachment 5**, the standards or TBCs in the OU I ROD have not changed, nor do they call into question the protectiveness of the remedy. Radiological soil cleanup levels and the MCLs for contaminants of concern are unchanged since the signing of the ROD in 1999. EPA's third Six-Year Review of the drinking water standards was completed in January 2017. EPA determined that National Primary Drinking Water Regulations for eight compounds are candidates for regulatory revision; however, they are not contaminants of concern.
- The issuance of the 2020 MCLs for PFOS, PFOA and 1,4-dioxane will require characterization of the presence of these compounds in OU I groundwater. Data collected to date and future remedial investigation and/or remedial actions will be incorporated under OU VIII.
- The soil cleanup levels for radionuclides are based on 15 millirem per year (mRem/yr) above background. As stated in the *EPA memorandum on Radiation Risk Assessment at CERCLA Sites: Q&A* (EPA 2014a), the Superfund recommendation is now 12 mRem/yr as the dose-based level protective of a target cancer risk of $1x10^{-4}$. This could have a minor effect on risk-based levels of radionuclides in soil. It should be noted that the soil cleanups performed to date have also met the NYSDEC guidance of 10 mRem/yr above background (ALARA goal).
- **Attachment 6** provides the cleanup levels for the OU I primary contaminants of concern.

OU I Changes in Exposure Pathways, Toxicity and Other Contaminant Characteristics, and Risk Assessment Methods

- There have been no changes in the physical conditions within OU I or in the use of the site that would reduce the protectiveness of the remedies or require updates to the risk assessment. The exposure assumptions used in the original risk assessment are consistent with current land use.
- In general, the changes in standard default exposure parameters from the EPA's memorandum *Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors, OSWER Directive 9200.1-120* issued on February 6, 2014 (EPA 2014b) (2014 Standard Default Exposure Factors) served to raise risk-based concentrations. In most cases the mix of higher and lower individual parameters, such as ingestion rates, body weights and exposure durations result in higher risk-based concentrations.
- Lead, a contaminant of concern in soil, has a cleanup level of 400 mg/kg, which is the EPA Regional Screening Level for residential soil and the New York State soil cleanup objective for residential and restricted residential use, and commercial or industrial use. This cleanup level is protective of residential exposure to lead in soil based on a target blood lead level of 10 micrograms per decaliter (µg/dL) in children. There has been renewed discussion within EPA on the possibility of revising the target blood lead level for CERCLA. If EPA revises the value to less than 10 µg/dL, then the 400 mg/kg cleanup level for lead in soil would require review in future Five-Year Reviews for continued protectiveness.
- Federal Guidance Report 15, entitled *External Exposure to Radionuclides in Air, Water and Soil* (EPA 2019b), updated and expanded the 1993 Federal Guidance Report No. 12 to include age-specific reference person effective dose rate coefficients based on external exposure. The changes include updated tissue weighting factors and radionuclide decay data. While this change does not affect MCLs, risk-based levels and risk assessment for external exposure may be affected.
- As part of the 2006 Five-Year Review, a preliminary screening of the OU I groundwater VOC plume was performed to evaluate the potential for soil-vapor intrusion. The Current Landfill is the only OU I area with VOC contamination that is close to an inhabited building. Although groundwater contamination immediately beneath the Current Landfill is shallow and the levels of several VOCs exceed MCLs, the closest office building is approximately 1,000 feet upgradient of the landfill. Therefore, the subsurface vapor to indoor air pathway is incomplete, and no further

evaluation is needed. The downgradient portion of the plume is deeper and has a clean layer of groundwater above. Therefore the contaminants are not present in the uppermost portion of the groundwater (i.e., water table) to present a soil-gas concern. As part of the 2021 Five-Year Review, *OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway From Subsurface Vapor Sources to Indoor Air,* dated June 2015 (EPA 2015), was reviewed. Although the contaminants of concern in the OU I shallow groundwater plume from the Current Landfill exceed either the MCLs or EPA's Vapor Intrusion Screening Levels (VISLs), the buffer distance laterally to the nearest building is 1,000 feet and there are no preferential vapor intrusion pathways. Consequently, the subsurface vapor to indoor air pathway is incomplete. As discussed in **Section 6.4.1**, no migration of methane gas is evident in the outpost soil-gas monitoring wells between the landfill and the National Weather Service building to the north. In the event that further construction is planned at BNL within the area of the OU I landfills or former HWMF, BNL will reevaluate any potential issues and, if necessary, undertake appropriate measures to address them. Any construction projects to be undertaken at BNL are reviewed for environmental, security, and safety and health concerns in the conceptual design or early planning phase. BNL procedure *EP-ES&H-500, Project Environmental, Security, Safety and Health Review*, includes an *ES&H 500A Evaluation Form* that requires any potential issues, such as potential soil-vapor gas intrusion, be identified, documented, and mitigated, if necessary. In addition, the LUCMP and the groundwater plumes fact sheet will be revised to reflect the potential for soil-vapor intrusion should new buildings be proposed.

- As discussed in **Section 6.4.1** above, in 2016 additional soil-gas samples were obtained southeast of the Current Landfill. There were no detections of soil gas in any of the samples. A second round of testing during a dry period in July 2016 also did not detect soil gas.

OU I Expected Progress in Meeting Remedial Action Objectives

- Projects completed to date within OU I continue to meet the remedial action objectives identified in the OU I ROD, based on post-excavation confirmatory soil sampling results, continued monitoring of the surface waters and sediment, groundwater monitoring downgradient of potential source areas, and visual inspections of remediated areas. Institutional controls continue to remain effective.
- The OU I groundwater restoration project is on schedule for meeting the ROD cleanup goal of reaching MCLs for VOCs in the Upper Glacial aquifer within 30 years (by 2030). Since there was no rebound of VOCs since the treatment system was shut down in 2013, a Petition for Closure was approved by the regulators in September 2019 (BNL 2019a). The system has successfully remediated VOCs in groundwater that originated from the Current Landfill and former HWMF. Monitored natural attenuation will reduce any remaining low-level VOCs in the plume to below MCLs.
- Based on groundwater modeling results, the Sr-90 from the former HWMF is projected to be at or near the drinking water standard when it reaches the site boundary by approximately 2040-2050. Monitoring of the plume will continue and comparison of the data with the model projected concentrations will be performed.

Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

There is no additional information that calls into question the protectiveness of the remedies at OU I.

7.2 Operable Unit II

The AOCs in this OU are documented in the OU I and OU III RODs, except for BLIP, which was documented in the g-2/BLIP/UST ROD. The following questions relate to remedial actions taken at the BLIP facility.

OU II Question A: Is the remedy functioning as intended by the decision documents?

- Silica grout was injected into the activated soil at the BLIP facility in 2000. This Removal Action was an additional protective measure to reduce the permeability of the activated soil. Moreover, it would reduce the potential impact of rainwater leaching radionuclides into the groundwater should the primary stormwater controls fail. The g-2/BLIP/USTs ROD included requirements for maintenance of the building roof drains and surrounding cap (including paved areas and gunite cap), and continued groundwater monitoring. No further monitoring of the silica grout injection is required.
- As reported in the *BLIP Closeout Report Removal Action AOC 16K* (BNL 2001d), the injection of the silica grout at BLIP can be characterized as successful; however, its deployment was not. Although the objectives of minimizing threats to human health, migration of contaminants to the groundwater, and migration from operations of the facility in the future appear to have been met, the displacement of contaminated soil-pore water during the grout injection process caused a short-term impact to groundwater quality. As a result, the goal of improving the control of the activation area "without harm to the environment" was not achieved. As discussed in **Section 6.4.2** above, the concentrations of tritium in the groundwater have remained less than the 20,000 pCi/L MCL since early 2006.
- The cap inspection and repair are included under BNL's Preventative Maintenance Program. The gunite cap, paved areas, and roof drains at BLIP are in good condition and are effectively controlling stormwater infiltration. Although direct inspection or maintenance of the silica grout is not possible, it is expected to be in good condition and would be effective in preventing significant leaching of tritium from the activation zone.
- Semiannual groundwater monitoring in the immediate vicinity of BLIP continues per the *2020 BNL Environmental Monitoring Plan* (BNL 2021a), and the monitoring results are summarized in the annual Groundwater Status Reports.

The final remedy for the BLIP facility was documented in the g-2/BLIP/USTs ROD, which was signed in 2007.

OU II Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of remedy selection still valid?

- The Remedial Action Objective to prevent further migration of radionuclides from the activated soil shielding to the groundwater is still valid. There have been no changes to the exposure assumptions or the MCLs.
- There have been no physical changes to the BLIP area except as an added measure of protection, a new protective concrete cap over the Linac-to-BLIP spur was constructed in late 2004, and the spur cap was further extended in several areas in 2015. The spur is where the beam line from the Linac is directed into the Linac-to-BLIP beam line, and is an area where beam losses have the potential to activate the surrounding soil shielding.

OU II Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

There is no additional information that calls into question the protectiveness of the remedy at BLIP.

7.3 Operable Unit III

OU III Question A: Is the remedy functioning as intended by the decision documents?

OU III Remedial Action Performance

- The OU III groundwater plumes are tracked and monitored via a comprehensive network of temporary and permanent monitoring wells on and off of the BNL property. Plume and system monitoring data, and system performance and recommendations for optimization are described in the annual *BNL Groundwater Status Reports.*
- The groundwater remediation program remains on track to reach the overall groundwater cleanup objectives as defined by the OU III ROD and modified by the OU III ESDs. These objectives are:
  - Meet MCLs for VOCs and tritium in the Upper Glacial aquifer by 2030.
  - Meet MCLs for Sr-90 at the former Chemical Holes plume and the BGRR/WCF plumes by 2040 and 2070, respectively.
  - Meet MCLs for VOCs in the Magothy aquifer by 2065.
- Remediation of the OU III plumes began in 1997. Fifteen of BNL's 18 groundwater treatment systems were implemented under OU III. Seven of these systems are currently in active operation. Five systems met the cleanup goals and were closed (Carbon Tetrachloride, Industrial Park East, HFBR Tritium Pump and Recharge, Building 452 Freon-11 and North Street) and two systems (Industrial Park and Chemical Holes Sr-90) are in standby mode and will be restarted if needed. The original North Street East VOC treatment system was administratively closed in 2020.
- The operational timeframes for several treatment systems have recently been extended to ensure capture of upgradient contamination. Four additional extraction wells were added to the Western South Boundary System in 2019 to address recently characterized deeper VOC contamination. Two extraction wells were added to the North Street East System and began operation in 2020 to address a recently characterized plume of EDB. With these modifications, these systems are on track to meet the cleanup objectives in the ROD.
- A detailed discussion of the progress of the OU III groundwater remediation is available in the *2020 BNL Groundwater Status Report* (BNL 2021g) (see **Attachment 2** for the USB drive or https://www.bnl.gov/gpg/gw-reports.php).
- DOE continues to offer free annual water testing to the one homeowner known to be using a private well for drinking water purposes in the OU III public water hookup area. The last time the homeowner accepted the annual test was in 2020. The test results indicate that the water quality complies with NYS drinking water standards.
- The additional extraction wells installed between 2012 and 2019 at the Middle Road, South Boundary, Western South Boundary, North Street East and Industrial Park systems are addressing the VOC/EDB contamination that is deeper than the extraction/recirculation wells originally installed in these areas. These wells are addressing contamination at or near the deep Upper Glacial/Magothy aquifer interface.

OU III System Operations/O&M

The operation of each of the treatment systems is evaluated in a number of ways: weekly during project status meetings, monthly during preparation of the NYSDEC SPDES discharge monitoring reports, quarterly during preparation of the quarterly operation reports, and annually during preparation of the Groundwater Status Report. These evaluations include review of the extraction well and system influent data, treatment system midpoint data, if appropriate, and the effluent data. The systems' O&M

manuals identify required preventative maintenance tasks. The systems are routinely inspected and are also being monitored remotely via a system which allows for the control panel information to be viewed from the Groundwater Protection Group office. There do not appear to be any issues that would impact continued operations or the effectiveness of the remedy. The BNL Preventive Maintenance Program helps to eliminate unnecessary system shutdowns due to routine wear and tear on equipment. Maintenance of remediation system recharge basins, such as periodic scraping to remove sediment buildup, is performed in accordance with the *Natural Resource Management Plan for Brookhaven National Laboratory* (BNL 2016f) to ensure protection of potential eastern tiger salamander habitats.

- Operational changes in system pumping during the previous five years as individual extraction wells neared or met the capture goal include the following:
    - Western South Boundary well WSB-2 was placed on stand-by in 2016. WSB-1 continues in full-time operation in addition to extraction wells WSB-3, WSB-4, WSB-5, and WSB-6 which began operation in 2019.
    - Building 452 Freon-11 Treatment System extraction well EW-18 was placed in standby in 2016 and operated briefly from November 2016 through March 2017 due to a rebound in concentrations. System closure was approved in November 2019.
    - Building 96 well RTW-1 remained operational during the previous five years. A larger pump and motor was installed in June 2019 to increase the capture zone of this well. The well was disconnected from the Building 96 Treatment System and re-routed to the nearby Building 452 Freon-11 System air stripper to handle the increased flow. Well RTW-2 operated from November 2018 until June 2020 when it was placed in standby. RTW-3 and RTW-4 remained in standby.
    - Middle Road well RW-1 was placed on standby in early 2016, as it had achieved the capture goal. RW-4, RW-5 and RW-6 were in standby. RW-2, RW-3, and RW-7 have been operational from 2016-2020 with minimal down time.
    - South Boundary wells EW-3, EW-5, EW-6, EW-7, EW-8, and EW-12 remained on standby mode. EW-4 has been operating in a pulsed pumping mode since October 2017. EW-17 has been in full-time operation.
    - Airport extraction wells RTW-1A, RTW-4A, and RW-6A were fully operational. RTW-2A and RTW-3A were in pulsed pumping mode until March 2020, when both were put on standby. RTW-5A was pulse pumping until placed on standby in September 2016 and LIPA extraction well EW-4L was operating full time until placed on standby in January 2017.
    - North Street wells NS-1 and NS-2 were on standby during this time frame, as the VOC system was shut down in 2016. The system was approved for closure in March 2020.
    - North Street East extraction wells NSE-1 and NSE-2 were approved for shutdown in 2014 and have remained in standby mode since that time. New EDB remediation extraction wells EW-3 and EW-4 began operation in July 2020.
    - BGRR extraction wells SR-1, SR-2, SR-3 and SR-9 were operating full time. SR-4 and SR-5 were placed in standby mode in October 2016, and SR-6 was placed in standby mode in October 2017. In October 2018, SR-7 was placed in standby mode and SR-8 was placed in pulsed pumping mode.
    - The Chemical Holes System was approved for shutdown in July 2018 and extraction wellsEW-1, ,EW-2, and EW-3 were placed in standby mode.

The VOC treatment systems mostly experienced only minor downtime or other operational issues over the past five years, and treatment system discharges have consistently met the NYSDEC SPDES discharge equivalency permit requirements. A summary of issues, successes, and lessons learned from the operation of the various treatment systems follows.

- The Middle Road, South Boundary and Western South Boundary treated effluent is distributed between the OU III basin and the RA V basin. This is accomplished through the use of a wet well adjacent to the air strippers and allows for the management of the amount of water that is discharged to each basin. This balancing of discharges, in combination with carefully coordinating water withdrawals from BNL's potable water supply wells, has been very successful in allowing for the maintenance of relatively steady groundwater flow directions on the BNL site and minimizing the potential shifting of plumes. Western potable supply well 7 provided the majority of the pumpage since 2019 due to low yield issues with well 4 and the detection of PFOS and PFOA in well 6. However, beginning in July 2020, pumpage from well 7 was significantly reduced. The eastern well field was responsible for the majority of the flow from July through December 2020. This was due to fouling of the western well 7 screen resulting in reduced yield. The well is being redeveloped and cleaned to help increase productivity.
- Resin usage for the Sr-90 treatment systems remains lower than originally estimated, resulting in lower operational costs. Due to the reduction in the number of extraction wells in full-time operation and the lower Sr-90 concentrations, the frequency of resin changeouts for the BGRR System has been reduced over the system's operational life from two to three times per year to annually.
- In 2015, a change was made to the method of disposal of the spent Sr-90 resin from the treatment systems which resulted in cost savings and waste minimization. Instead of disposing of the entire vessel that contains the spent resin as low-level radioactive waste, the resin is now vacuumed from the vessels and disposed of in 55-gallon drums. The vessels are then reused.
- Western South Boundary extraction well WSB-1 was off for most of the fourth quarter of 2018 as a result of the system modification work to add four new extraction wells.
- Lightning strikes in the vicinity of the treatment systems have caused occasional problems with the control systems. Systems are periodically disabled due to this issue. The programs for each system are backed up and spares of parts frequently impacted are stocked in order to mitigate system downtime. This is also a sitewide problem for other BNL utilities.
- Systems have been placed in standby several times over the period as a result of winter storms. During these events, the systems are placed in standby as a precautionary measure due to the fact that they become inaccessible for days to weeks.

OU III Costs of System Operations/O&M

- The O&M costs over the past five years for the OU III treatment systems are presented in **Table 4-1** in **Section 4.3**. The largest overall cost drivers for the systems are electricity, disposal or reuse of spent carbon and resins, and annual access payments to off-site property owners. It should be noted that the O&M costs in this document do not include costs for field engineering and project management or costs associated with sampling and analysis of the monitoring wells associated with each project.
- BNL continues to successfully minimize costs for many of the systems by shutting off extraction wells when influent concentration data and groundwater contamination levels at a given location are very low and meet the shutdown criteria. The extraction wells remain in standby mode and continue to be monitored. A few of the extraction wells were restarted due to rebound in VOC concentrations. A depiction of the current operating status of the individual extraction wells is provided on **Figure 4-1**.
- Due to the extensive use of activated carbon for the treatment of VOCs, a large-scale carbon services contract was awarded based on competitive bidding. The contractor performing this work regenerates the carbon in batches and returns the cleaned carbon back to that specific project the next time a carbon replacement is needed.

- Access agreements were negotiated with private property owners to allow the operation of treatment systems on their property. In consideration for access for the North Street East system, payments of $85K per year are made to the property owners for as long as the treatment system is on their property. Although access agreements are also in place for the other off-site treatment systems (Industrial Park, North Street, Airport and LIPA), no lease fees are required because they are either constructed on publicly owned property or along public right-of-ways, or the property owner did not request compensation for the use of the property.

OU III Implementation of Institutional Controls and Other Measures

Institutional controls are in place at BNL to ensure the effectiveness of all groundwater remedies. The OU III groundwater LUICs continue to be maintained and are effective in protecting human health and the environment. During the past five years, there have been no activities at any of the OU III areas that would have violated these institutional controls.

The LUICs that are in place and maintained for OU III include:

- Monitoring groundwater quality in the vicinity of each treatment system to evaluate the system's performance and to detect any change in conditions that might result in the system not meeting its stated objective or that might allow a plume to threaten a water supply source. The details of this monitoring program are described in the *BNL Environmental Monitoring Plan* (BNL 2021a).
- An extensive groundwater monitoring program to track contaminant plumes and reporting of the data.
- Monitoring of BNL potable supply system and Suffolk County Water Authority (SCWA) monitoring of the SCWA's water supply wells closest to BNL.
- Continual assessment of remediation progress by project managers and reported annually in the Groundwater Status Report.
- Performing five-year reviews in accordance with CERCLA until cleanup goals are met. These reviewshelp determine the effectiveness of the groundwater remediation program.
- Controls placed on the installation of new supply wells and recharge basins on BNL property.
- Offering public water service in plume areas south of BNL.
- BNL maintaining an internal Water and Sanitary Planning Team to coordinate operational activities on the BNL site that may impact groundwater flow directions and possible plume migration pathways. The committee also tracks and evaluates changes in groundwater management activities off of the BNL site (i.e. water withdrawals and recharge operations) to determine if they could affect BNL groundwater remedies.
- Property access agreements for treatment systems off of BNL property are in place and the requirements are being met. BNL is currently working to renew an expired agreement and execute a new agreement with another property owner.
- Protecting the treatment systems installed off of the BNL site. These systems are fenced, and have locked and alarmed buildings. No significant security violations have occurred.

OU III Monitoring Activities

- Monitoring data for the treatment systems and associated groundwater monitoring wells are used to evaluate the performance and effectiveness of the remediation activities. These data are reported in the annual BNL Groundwater Status Report.
- Proposed changes to the groundwater monitoring program are presented each year in the annual BNL Groundwater Status Report and are implemented following regulatory approval. Changes to several of the OU III plume monitoring networks were recommended in the *2020 BNL Groundwater Status Report* (BNL 2021g). Typically, these modifications include the installation of additional permanent and temporary monitoring wells, changes in sampling frequency for wells, and changes in analytical procedures. Decommissioning of monitoring wells will be evaluated once the characterization of PFAS and 1,4-dioxane plumes are complete. Proposed changes are designed to improve contaminant plume tracking and obtain the information required to assess remediation

progress. **Tables 6-3 and 6-4** summarize the permanent monitoring and extraction wells installed and decommissioned over the last five years.

OU III Early Indicators of Potential Issues

- In 2010, groundwater modeling results suggested that following the removal of the PCE-contaminated soil from the Building 96 source area, the treatment system should achieve the capture goal of 50 µg/L TVOCs in three to six years (by 2016). The expected system shutdown is now 2023. The most likely cause for the increased remedial pumping duration is the slower than anticipated release of residual amounts of PCE beneath the excavated source area to groundwater. Additional sources of VOCs in the area appear unlikely due to results of extensive soil-gas surveys and soil sampling conducted in the area in 2008 and 2015. In 2016, the capture goal was exceeded in ten monitoring wells, with a maximum TVOC concentration of 200 µg/L. In 2020, the capture goal was exceeded in two wells with a maximum TVOC concentration of 98 µg/L. Monitoring well 085-379 is located at the southern edge of the excavated source area. The October 2020 TVOC concentration in this well was 38 µg/L, which is below the system capture goal of 50 µg/L, and the lowest value observed since the well was installed in 2010 following the source area cleanup. A concentration of 59 µg/L was observed in this well in the subsequent January 2021 sampling round. Although TVOC concentrations declined dramatically in the two years following the 2010 source area soil excavation from over 2,400 µg/L to 90 µg/L, the rate of decline leveled off in the subsequent eight years. The persistence of TVOC concentrations above 50 µg/L requires the continued operation of extraction well RTW-1 and could jeopardize achieving the 2030 cleanup goal.
- While the existing data from the Industrial Park plume monitoring program suggest that the system is on track to achieve the 2030 cleanup goal, there is some uncertainty to achieving this goal due to higher than expected contaminant concentrations in several upgradient monitoring wells (e.g., 000-541, 000-529, and 000-548). Although the installation of additional monitoring wells in these upgradient areas would be beneficial to more fully characterize this contamination, there is limited access in these areas due to the presence of buildings, utilities and other structures. Continued groundwater monitoring and tracking contaminant trends in existing monitoring wells and extraction wells IP-EW-8 and IP-EW-9 will continue.
- Airport extraction well RW-6A continues full-time operation. The nearest upgradient monitoring well, 800-94 (1,500 feet to the north), continues to show a very slow rate of decline in TVOC concentrations. Because there are a limited number of upgradient wells due to access constraints, there is uncertainty as to the extent of the higher contaminant concentrations in this area. Given these access constraints, continued monitoring is required until a clear decline in VOC concentrations is observed.
- Several of the Sr-90 plumes on the site have similar issues:
    - Monitoring downgradient of the BGRR building has shown a correlation between the water-table elevation fluctuations and the release of residual Sr-90 in the deep vadose zone. The fluctuations are not controlled or caused by on-site activities; rather, they are the result of natural fluctuations in the elevation of the water table due to seasonal variations in precipitation and subsequent recharge of the aquifer. The persistence of this residual Sr-90 source, which was not accounted for in the groundwater modeling projections, required extraction well SR-3 to operate longer than originally planned. The operation of this well may be required following periods of high water-table elevation as Sr-90 is released to groundwater. Following periods of lower water-table elevations, this well can be placed in standby mode when Sr-90 concentrations decrease in monitoring wells 075-701 and 075-664 and extraction well SR-3.
    - Periodic increases in Sr-90 concentrations at the former WCF present a similar issue to that discussed above for the BGRR. These extraction wells are also operating longer than originally planned. To help optimize the groundwater cleanup at this area, WCF Buildings

810 and 811 along with contaminated soil were removed between 2015 and 2017, thereby reducing the levels of residual Sr-90 that could be leached to the groundwater. However, the buildings and other paved areas served to cap underlying residual Sr-90 in soil; therefore, as expected, Sr-90 concentrations increased in groundwater following the decommissioning activities. This is similar to increases that were observed in OU I at the former HWMF source area following remedial actions. The operation of extraction wells SR-1 and SR-2 will capture and contain the Sr-90 released to groundwater.

- Sr-90 concentrations increased in several wells located in the area just south of the former Pile Fan Sump and Building 801, most notably in monitoring well 065-325 at a concentration of 186 pCi/L in January 2020, which is an historical high concentration for this well. Monitoring well 065-325 is located immediately downgradient of Building 801 and immediately upgradient of the former Pile Fan Sump and is screened across the water table. This well was installed in 2002 in response to a 2001 stormwater flood of the Building 801 basement. The water became contaminated with Sr-90 after coming into contact with contaminated sections of the basement floor and waste storage apparatus. Some of this water leached out of the basement and into the surrounding soils. Underground piping and Sr-90 contaminated soils related to the former Pile Fan Sump were removed back in 2000 as part of a BGRR removal action. Downgradient monitoring wells have exhibited Sr-90 concentrations less than 50 pCi/L, although monitoring well 065-405, located approximately 40 feet south of Building 801, has shown a gradual increase in Sr-90 concentrations since 2018. The attenuation mechanisms are due to dilution and the relatively short half-life for Sr-90, which is 28.8 years. At the observed concentrations, the Sr-90 is expected to attenuate to below the 8 pCi/L MCL within several hundred feet of the source area. Groundwater monitoring will continue and any significant increase from current concentrations will be evaluated.

- Although the operational period of several of the treatment systems has been extended compared to the original operational periods defined at the time the systems were designed, it is expected that the overall groundwater cleanup objectives will be met.
- There do not appear to be any problems or issues at this time that could place protectiveness of the remaining remedies at risk.

OU III Opportunities for Optimization

Optimization of several of the OU III groundwater treatment systems is planned, with some of these activities already implemented. The status of each groundwater treatment system and the operational status of the extraction wells are provided on **Figure 4-1**. The changes made or planned were based on an evaluation of treatment system and monitoring well contaminant concentration trends. Optimization activities and opportunities include:

- Additional groundwater extraction wells were installed from 2018 through 2020 to address the deep VOC contamination associated with the Western South Boundary plume and EDB in the North Street East area. These modifications will help ensure that the cleanup objectives for the Upper Glacial and Magothy aquifers will be met.
- As noted in **Section 6.4.3**, many of the treatment system extraction wells have been in pulsed pumping mode (e.g., on one month, off the next) due to a reduction in contaminant concentrations, or have been shut down. In several cases, entire systems have been shut down following regulatory approval. The systems and monitoring wells continue to be monitored to evaluate if any rebound in contamination is occurring. In some cases, systems have been turned back on temporarily to address this situation. **Table 6-1** provides the operational status of each treatment system.
- The current operations of the Building 96 Treatment System combined with the 2010 source area excavation have resulted in a dramatic reduction in both groundwater contaminant concentrations and the overall areal extent of groundwater contamination. However, the rate of groundwater contaminant concentration decrease at source area well 085-379 and current concentrations warrant

the continued operation of extraction well RTW-1 and could indicate that this area may not achieve the cleanup goal for PCE of 5 µg/L by 2030. In addition to closely monitoring VOC trends in well 085-379, an active remediation technology should be considered to reduce concentrations near source area monitoring well 085-379. Liquid carbon injection and zero valent iron technology should be evaluated to capture dissolved residual source area compounds and treat them in-situ. Because the treatment area is relatively small and not very deep, this technology is cost effective compared to other source area treatment approaches. The approach is not expected to negatively impact groundwater geochemistry or the operation of the groundwater treatment system. Interbedded silts and clays that extend into the saturated zone may make the injections more difficult to distribute evenly but should not prevent the necessary distribution to achieve the cleanup goals.

- Groundwater contaminant concentrations and areal extent of the OU III plume have decreased significantly due to the operation of the Middle Road Treatment System. However, several monitoring wells are not declining at a rate that will definitively achieve the cleanup goal of 5 µg/L for PCE by 2030. These monitoring wells include 104-37, 105-68, and 105-66 (**Figure 6-5**). In order to accelerate the rate of decline of VOC concentrations, additional extraction wells will be required to increase the rate of removal of contaminated groundwater. For example, an additional extraction well downgradient of monitoring well 104-37 and an additional extraction well immediately upgradient of 105-68 may be sufficient to achieve cleanup goals by 2030. Additional data, consisting of one or two vertical profile borings (VPBs) to confirm distribution of VOC concentrations in the area of the potential additional extraction well(s) location, would be helpful. Groundwater modeling would be used to help determine the best location, extraction rates, and number of extraction wells to optimize the system.
- The OU III VOC plume between the Middle Road and South Boundary systems is progressing much like the area immediately north, and discussed above. Monitoring wells along the fringe of the plumes and near the extraction wells are on track to achieve cleanup goals by the 2030. The TVOC concentrations in monitoring well 121-45 along the eastern edge of the plume has decreased from 500 µg/L in 2006 to less than the system capture goal of 50 µg/L (**Figure 6-5**). Monitoring well 121-49 near the extraction wells for the South Boundary Treatment System has had contaminant concentrations decrease from 1,265 µg/L TVOCs in November 2011 to less than 100 µg/L in 2019. However, similar to the Middle Road Treatment System, a monitoring well (121-54) located approximately halfway between the Middle Road and South Boundary Treatment System has VOC concentrations that are not decreasing at a rate that will likely achieve cleanup goals by 2030. In order to accelerate the rate of VOC removal, an additional extraction well will be necessary. For example, an additional extraction well near monitoring well 121-54 may be sufficient to achieve cleanup goals by 2030. Groundwater modeling would be used to help determine the best location, extraction rate(s), and number of extraction wells to optimize the system. A pre-design investigation consisting of one or two vertical profile borings is needed to confirm distribution of VOC concentrations.
- Optimization of the groundwater monitoring program is performed on an annual basis. Adjustments to sampling frequencies are performed based on a review of the plume data and the data quality objectives. For example, the HFBR tritium plume monitoring program has seen a reduction in the number of permanent wells needed to monitor the plume, from 103 wells in 2011 to 10 wells in 2019. Four new wells were added to the OU IV Sr-90 monitoring program in 2020 to increase monitoring downgradient of the recently decommissioned Building 650 and to account for a shift in the Building 650 Sump Outfall Sr-90 plume. Additional modifications to groundwater monitoring programs are discussed elsewhere in this report.

OU III Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid?

OU III Changes in Standards and TBCs

- The standards or TBCs identified in the OU III ROD have not changed, nor do they call into question the protectiveness of the remedy.
- Guidance for radioactively contaminated soils has been issued in 2013 (NYS) but the dose limit of 10 mRem/year above background that was used to set BNL cleanup levels has not changed.
- EPA's third Six-Year Review of the drinking water standards was completed in January 2017. EPA determined that National Primary Drinking Water Regulations for eight compounds are candidates for regulatory revision; however, they are not OU III COCs.
- **Attachment 5** provides a review of any changes to the soil cleanup and drinking water standards and **Attachment 6** provides the cleanup levels for the OU III primary contaminants of concern (COCs). The PCB soil cleanup levels and MCLs for OU III groundwater COCs have remained the same since 1999.
- The issuance of the 2020 MCLs for PFOS, PFOA and 1,4-dioxane will require characterization of the presence of these compounds in OU III groundwater. Data collected to date and future remedial investigation and/or remedial actions will be incorporated under OU VIII, and are summarized in **Section 6.4.7**.

OU III Changes in Exposure Pathways, Toxicity and Other Contaminant Characteristics, and Risk Assessment Methods

- There have been no changes in the physical conditions within OU III or in the use of the site that would reduce the protectiveness of the remedies or render the initial risk analysis invalid. Also, the exposure assumptions have not changed since the ROD was signed in 2000.
- In general, the changes in standard default exposure parameters from the EPA's memorandum *Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors, OSWER Directive 9200.1-120 issued on February 6, 2014* (EPA 2014b) served to raise risk-based concentrations. In most cases the mix of higher and lower individual parameters, such as ingestion rates, body weights and exposure durations, result in higher risk-based concentrations.
- Federal Guidance Report 15, entitled *External Exposure to Radionuclides in Air, Water and Soil* (EPA 2019b), updated and expanded the 1993 Federal Guidance Report No. 12 to include age-specific reference person effective dose rate coefficients based on external exposure. The changes include updated tissue weighting factors and radionuclide decay data. While this change does not affect MCLs, risk-based levels and risk assessment for external exposure may be affected.
- The number of homes that continue to use their private well as their sole source of drinking water was reduced over the last five years from three to one within the OU III area. DOE continues to offer free annual water testing to this homeowner.
- Following regulatory approval, the hexavalent chromium ion exchange treatment system at Building 96 was decommissioned in 2018.
- A preliminary initial soil vapor screening of the OU III VOC groundwater plumes and the potential impact to newly planned buildings was documented in the 2011 *Five-Year Review Report* (2011a). Since a clean layer of groundwater exists above these plumes, the subsurface to indoor air pathway is incomplete and no further evaluation was needed at that time. Since 2011, no additional buildings were constructed at BNL that weren't previously evaluated. As part of the 2021 Five-Year Review, the EPA *OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway From Subsurface Vapor Sources to Indoor Air*, dated June 2015 (EPA 2015), was reviewed. The closest OU III VOC plume to an on-site building is the northern-most portion of the Western South Boundary. Building 423, the government service station, is located approximately 475 feet from the plume. COCs in this portion of the plume do not exceed MCLs; however, trichloroethene (TCE) does exceed EPA's VISL. Due to the significant buffer distance laterally and

vertically (>100 feet) from the plume to Building 423, there are no preferential vapor intrusion pathways. Consequently, the subsurface vapor to indoor air pathway is incomplete.

- An upcoming construction project that BNL has been envisioning for the last few years is a Federal land-use project to create a science and technology gateway zone. This *Discovery Park* would be located outside the main security area to foster complimentary community and economic impact. The proposed site, the previously developed 40-acre apartment area, is contiguous to the research core of BNL and adjacent to the main entrance and William Floyd Parkway. The project would include offices, housing, and technical space. A traffic circle to access the planned facilities became operational in early 2020. The Science and User Support Center (SUSC) is the first building being designed for Discovery Park with construction potentially beginning in the fall of 2021. The closest VOC plume is the Western South Boundary, which is approximately 2,000 feet to the east. Due to the distance laterally and vertically from the plume, the subsurface vapor to indoor air pathway is incomplete. In the event that further construction is planned at BNL within the area of the OU III VOC groundwater plumes, BNL will reevaluate any potential exposure issues and, if necessary, undertake appropriate measures to address them. Any construction projects to be undertaken at BNL are reviewed for environmental, security, and safety and health concerns in the conceptual design or early planning phase. BNL procedure *EP-ES&H-500, Project Environmental, Security, Safety and Health Review,* includes an *ES&H 500A Evaluation Form* that requires any potential issues, such as potential soil-vapor intrusion, be identified, documented, and mitigated, if necessary. In addition, the *BNL Land Use Controls Management Plan* and the LUIC groundwater plume fact sheets will be revised to reflect the potential for soil-vapor intrusion should new buildings be proposed.

OU III Expected Progress in Meeting RAOs

- There are currently seven groundwater remediation systems in operation under OU III. Although there are some potential concerns identified above, the systems are on track for meeting the ROD and ESDs cleanup goal of reaching MCLs in the aquifer and preventing or minimizing plume growth. The *2020 BNL Groundwater Status Report* (BNL 2021g) evaluates each system's performance based on decision rules identified from the BNL groundwater DQO process (see *BNL Environmental Monitoring Plan* [BNL 2021a] for discussions of the DQO process).
- **Figure 7-1** provides a graphical representation of the status of the planned operational timeline of each treatment system. Although the original planned operational period of several systems has been extended, they are still on track to meet their overall groundwater cleanup goals. Of the 14 treatment systems in OU III, five have met their goals and were closed, and two were shut down and are currently in standby mode.
- The Building 452 Freon-11 groundwater treatment system has successfully remediated the high Freon-11 concentrations to below the capture goal and was approved for closure by the regulatory agencies in August 2019. Current Freon-11 concentrations are near or below the MCL. This is consistent with the original projections identified in the 2012 ESD. The air stripping system has been repurposed for treating water from Building 96 extraction well RTW-1. The remaining system infrastructure will not be decommissioned until it is determined that components aren't needed for PFAS or 1,4-dioxane monitoring or remediation.
- The Western South Boundary System was modified to incorporate four new extraction wells to remediate deeper VOC contamination. It is anticipated that this modification will allow for groundwater cleanup goals to be achieved by 2030. Groundwater monitoring upgradient of original system extraction well WSB-1 indicates that VOC concentrations are steadily declining in this area and once the capture goal is met, this well can be placed on standby. Extraction well WSB-2 was placed in standby in 2016.
- The North Street East System was modified to include two new extraction wells to address recently characterized EDB contamination. These wells began operation in 2020, and the treatment system is expected to achieve its cleanup goals by 2030.

- Significant VOC cleanup progress has been accomplished in the Middle Road and South Boundary areas. Despite this progress, additional extraction wells may be required to ensure that the system's cleanup goals are achieved by 2030.
- BNL will remain alert to any new Sr-90 remediation techniques and technologies, as well as any operational efficiency that might accomplish cleanup sooner.
- The property access agreements for the groundwater treatment systems off of BNL property need to be recorded with the County Clerk.
- There are no known issues with any of the institutional controls that could jeopardize their future operation.

OU III Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

No additional information has come to light that calls into question the protectiveness of the OU III remedies. No newly identified ecological risks or impacts from natural disasters have been found within OU III.

7.4 Operable Unit IV

OU IV Question A: Is the remedy functioning as intended by the decision documents?

Although the OU IV ROD states that a Five-Year Review of this remedial action is not necessary, the following items are provided as a summary.

- The OU IV remedial action objectives have been satisfied. The soil/groundwater treatment AS/SVE system met its cleanup objectives and the regulators approved its dismantlement in 2003. A fence was installed as an interim measure around the Building 650 Sump Outfall in 1995 prior to excavation of the soil. The excavation of the radiologically contaminated soil in the Building 650 Sump, along with the discharge pipe and Sump Outfall, was included under the OU I ROD and was completed in 2002.
- From the fall of 2020 through the winter of 2021, Building 650 was decontaminated and dismantled. An as-left radiological survey of the building footprint and surrounding worksite will be performed. This demolition was not included in the scope of the original OU IV remedial action; however, the regulators were kept informed of progress during monthly IAG teleconferences.
- The remediation has achieved the objectives of preventing or minimizing the leaching of contaminants from the soil into the groundwater, human exposure (including ingestion, inhalation, and dermal contact), and the uptake of contaminants present in the soil and groundwater by plants and animals.
- BNL continues to monitor for VOCs in groundwater at select wells downgradient of the former AS/SVE system, as well as monitoring for Sr-90 at the Building 650 Sump and Sump Outfall per the *BNL Environmental Monitoring Plan* (BNL 2021a). In 2020, the installation of three temporary and two new monitoring wells enhanced monitoring of the plume core area, which has been subject to shifting groundwater flow conditions resulting from changes in nearby groundwater recharge. Sr-90 continues to attenuate as predicted as it migrates slowly to the south. Groundwater monitoring results are reported in the 2020 *BNL Groundwater Status Report* (BNL 2021g). Two new monitoring wells were also installed immediately downgradient of former Building 650 to assist in the monitoring of any impacts to groundwater from the building demolition.
- The AS/SVE-remediated area is classified for unrestricted industrial use.

OU IV Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of remedy selection still valid?

- The standards or TBCs identified in the OU IV ROD have not changed, nor do they call into question the protectiveness of the remedy. The radiological soil cleanup levels and the MCLs for COCs in drinking water have remained the same since 1999. **Attachment 6** provides the cleanup levels for the OU IV primary COCs.
- EPA determined that National Primary Drinking Water Regulations for eight compounds are candidates for regulatory revision; however, they are not COCs in OU IV.
- The remedial action objectives have been met and have not changed.
- The soil cleanup levels for radionuclides are based on 15 mRem/yr above background. As stated in the *EPA memorandum on Radiation Risk Assessment at CERCLA Sites: Q&A* (EPA 2014a), the Superfund recommendation is now 12 mRem/yr as the dose-based level protective of a target cancer risk of $1x10^{-4}$. This could have a minor effect on risk-based levels of radionuclides in soil. It should be noted that the soil cleanups performed to date have also met the NYSDEC guidance of 10 mRem/yr above background (ALARA goal).
- Lead, a contaminant of concern in soil, has a cleanup level of 400 mg/kg, which is the EPA Regional Screening Level for residential soil and the New York State soil cleanup objective for residential and restricted residential use, and commercial or industrial use. This cleanup level is protective of residential exposure to lead in soil based on a target blood lead level of 10 µg/dL in children. There has been renewed discussion within EPA on the possibility of revising the target blood lead level for CERCLA. If EPA revises the value to less than 10 µg/dL, then the 400 mg/kg cleanup level for lead in soil would require review in future Five-Year Reviews for continued protectiveness.
- Federal Guidance Report 15, entitled *External Exposure to Radionuclides in Air, Water and Soil* (EPA 2019b), updated and expanded the 1993 Federal Guidance Report No. 12 to include age-specific reference person effective dose-rate coefficients based on external exposure. The changes include updated tissue weighting factors and radionuclide decay data. While this change does not affect MCLs, risk-based levels and risk assessment for external exposure may be affected.
- The groundwater within OU IV is not contaminated with VOCs; therefore, subsurface vapor intrusion is not an issue.
- Changes in toxicity values since the 2016 Five-Year Review include the trimethylbenzenes, benzo(a)pyrene, and polycyclic aromatic hydrocarbons. While these changes in toxicity values do not have bearing on the New York State Soil Cleanup Objectives developed in 2010 or maximum contaminant levels, which are not necessarily risk based, they are changes from what was estimated at the time of the ROD.

OU IV Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

No additional information calls into question the protectiveness of the remedy at OU IV.

7.5 Operable Unit V

OU V Question A: Is the remedy functioning as intended by the decision documents?

OU V Remedial Action Performance

- VOC concentrations were below MCLs as of 2013 and tritium concentrations remain less than the 20,000 pCi/L MCL. As a result, all groundwater monitoring requirements for OU V have been met.
- In 2017, supplemental sediment remediation of PR-WC-06 was completed.
- The Peconic River remedy performed as intended:

- As stated in the Peconic River ROD, the long-term monitoring program will continue to evaluate all available data to determine if additional remediation is required to ensure the protection of human health and the environment. Based on regulatory concurrence with the Peconic River sediment removal closeout reports, the most recent being Area PR-WC-06 in 2018, no additional sediment sampling is required.
- As described in the 2016 *Five-Year Review Report*, no additional surface-water monitoring is required.
- The 2004/2005 and 2011 Peconic River cleanup of mercury in the sediment has led to substantially reduced mercury concentrations in fish. The cleanup goal in the Peconic River ROD after remediation is limited to mercury in sediment, and no "acceptable level" in fish was identified. The annual fish monitoring results from 2006 through 2015 show a substantial reduction in post-cleanup fish tissue average mercury concentrations relative to pre-cleanup (1997 and 2001) average concentrations. Reduced mercury concentrations mitigate potential health impacts for human and wildlife consumers of fish.
- In addition to the ROD-related environmental cleanups of the BNL STP soils and the Peconic River on-site and off-site sediment, remediation of the STP digester sludge and sand filter beds were completed in 2009.
- To help further improve Peconic River water quality, beginning in September 2014 the treated STP effluent is now recharged directly to groundwater rather than continuing to discharge into the Peconic River.

OU V System Operations/O&M

As required by the OU V Peconic River ROD, a long-term monitoring program was implemented to ensure protection of human health and the environment. This monitoring program, conducted from 2006 through 2010, included: mercury, PCBs and cesium-137 in sediment; total mercury and methyl mercury in the water column; and mercury, PCBs and cesium-137 in fish on and off of BNL property, as appropriate. The sediment, surface-water and fish monitoring results for each year since completion of the 2004/2005 cleanup (i.e. 2006-2011) are available in the annual *Peconic River Monitoring Reports* (BNL 2007f, 2008a, 2009e, 2010f, 2011h and 2012g). Beginning in 2012, the monitoring results are summarized in the annual *BNL Site Environmental Report* which can be found at https://www.bnl.gov/esh/env/ser/. As noted in **Section 6.4.5** above, further post-cleanup sediment, surface-water and fish monitoring of the Peconic River was discontinued in 2015.

OU V Costs of System Operations/O&M (Not applicable for this project.)

OU V Implementation of Institutional Controls and Other Measures

Institutional controls are in place at BNL to ensure the effectiveness of all remedies. The OU V land use and institutional controls continue to be maintained and effective in protecting human health and the environment. During the past five years, there have been no activities at any of the OU V areas that would have violated these institutional controls.

The land use and institutional controls that are in place and maintained for OU V include:

- The New York State general advisory on the consumption of freshwater fish caught from New York freshwaters applies to the Peconic River. The advisory is to eat no more than one meal (1/2 pound) of fish per week.
- The DOE does not envision any sale or transfer of property in the Peconic River area. If it were to occur, the sale or transfer would meet the requirements of Section 120 (h) of CERCLA to ensure that future users are not exposed to unacceptable levels of contamination.
- In accordance with CERCLA, five-year reviews are performed until cleanup goals are met and to determine the effectiveness of the groundwater monitoring program and sediment remediation. Following the 2017 supplemental sediment cleanup of Area PR-WC-06, sediment cleanup goals for the Peconic River have been met.

- Controls have been placed on the installation of new supply wells and recharge basins on BNL property.
- NYSDEC regulates all work within 100 feet of wetlands with confirmed protected species habitats. Any work activities within 100 feet of a wetland requires DOE and NYSDEC notification and approval.
- BNL limits activities within 850 feet of wetlands with confirmed protected species habitats.

OU V Monitoring Activities

- Twenty-seven confirmatory soil samples were collected following the sediment excavation of PR-WC-06 in 2017. The average mercury concentration for the 27 samples was less than 1 mg/kg (0.06 mg/kg), with no individual samples exceeding the 2 mg/kg cleanup goal.
- As recommended in the 2016 *Five-Year Review Report* and following the successful 2017 supplemental sediment cleanup of Area PR-WC-06, no further Peconic River post-cleanup sediment, surface-water or fish monitoring was performed.
- In January 2021, NYSDEC concurred that the wetland monitoring and maintenance performed by BNL from 2017 through 2019 at Area PR-WC-06 satisfied the conditions in the equivalency permit, and no further monitoring was needed. The details of the monitoring efforts are presented in the *2019 Peconic Wetland Monitoring Final Report – Area PR-WC-06* (BNL 2019e). BNL will continue to monitor the vegetation and control the invasive species as necessary (not to exceed 10 percent of cover) an additional three years (through September 2022), to meet the federal duration requirements.
- All groundwater monitoring requirements were met in 2014, and no further sampling is needed.

OU V Early Indicators of Potential Issues

- None.

OU V Opportunities for Monitoring Optimization

- An optimization to the Peconic River remedy was performed in 2017 with supplemental sediment removal in Area PR-WC-06. Post-excavation sediment samples indicated that the cleanup met the goals in the ROD.
- In accordance with the 2016 Five-Year Review monitoring recommendations and following the successful supplemental sediment cleanup of Area PR-WC-06, the regulators agreed that no additional Peconic River sediment or surface-water sampling is needed.
- In response to a NYSDEC request, BNL recommends sampling of fish for mercury and PCBs in on-site portions of the Peconic River as part of the site environmental surveillance monitoring program. This will include:
  - Human Health: Filets analyzed for radionuclides, mercury, and PCBs
  - Ecological: Small whole fish for mercury and PCBs
- Fish sampling would be limited to times, as determined by BNL, when river conditions allow adequate size, number, and fish mobility to ensure results accurately represent risk levels to human health and the environment.
- Details of the sampling plan will be documented in an updated Peconic River Fish Surveillance Monitoring Data Quality Objective.

OU V Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid?

OU V Changes in Standards and TBCs

- The standards or TBCs identified in the OU V ROD have not changed, nor do they call into question the protectiveness of the remedy. The mercury sediment cleanup level and the MCLs for drinking water have remained the same since 1999. An Interim Drinking Water Health Advisory

for perchlorate of 15 µg/L was established by EPA in 2008. However, in July 2020 EPA published a final action regarding the regulation of perchlorate under the Safe Drinking Water Act (SDWA). The EPA determined that perchlorate does not meet the criteria for regulation as a drinking water contaminant under the SDWA, withdrew the 2011 regulatory determination, and is making a final determination to not issue a national regulation for perchlorate at this time. The NYSDOH Action Level for perchlorate is 18 µg/L in drinking water supply wells. **Attachment 5** provides a review of the applicable standards and **Attachment 6** provides the cleanup levels for the OU V primary contaminants of concern.

- The August 2020 issuance of NYS MCLs for PFOS, PFOA and 1,4-dioxane will require characterization of the presence of these compounds in OU V groundwater. Data collected to date and future remedial investigation and/or remedial actions will be incorporated under OU VIII and are summarized in **Section 6.4.7**.
- The soil cleanup levels for radionuclides are based on 15 mRem/yr above background. As stated in the *EPA memorandum on Radiation Risk Assessment at CERCLA Sites: Q&A* (EPA 2014a), the Superfund recommendation is now 12 mRem/yr as the dose-based level protective of a target cancer risk of $1x10^{-4}$. This could have a minor effect on risk-based levels of radionuclides in soil. It should be noted that the soil cleanups performed to date have also met the NYSDEC guidance of 10 mRem/yr above background (ALARA goal).

OU V Changes in Exposure Pathways, Toxicity and Other Contaminant Characteristics, and Risk Assessment Methods

- There have been no changes in the physical conditions within OU V or in the use of the STP, the Peconic River, or the groundwater that would reduce the protectiveness of the remedies or render the initial risk analysis invalid. The exposure assumptions used in the original risk assessment are consistent with current land use.
- The diversion of the STP effluent from the Peconic River to a nearby groundwater recharge basin in September 2014 has resulted in a significant change in the extent of wet stream-bed and open water in the on-site portions of the Peconic River. This in turn affects the potential availability of fish sampling on site. This change also eliminated continued discharges of low levels of metals (such as mercury) to the river. The on-site portion of the Peconic River is still considered a stream, regardless of the intermittent flow patterns.
- DOE continues to offer free annual water testing to the one homeowner known to be using a private well for drinking water purposes in the OU V public water hookup area. The last time the homeowner accepted the annual test was in January 2021. To date, all test results indicate that the water quality complies with NYS drinking water standards.
- PFAS and 1,4-dioxane were recently detected in groundwater within the OU V area. These contaminants will be evaluated under OU VIII.
- The toxicity values for PCBs and methyl mercury are currently being reassessed under Integrated Risk Information System (IRIS) as part of Step 1 of the process (which includes a comprehensive search and systematic review of the scientific literature).

OU V Expected Progress in Meeting RAOs

- Excavation of the radiologically and metal-contaminated sediment at the STP and in the Peconic River on and off of BNL property met the appropriate cleanup levels and remedial action objectives specified in the OU V STP and Peconic River RODs. A monitoring program was implemented to demonstrate the effectiveness of the Peconic River cleanup to mitigate potential ecological effects.
- Based on 10 years of post-cleanup, long-term monitoring, the Peconic River remedy remains protective of human health and the environment. Supplemental remediation, followed by post-excavation confirmatory sampling in one small area was completed in 2017. As a result, further post-cleanup monitoring of the Peconic River under the ROD has been discontinued.

- Groundwater monitoring in OU V has demonstrated that MCLs for VOCs were met in 2013 and no further monitoring was needed. The need to monitor OU V groundwater for PFAS and 1,4-dioxane will be determined under OU VIII.

OU V Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

No newly identified ecological risks or impacts from natural disasters have been found within OU V. No additional information has come to light that calls into question the protectiveness of the OU V remedies.

7.6 Operable Unit VI

OU VI Question A: Is the remedy functioning as intended by the decision documents?

OU VI Remedial Action Performance

- The trailing edge of the OU VI EDB groundwater plume migrated off-site in 2009 and continues to be monitored via a network of monitoring wells off of BNL property.
- The EDB groundwater treatment system was installed in accordance with the OU VI ROD, and began operating in August 2004. EDB is being captured by the extraction wells, and the hydraulic capture performance of the system is being met as described in the *2020 BNL Groundwater Status Report* (BNL 2021g). Recent data obtained indicate the presence of EDB at greater depths in the Upper Glacial aquifer than previously observed. DOE continues to offer free annual water testing to the two remaining known homeowners still using private wells for drinking water purposes in the OU VI public water hookup area. The results for all samples have shown compliance with the NYS drinking water standards.

OU VI System Operations/O&M

- The system O&M manual identifies required preventative maintenance tasks. There do not appear to be any issues that would impact continued operations or the effectiveness of the remedy. The BNL Preventive Maintenance Program helps to eliminate unnecessary system shutdowns due to routine wear and tear on equipment. During 2019, the system was off approximately 20% of the time due to diffusion well development and various maintenance-related issues. During 2020, EW-1E was off for the month of January to replace the pump and motor. The system was down again for approximately two months for replacement of the electric control panel.
- The treatment system operation is evaluated monthly during preparation of the discharge monitoring reports, quarterly during preparation of the quarterly operation reports, and annually in the BNL Groundwater Status Reports. These evaluations include review of the extraction well and system influent data, treatment system midpoint data, and the effluent data.

OU VI Costs of System Operations/O&M

- The system has been operational for 16 years and the average annual O&M cost is approximately $235K. The largest overall cost drivers for the system are annual property access payments, carbon change-outs, and electricity.
- Since the OU VI ROD was signed in 2001, two access agreements were negotiated with private property owners to allow for treatment system operations on their property. In consideration for the agreements, total payments of $85K per year are made to the property owners as long as the treatment system is on their property.

OU VI Implementation of Institutional Controls and Other Measures

The OU VI groundwater land use and institutional controls continue to be maintained and effective in protecting human health and the environment. Based on inspections, no activities were observed at OU VI that would have violated these institutional controls.

OU VI Monitoring Activities

- The monitoring data obtained from the EDB treatment system and the plume monitoring wells provide the basis to evaluate the remediation system's performance and effectiveness.
- Several temporary and permanent monitoring wells have been incorporated into the OU VI plume monitoring network over the past five years, as recommended in the annual BNL Groundwater Status Reports. These modifications increase BNL's confidence in tracking the plume's distribution and evaluating remediation progress.

OU VI Opportunities for Optimization

Based on a recommendation from the *2020 BNL Groundwater Status Report,* in 2021 BNL began a study to determine the reason for the longer than anticipated cleanup time for this system as well as confirmation of the depth of the EDB contamination. Based on the results to date, additional extraction wells will be required to accelerate cleanup, address the deeper EDB, and meet the 2030 cleanup goal.

OU VI Early Indicators of Potential Issues

The current array of two extraction wells has been effective at capturing and remediating the leading edge of the plume. The plume has been migrating more slowly than predicted which has resulted in the system remaining in operation well beyond the 2015 estimate. A comparison of peak EDB concentrations in monitoring wells indicates that the plume migration rate has slowed as it moved south of well 000-284. This reduction in migration rate aligns with recently obtained geologic data in this area indicating the presence of an Upper Glacial silt and clay deposit that may be impeding plume migration. Data was obtained from five vertical profile wells in 2020-2021 to address data gaps in the groundwater model geologic framework and verify the vertical distribution of EDB in the aquifer. The data obtained from these temporary wells indicate that a significant adjustment was needed to the geologic framework, and that EDB is present at greater depths in the Upper Glacial aquifer than previously observed. EDB was detected at concentrations above the MCL of 0.05 µg/L in a vertical profile well approximately 70 feet below the bottom of the EW-1E screen zone. EDB was also detected at concentrations above the MCL in a vertical profile well approximately 50 feet below the bottom of the EW-2E screen zone. These two vertical profile wells were located immediately adjacent to the extraction wells. A vertical profile approximately 400 feet to the south of EW-2E did not detect EDB, indicating that the plume has not bypassed EW-2E.

OU VI Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid?

OU VI Changes in Standards and TBCs

- The regulatory standards or TBCs identified in the OU VI ROD have not changed, nor do they call into question the protectiveness of the remedy. The EDB standard and the MCL of 0.05 µg/L for drinking water have remained the same since 1999. **Attachment 6** provides the cleanup level for the OU VI primary contaminant of concern.
- There have been no detections of EDB in the system effluent above SPDES equivalency permit levels since the system began operations in 2004. In 2009, the NYSDEC changed the SPDES equivalency permit discharge level for EDB from 0.05 µg/L to 0.03 µg/L. There have been no detections of EDB in the system effluent above this more stringent discharge level.
- EPA's third Six-Year Review of the drinking water standards was completed in January 2017. EPA determined that National Primary Drinking Water Regulations for eight compounds are candidates

for regulatory revision; however, they do not include the OU VI COC.
- The August 2020 issuance of the NYS MCLs for PFOS, PFOA and 1,4-dioxane will require characterization of the presence of these compounds in OU VI groundwater. Data collected to date and future remedial investigation and/or remedial actions will be incorporated under OU VIII and are summarized in **Section 6.4.7**.

OU VI Changes in Exposure Pathways, Toxicity and Other Contaminant Characteristics, and Risk Assessment Methods
- There have been no changes in the physical conditions within OU VI or in the use of the site that would reduce the protectiveness of the remedies or render the initial risk analysis invalid. Also, the exposure assumptions have not changed since the ROD was signed in 2001.
- In general, the changes in standard default exposure parameters from the EPA's memorandum *Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors, OSWER Directive 9200.1-120 issued on February 6, 2014* (EPA 2014b) served to raise risk-based concentrations. In most cases the mix of higher and lower individual parameters, such as ingestion rates, body weights and exposure durations result in higher risk-based concentrations.
- DOE continues to offer free annual water testing to the two homeowners in the OU VI plume area who are still using their private wells for drinking purposes. The results for all samples were in compliance with NYS drinking water standards.
- A preliminary initial screening of the OU VI groundwater VOC plume was performed during the 2011 Five-Year Review to evaluate the potential for soil-vapor intrusion. The portion of the plume that exceeds the MCL is located off of the BNL property, is deeper, and has a clean layer of groundwater above. Therefore, the contaminants are not present in the uppermost portion of the groundwater to complete an exposure pathway and present a soil-gas concern.

OU VI Expected Progress in Meeting RAOs
- The annual *BNL Groundwater Status Report* evaluates the system's performance based on decisions identified from the BNL groundwater DQO process (See *BNL Environmental Monitoring Plan* [BNL 2021a] for the DQO process). As noted above, two or more additional extraction wells may be required to meet MCLs by 2030.
- The two property access agreements for the groundwater treatment system need to be recorded with the County Clerk.

OU VI Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

No newly identified ecological risks or impacts from natural disasters have been found within OU VI. No additional information has come to light that calls into question the protectiveness of the OU VI remedy.

7.7 Operable Unit VIII

OU VIII Question A: Is the remedy functioning as intended by the decision documents?

OU VIII Remedial Action Performance
- A TCRA for the construction of PFOS/PFOA groundwater treatment systems downgradient of the Current and Former Firehouses is being planned. A draft Action Memorandum for the TCRA was submitted to the regulators for review in June 2021. Construction of the treatment systems is anticipated to begin mid-2021.
- The TCRA will ultimately be documented in an OU VIII ROD.

OU VIII System Operations/O&M

- The TCRA treatment systems downgradient of the Current and Former Firehouses are not yet constructed.

OU VIII Costs of System Operations/O&M

The TCRA treatment systems downgradient of the Current and Former Firehouses are not yet constructed.

OU VIII Implementation of Institutional Controls and Other Measures

- During 2021, new fact sheets and maps will be prepared for the Former Firehouse (Sub-Area of Concern 33E) and Current Firehouse (Sub-Area of Concern 33D) to maintain institutional control over PFAS-contaminated groundwater and soil.

OU VIII Monitoring Activities

- As discussed in detail in **Section 6.4.7**, several phases of groundwater characterization have been performed since 2018 on the nature and extent of PFAS and 1,4-dioxane on and off of BNL property.
- A detailed characterization effort was conducted in 2020 and early 2021 of the high concentration segments of the PFAS plumes associated with BNL's Current and Former Firehouse facilities. The data were used to delineate the plumes downgradient of these source areas and aid in the design of groundwater treatment systems. 1,4-Dioxane was also sampled for at select locations.

OU VIII Opportunities for Optimization

Based on the PFAS and 1,4-dioxane characterization performed to date, a TCRA for the construction of PFOS/PFOA groundwater treatment systems downgradient of the Current and Former Firehouses is being planned. This accelerated action is being taken to immediately address these sources of contamination in lieu of waiting for the OU VIII RI/FS and ROD.

OU VIII Early Indicators of Potential Issues

- Groundwater treatment for 1,4-dioxane is not performed with traditional remediation methods and is costly to install and operate. Fortunately, based on the low concentrations and depth of 1,4-dioxane in the aquifer compared to the location of the proposed extraction wells, it is not expected to be entrained in the influent of the planned PFAS treatment systems.
- Based on characterization data collected since 2017, 1,4-dioxane has been detected in the effluent from four existing treatment systems at concentrations above the 1.0 µg/L MCL, with a maximum concentration of 7.1 µg/L in an effluent sample from the Industrial Park system. Currently, 1,4-dioxane is not identified as a parameter on the existing SPDES equivalency permits. Should treatment for 1,4-dioxane be required in the future for these systems, the cost is expected to be significant.
- Except for drinking water (EPA Method 537.1), standardized procedures for PFAS analysis in other environmental matrices (e.g., non-potable water, soils, biota) are not readily available. Standardized procedures for these other matrices are being developed, and are expected to be available within the next year.

OU VIII Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid?

OU VIII Changes in Standards and TBCs

- In August 2020, New York State issued MCLs for PFOS (10 ng/L), PFOA (10 ng/L) and 1,4-dioxane (1.0 µg/L). This requires characterization of the presence of these compounds in groundwater on and off of the BNL property. BNL has been proactively characterizing the extent of

these contaminants in groundwater since 2017 compared to the EPA Lifetime Health Advisory Level of 70 ng/L for combined PFOS and PFOA. Data collected to date and future remedial investigation and/or remedial actions will be incorporated under OU VIII.

- EPA's third Six-Year Review of the drinking water standards was completed in January 2017. EPA determined that National Primary Drinking Water Regulations for eight compounds are candidates for regulatory revision; however, they are not OU VIII COCs.

OU VIII Changes in Exposure Pathways, Toxicity and Other Contaminant Characteristics, and Risk Assessment Methods

- In March 2021, EPA proposed the fifth *Unregulated Contaminant Monitoring Rule* (UCMR 5). This action identifies a new list of 29 unregulated PFAS compounds for public water system monitoring between 2023-2025. The UCMR 5 proposal fulfills a key commitment of the *EPA's 2019 Per- and Polyfluoroalkyl Substances (PFAS) Action Plan* (EPA 2019a) by including the collection of drinking water occurrence data for a broader group of PFAS (i.e., building on the monitoring for six PFAS that took place under UCMR 3). Some of these compounds have been detected during BNL groundwater characterization activities.
- There are several buildings located within the PFAS plumes associated with the Current and Former Firehouses. However, PFAS are not volatile compounds. There are however, detections of 1,4-dioxane in portions of these plumes. Although 1,4-dioxane is considered volatile and has been detected above the MCL, EPA's VISL is significantly higher than the maximum concentration detected in the plumes. As a result, the subsurface vapor to indoor air pathway is incomplete.

OU VIII Expected Progress in Meeting RAOs

Remedial action objectives have not yet been identified in a ROD. However, the objectives of the TCRA for the two treatment systems downgradient of the firehouses will be reviewed for consistency with the final ROD.

OU VIII Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

No newly identified ecological risks or impacts from natural disasters have been identified at this time.

7.8 BGRR

BGRR Question A: Is the remedy functioning as intended by the decision documents?

BGRR Remedial Action Performance

- As described in the completion and closeout reports to date, site inspections, and regulatory interviews, the interim cleanup measures were implemented in accordance with the Action Memoranda and NEPA categorical exclusions, and are consistent with the BGRR ROD. This has achieved the remedial action objectives of protecting human health from the hazards posed by the radiological inventory at the BGRR using the ALARA principle (i.e., limiting worker exposure) and implementing monitoring, maintenance, and institutional controls to manage remaining hazards. Specific activities completed to help reduce the radiological inventory, to reduce the potential for exposure, and to prevent the future migration of radiological contamination into surrounding soil and groundwater include:
  - Removal of primary air cooling fans – Removed and properly disposed of contaminated equipment in the fan rooms and decontaminated or fixed surface contamination (Note: Fan house buildings and soil were removed under the HFBR ROD).
  - Removal of the Pile Fan Sump, pipes, and contaminated soil.

    - Removal of above-ground ducts, pipes, and contaminated soil – Prevented low-level radioisotopes from being released to soil and potential migration into groundwater.
    - Removal of canal and water treatment house, piping, and accessible contaminated soils – Reduced the amount of contamination in the concrete structures of the canal and removed contaminated surface soil.
    - Removal of the exhaust cooling coils and filters.
    - Removal of BGD primary liner.
    - Sealing of the BGDs.
- The April 2005 completion of the removal of the canal structure and subsurface contaminated soil located outside the footprint of the reactor building was performed in accordance with the Action Memorandum (BNL 2005g) and is consistent with the selected remedy in the BGRR ROD. A completion report was prepared and issued to the regulators in 2005.
- In 2005, a temporary asphalt cap was installed over the soil areas to minimize water infiltration prior to the final cap installation.
- In May 2010, Graphite Pile removal was completed in accordance with the ROD. A final closeout report was issued to the regulators in October 2010.
- In May 2012, the biological shield removal and the final engineered cap installation to prevent water infiltration were completed.

BGRR System Operations/O&M

As required by the BGRR ROD, long-term surveillance and maintenance activities are conducted to ensure effectiveness of the remedy. Specific measures are being implemented for the BGRR project. They include the following:

- Routine environmental health and safety monitoring
- Radiation detection monitoring
- Secure access via locked doors
- Periodic structural inspections of Building 701
- Water intrusion monitoring
- Preventive maintenance of Building 701 and the infiltration management system
- Groundwater monitoring required as part of the OU III ROD and the ESD
- Periodic inspections of the below-ground ducts
- Periodic maintenance and repairs as identified during the inspections, such as enhancements for roof access in 2019, sealing of precipitation infiltration areas, and minor repairs to the cap.
- An update to the *Long-Term Surveillance and Maintenance Manual for the BGRR* was issued in December 2018 (BNL 2018b).

BGRR Costs of System Operations/O&M

The annual surveillance and maintenance cost over the past five years are $101K (2016), $65K (2017), $15K (2018), $10K (2019) and $13K (2020). The annual O&M costs for the groundwater treatment system are provided in **Table 4-1**. Additionally, surveillance and maintenance costs for the BGRR include upkeep every 10 years for the infiltration barrier and every 20 years to refurbish the Building 701 exterior facade and roof system. The surveillance and maintenance activities include radiation and environmental monitoring, the testing, inspection and maintenance/repair of essential equipment and components, and verification of conditions throughout the facilities including the below-ground ducts. Activities also include preventative and corrective maintenance on the temporary asphalt cap to ensure its integrity.

BGRR Implementation of Land Use and Institutional Controls and Other Measures

In addition to the administrative controls placed on the future land use at BNL, the following specific institutional controls are being implemented:

- Control measures for future excavation of residual subsurface contamination. No digging, drilling, ground-disturbing activities, or groundwater shall be extracted within the area designated on Figure 10-1 of the BGRR ROD (https://www.bnl.gov/bgrr/docs/BGRRRecordofDecision.pdf) unless the activity has undergone a BNL review process, which includes, but is not limited to, the restrictions in BNL's LUCMP and the BNL digging permit review for any excavations. Any activity that occurs deeper than 15 feet will require EPA concurrence.
- Specific land-use restrictions are established within the BNL LUCMP limiting future use and development of the BGRR complex to commercial or industrial uses only. Additionally, any future plans for excavation of the inaccessible contaminated soils will include the assessment of risk to human health and the environment based on the actual distribution, depth, and concentrations of the residual radioactive material encountered.
- Annual certification is provided to the regulators verifying that the institutional controls and engineering controls put in place are unchanged from the previous certification, and that nothing has occurred that would impair the ability of the control to protect public health or the environment. The annual certification is prepared and submitted by a professional engineer or environmental professional accepted by NYSDEC.
- Land-use restrictions and reporting requirements will be passed on to any/all future landowners through an environmental easement on the deed to the property. In light of the fact that a deed does not exist for property owned by a federal entity, DOE will be responsible for implementing, enforcing, maintaining, and reporting on these controls. Although DOE may later transfer these procedural responsibilities to another party by contract, property transfer agreement, or through other means, the DOE or its successor agency shall retain ultimate responsibility for remedy integrity. Upon transfer of the property to a nonfederal entity by the U.S. government, a deed will be established and an environmental easement will be added to the deed at that time.

BGRR Monitoring Activities

- Monitoring environmental health and safety, such as radiological dose monitoring, is an important component of the surveillance and maintenance work. Work is planned to limit worker exposure throughout all phases of the surveillance and maintenance effort.
- Groundwater monitoring in the vicinity of the BGRR complex will continue throughout the institutional control period. Results of the OU III BGRR/WCF monitoring program will be used to help verify the effectiveness of the BGRR remedy.
- Water intrusion monitoring is routinely performed in accordance with the surveillance and maintenance manual for the BGRR to ensure that water does not infiltrate into contaminated areas of the BGRR complex, which could potentially cause the migration of radiological contamination into surrounding soils and groundwater.

BGRR Opportunities for Optimization

- Inspections of the below-ground ducts will be changed to annual starting in 2021. Inspections since 2012 have shown little physical change, and only minor water accumulation has been observed which appears to be from condensation. The leak detection sensors placed in each duct can remotely monitor for water impacts. These factors, in conjunction with the slippery and steep conditions for inspectors, warrant an inspection frequency reduction.

BGRR Early Indicators of Potential Issues

- A continuing source of Sr-90 contamination in the vadose zone soils beneath the BGRR below-ground ducts is a concern for the groundwater remediation system. See **Section 7.3** for additional discussion.

- Water intrusion from the roof and walls, although minor at this time, is accelerating the degradation of the brick work on the south wall and may be an issue for the long-term maintenance of Building 701. The quantity of water has not been enough to cause any accumulation of water in the building.

BGRR Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid?

BGRR Changes in Standards and TBCs

- The standards or TBCs, including DOE Orders, identified in the BGRR ROD have not changed, nor do they call into question the protectiveness of the remedy. See **Attachment 5** for a review of the standards and TBCs.
- The soil cleanup levels for radionuclides are based on 15 mRem/yr above background. As stated in the *EPA memorandum on Radiation Risk Assessment at CERCLA Sites: Q&A* (EPA 2014a), the Superfund recommendation is now 12 mRem/yr as the dose-based level protective of a target cancer risk of $1x10^{-4}$. This could have a minor effect on risk-based levels of radionuclides in soil. It should be noted that the soil cleanups performed to date have also met the NYSDEC guidance of 10 mRem/yr above background (ALARA goal).

BGRR Changes in Exposure Pathways, Toxicity and Other Contaminant Characteristics, and Risk Assessment Methods

- There have been no changes in the physical conditions within the BGRR complex or in the use of the site that would reduce the protectiveness of the remedies, nor render the initial risk analysis invalid. Also, the exposure assumptions have not changed since the ROD was signed in 2005.
- No new contaminants or sources of contamination have been identified within the BGRR, and no unanticipated toxic byproducts have been detected.

BGRR Expected Progress in Meeting RAOs

- The removal and disposal of contaminated components, structures, water, and soil at the BGRR complex is complete. Based on sampling results, continued monitoring and surveillance of the facility, groundwater monitoring downgradient of potential source areas, and visual inspections of remediated areas, those projects completed to date continue to meet the remedial action objectives identified in the ROD.
    - The overall remedy removed over 99 percent of the radioactive material inventory at the BGRR complex.
    - The remaining radiological inventory has been stabilized as a result of the cleanup actions.
    - The implementation of long-term monitoring, maintenance, and institutional controls continues for the BGRR.
    - Water infiltration management and institutional controls are effective in protecting human health and the environment. The Building 701 structure and engineered cap protect the contaminated soil and components that will remain under the building footprint. It forms a significant barrier to possible direct exposure to individuals entering this area, and serves as an effective stormwater control to prevent water infiltration and leaching of the remaining contaminants to groundwater.
    - As noted in **Section 7.3** above, BNL is evaluating the performance and efficiency of the Sr-90 ion exchange treatment system currently used to remediate the BGRR/WCF plumes to ensure that these systems are on track to meet the objective, as stated in the OU III ROD and ESD, of meeting the MCL in the aquifer within 70 years. As discussed in **Section 7.3**, BNL has and will continue to evaluate any new Sr-90 remediation techniques and technologies as well as any operational efficiencies that might accomplish cleanup sooner and with less remediation waste. Continued evaluation of the continuing source of Sr-90 contamination in the vadose zone soils below the BGRR will be performed.

BGRR Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

No newly identified risks, impacts from natural disasters, or land use changes have been found within the BGRR complex. No additional information has come to light that calls into question the protectiveness of the BGRR remedy.

7.9 g-2/BLIP/USTs

g-2/BLIP/USTs Question A: Is the remedy functioning as intended by the decision documents?

g-2/BLIP/USTs Remedial Action Performance

- Groundwater monitoring at the BLIP source area has shown that the stormwater controls have been effective in preventing additional leaching of radionuclides from the activated soil shielding. All tritium concentrations in groundwater have been below the 20,000 pCi/L MCL since early 2006. Over the last five years, the maximum tritium concentration in the BLIP monitoring wells was 5,000 pCi/L in 2019. The stormwater controls (e.g., gunite cap, paved area, and drainage system for the building) are routinely inspected and maintained. Furthermore, the silica grout injected into the activated soil at the BLIP facility during the 2000 Removal Action provides an additional protective measure by reducing the permeability of the activated soil and the ability of rainwater to leach out contaminants should the primary stormwater controls fail. Although direct inspection or maintenance of the silica grout is not possible, it is expected to be in good condition.
- The cap at the g-2 source area is routinely inspected and maintained. Although the cap is effectively preventing rainwater infiltration into the remaining activated soil shielding, tritium concentrations in source area monitoring wells continue to periodically exceed the 20,000 pCi/L MCL. The maximum tritium concentration in the source area wells over the last five years was 35,500 pCi/L in 2018. As in past years, periodic, short-term increases in tritium concentrations appear to be related to water-table fluctuations and the flushing of residual tritium from the deep portion of the vadose (unsaturated) zone below the source area. The overall reductions in tritium concentrations observed in source area wells suggest that the amount of residual tritium that is available to be flushed out of the deep vadose zone is decreasing. Continued monitoring is required to verify the long-term effectiveness of the engineered controls.
- Tritium concentrations in the downgradient g-2 plume segment south of the Alternating Gradient Synchrotron facility have attenuated (via radioactive decay and dispersion) to concentrations less than the 20,000 pCi/L MCL. The reductions in tritium concentrations are consistent with model predictions of decay and dispersion effects on the plume segments with distance from the source area. No additional remedial actions or continued monitoring for this plume segment are required.
- No groundwater monitoring is required for the former UST areas.

g-2/BLIP/USTs System Operations/O&M

As required by the 2007 ROD, long-term cap maintenance activities are conducted to ensure effectiveness of the remedy. The BNL LUCMP contains sitewide control measures and land-use restrictions to prevent exposure to environmental contamination and to protect the integrity of remedies specified within the g-2/BLIP/USTs ROD and other approved RODs. To accomplish this objective, specific measures are being implemented for the g-2/BLIP project. They include the following:

- Routine inspections and maintenance of the caps and other stormwater controls at the g-2 source area and BLIP facility.
- Groundwater monitoring required to verify that the source controls remain effective.
- There are no actions associated with the former UST areas.

g-2/BLIP/USTs Costs of System Operations/O&M

The estimated annual costs for routine cap inspections and groundwater monitoring are:

- Approximately $10,000 for routine inspections and minor maintenance of the caps and other stormwater controls at the g-2 source area and BLIP facility.
- Approximately $10,000 for groundwater monitoring at the g-2 source area and approximately $4,000 for monitoring groundwater at the BLIP facility.
- There are no costs associated with the former UST areas.

g-2/BLIP/USTs Implementation of LandUse and Institutional Controls and Other Measures

- The *BNL Land Use Controls Management Plan* (BNL 2018c) provides an overview of land use and other controls that are deployed at BNL to prevent exposure to residual environmental contamination. The web-based *Land Use and Institutional Controls Mapping* tool contains map locations and fact sheets for the g-2 and BLIP facilities. The LUCMP is a living document and is periodically updated to stay current with evolving management techniques.
- There are no LUCMP issues associated with the former USTs.

g-2/BLIP/USTs Monitoring Activities

- Groundwater monitoring at the g-2 and BLIP source areas will continue throughout the institutional control period. Results of the g-2 and BLIP monitoring programs will be used to help verify the effectiveness of the remedy.
- No groundwater monitoring is required for the former UST areas.

g-2/BLIP/USTs Opportunities for Optimization

- Monitoring data indicate that the source area controls are effective.

g-2/BLIP/USTs Early Indicators of Potential Issues

- There have been no changes in the physical conditions at the g-2 or BLIP facilities or in the use of the site that would reduce the protectiveness of the remedies, nor render the initial risk analysis invalid. Also, the exposure assumptions have not changed since the ROD was signed in 2007.
- Groundwater monitoring data from both facilities suggest that the caps and other stormwater controls are effective.
- Because the g-2 facility has not operated since the completion of the project in April 2001, no additional buildup of radioactivity has occurred. Therefore, with natural radioactive decay, radionuclide levels in the soil shielding at the g-2 source area are less than when they were evaluated at the time of the 2007 ROD. Because BLIP is an active facility, additional buildup of radioactivity is occurring in a zone of soil shielding. In addition to the surface controls to prevent rainwater infiltration, the colloidal silica grout that was injected into the zone of activated soil shielding in 2002 offers additional protection from potential stormwater infiltration.

g-2/BLIP/USTs Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid?

g-2/BLIP/USTs Changes in Standards and TBCs

The standards or TBCs identified in the ROD have not changed, nor do they call into question the protectiveness of the remedy. See **Attachment 5**.

g-2/BLIP/USTs Changes in Exposure Pathways, Toxicity and Other Contaminant Characteristics, and Risk Assessment Methods

- There have been no changes in the physical conditions within the g-2 or BLIP facilities or use of the site that would reduce the protectiveness of the remedies, nor render the initial risk analysis

invalid. Also, the exposure assumptions have not changed since the ROD was signed in 2007. There are no risks associated with the former UST areas.

- Federal Guidance Report 15, entitled *External Exposure to Radionuclides in Air, Water and Soil* (EPA 2019b), updated and expanded the 1993 Federal Guidance Report No. 12 to include age-specific reference person effective dose rate coefficients based on external exposure. The changes include updated tissue weighting factors and radionuclide decay data. While this change does not affect MCLs, risk-based levels and risk assessment for external exposure may be affected.

g-2/BLIP/USTs Expected Progress in Meeting RAOs

- Groundwater monitoring at the g-2 and BLIP source areas has shown that the stormwater controls have been effective in preventing additional leaching of radionuclides from the activated soil shielding. At the BLIP facility, all tritium concentrations in groundwater have been less than the 20,000 pCi/L MCL since early 2006. However, tritium concentrations continue to periodically exceed 20,000 pCi/L in the g-2 source area groundwater monitoring wells. The continued detection of tritium is related to water-table fluctuations and the flushing of residual tritium from the deep portion of the vadose (unsaturated) zone below the source area. The overall reductions in tritium concentrations observed in the g-2 source area wells since 2003 indicate that the amount of residual tritium that is available to be flushed out of the deep vadose zone is decreasing by means of this flushing mechanism and natural radioactive decay.
- The downgradient segment of the g-2 tritium plume had been tracked to the vicinity of the National Synchrotron Light Source II facility. Monitoring conducted in 2015 confirmed that natural attenuation (dispersion and radioactive decay) reduced tritium concentrations to less than the 20,000 pCi/L MCL. As a result, groundwater monitoring in the area south of the Alternating Gradient Synchrotron facility was discontinued.
- There are no continued environmental concerns associated with the former UST areas.

g-2/BLIP/USTs Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

No newly identified risks or any changes in land use have been found at the g-2 or BLIP facilities. There are no continued environmental concerns associated with the former UST areas. No additional information has come to light that calls into question the protectiveness of the remedy defined in the ROD.

7.10 HFBR

HFBR Question A: Is the remedy functioning as intended by the decision documents?

HFBR Remedial Action Performance

As described in the completion and closeout reports to date, site inspections, and regulatory interviews, the interim cleanup measures were implemented in accordance with the Action Memoranda (BNL 2007d and 2008b) and *National Environmental Policy Act* (NEPA) categorical exclusions, and are consistent with the HFBR ROD. This has achieved the remedial action objectives of protecting human health from the hazards posed by the radiological inventory at the HFBR using the ALARA principle, and implementing monitoring, maintenance, and institutional controls to manage potential hazards. Specific activities completed to help reduce the radiological inventory, to reduce the potential for exposure, and to prevent the future migration of radiological contamination into surrounding soil and groundwater include:

- The fuel was removed and sent to an off-site facility.
- The primary coolant was drained and sent to an off-site facility.
- The cooling tower superstructure was dismantled.

- The spent fuel canal was modified to meet Suffolk County Article 12 requirements.
- The Stack Monitoring Facility (Building 715) was dismantled.
- The Water Treatment House (Building 707B) was dismantled.
- The Cold Neutron Facility (Building 751) contaminated systems were removed.
- The Guard House (Building 753) was dismantled.
- Control rod blades and beam plugs were removed.
- Ancillary buildings and associated soils were removed.
- Fan houses were removed.
- Contaminated underground pipes and utilities were removed.
- Soils at the former HWMF WLA were excavated and disposed of.
- Buildings 801-811 underground waste transfer lines and associated soil were removed.
- Stack was demolished, and the stack drain tank, residual silencer structure and contaminated soil were removed.

HFBR System Operations/O&M

Long-term surveillance and maintenance activities are being conducted in accordance with the *Long-Term Surveillance and Maintenance Plan for the HFBR* (BNL 2011g) to ensure effectiveness of the remedy. The BNL LUCMP contains sitewide control measures and land-use restrictions to prevent exposure to environmental contamination and to protect the integrity of remedies specified within the HFBR ROD and other approved RODs. To accomplish this objective, specific measures are being implemented for the HFBR project. They include the following:

- Routine environmental health and safety monitoring including radiological surveys.
- Secure access via locked doors.
- Periodic structural inspections of Building 750.
- Periodic inspections of the stack and grounds (stack inspections complete in 2020).
- Water intrusion monitoring.
- Preventive maintenance of Building 750 and the infiltration management system.
- Management and disposal of water generated from precipitation through the stack (complete in March 2021).
- Groundwater monitoring required as part of the OU III ROD.

HFBR Costs of System Operations/O&M

The annual surveillance and maintenance cost required to ensure that the HFBR remained in a safe and stable condition during the safe storage phase for the confinement building/stack and grounds over the past five years are $26K/$40K (2016), $23K/$50K (2017), $9K/$70K (2018), $8K/$21K (2019) and $11K/$3K (2020). The surveillance and maintenance activities include radiation and environmental monitoring, management and disposal of stack drain water (through March 2021), the testing, inspection, and maintenance/repair of essential equipment, and verification of conditions throughout the facilities.

HFBR Implementation of Land Use and Institutional Controls and Other Measures

The HFBR remedy includes the continued implementation of LUICs in accordance with the LUCMP. These include:

- Measures for controlling future excavation and other actions that could otherwise disturb residual subsurface contamination.
- Land-use restrictions and an acceptable method for evaluating potential impact that the remaining contaminants have on future development.
- Annual certification to EPA and NYSDEC stating that the institutional and engineering controls put in place are unchanged from the previous certification, and that nothing has occurred that would impair the ability of the control to protect public health or the environment or constitute a violation

or failure to comply with the site management plan. This annual certification is prepared and submitted to NYSDEC on an annual basis as part of the LUIC letter report.

DOE is currently responsible for implementing the land-use controls with regard to the property that is the subject of the HFBR ROD. If the property is transferred out of federal ownership, it is DOE's intention that all continuing land-use restrictions, reporting requirements, and any other obligations relating to the property of DOE (or any other successor federal entity on behalf of the United States) will be satisfied through the United States' conveyance of a deed restriction/environmental easement prior to any such transfer of any deed(s) to the property.

While it is DOE's intention that any such deed restriction/environmental easement would require that the transferee (and subsequent transferees) would be required to satisfy all of DOE's obligations relating to the property, DOE acknowledges that, notwithstanding this intention, it (or any other successor federal entity on behalf of the United States) remains ultimately responsible for satisfying DOE's remedial obligations set forth in this ROD relating to the property if any subsequent transferee fails to satisfy the remedial obligations in this regard.

DOE will address any activity that is inconsistent with the land-use restrictions or actions that may interfere with the effectiveness of the institutional controls established for the HFBR complex with EPA and NYSDEC, as outlined in the BNL LUCMP. LUICs will be maintained until the hazardous substances reach levels that allow unlimited use and unrestricted exposure.

HFBR Monitoring Activities

The *Long-Term Surveillance and Maintenance Plan for the HFBR* was developed to manage the inventory of radioisotopes that will remain in the HFBR Confinement Building during the safe storage (decay) period and subsequent decontamination and dismantlement (BNL 2011g). The details of the surveillance and maintenance processes are contained in a supporting document – the *Long-Term Surveillance and Maintenance Manuals* (BNL 2018d,e). The Surveillance and Maintenance Plan and Manual are implemented to ensure that the inventory of stored radioisotopes and all residual contamination is maintained in a safe condition, and to preclude future human exposure pathways or migration from their locations within the HFBR. Inspections of the HFBR have been ongoing since the facility was placed in a long-term safe storage mode in 2012. The building is structurally sound and little deterioration has been observed to date. There have been no water intrusion alarms sounded in the facility. Minor maintenance and repair work have been performed including removal of asbestos containing material on the floor, repair of the overhead piping insulation, resealing the openings on the air intakes on the exterior walls adjacent to the generator room, and repairing cracked masonry on the east side exterior of the confinement building. Radiation measurements of the V-14 port (located at the top of the reactor vessel) were conducted in 2010, 2015 and 2020 as a means to confirm that radioactive decay in the vessel is occurring at the modeled rate. The measurements to date suggest that decay is occurring as expected and that the selected 65-year decay period (until 2072) is justified. See **Attachment 5** for additional information. The water (from precipitation) generated from the stack was routinely pumped out and disposed of until March 2021, when the tank was removed.

HFBR Opportunities for Optimization

Removal of the reactor and its components requires underwater cutting for size reduction to fit into shipping containers. There have been no major advances in this field in the past several years. There are no technique or technology developments that would allow for the removal of the reactor vessel prior to the current 65-year-decay period. **Attachment 5** provides further discussion.

HFBR Early Indicators of Potential Issues

Protection of workers during the demolition of the stack was an important consideration. Strict safety controls developed and implemented by the demolition contractor were used to help mitigate potential risk during the abatement and demolition process. There were no injuries reported during the demolition activities.

HFBR Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid?

HFBR Changes in Standards and TBCs

- The standards or TBCs, including DOE Orders, identified in the HFBR ROD have not changed, nor do they call into question the protectiveness of the remedy. **Attachment 5** provides a review of the standards.
- The soil cleanup levels for radionuclides are based on 15 mRem/yr above background. As stated in the *EPA memorandum on Radiation Risk Assessment at CERCLA Sites: Q&A* (EPA 2014a), the Superfund recommendation is now 12 mRem/yr as the dose-based level protective of a target cancer risk of $1x10^{-4}$. This could have a minor effect on risk-based levels of radionuclides in soil. It should be noted that the soil cleanups performed to date have also met the NYSDEC guidance of 10 mRem/yr above background (ALARA goal).

HFBR Changes in Exposure Pathways, Toxicity and Other Contaminant Characteristics, and Risk Assessment Methods

- There have been no changes in the physical conditions within the HFBR complex or in the use of the site that would reduce the protectiveness of the remedies, nor render the initial risk analysis invalid.
- Lead, a contaminant of concern in soil, has a cleanup level of 400 mg/kg which is the EPA Regional Screening Level for residential soil and the New York State soil cleanup objective for residential and restricted residential use, and commercial or industrial use. This cleanup level is protective of residential exposure to lead in soil based on a target blood lead level of 10 µg/dL in children. There has been renewed discussion within EPA on the possibility of revising the target blood lead level for CERCLA. If EPA revises the value to less than 10 µg/dL, then the 400 mg/kg cleanup level for lead in soil would require review in future Five-Year Reviews for continued protectiveness.
- Federal Guidance Report 15, entitled *External Exposure to Radionuclides in Air, Water and Soil* (EPA 2019b), updated and expanded the 1993 Federal Guidance Report No. 12 to include age-specific reference person effective dose rate coefficients based on external exposure. The changes include updated tissue weighting factors and radionuclide decay data. While this change does not affect MCLs, risk-based levels and risk assessment for external exposure may be affected.
- No new contaminants or sources of contamination have been identified within the HFBR, and no unanticipated toxic byproducts have been detected.
- In accordance with the HFBR ROD, DOE continues to determine the feasibility of reducing the 65-year safe storage (decay) period and completing the removal of large activated components earlier taking into consideration the following factors:
    - Advancements in cleanup technologies and transportation methods.
    - Availability of waste disposal facilities.
    - Changes in standards and regulations for worker, public, and environmental protection.
    - Worker safety impacts.
    - Environmental impacts.
    - Public health impacts.
    - Economic impacts.
    - Land use.

    - Existing stabilization and safety of the facility and hazardous materials.
    - Projected future stability and safety of the facility and hazardous materials.
- As discussed in **Attachment 5**, no advances in new technologies or other factors have been identified since the ROD was finalized in 2009 that would warrant a reduction in the 65-year safe storage (decay) period.
- Recognizing that there are uncertainties inherent in activation analyses, per the ROD, DOE conducted an additional investigation involving the following steps:
    - Performed radiation surveys (measurements of radiation levels) after the removal of the control rod blades from the reactor vessel. (Surveys before the removal of control rod blades with high dose rates would not yield reliable results).
    - Reevaluated the dose rate at 1 foot from the large activated components (reactor vessel, thermal shield, and biological shield) based on the radiation surveys performed in 2015 and 2020.
    - Using the reevaluated dose rates, determined the decay period necessary for the dose rate at 1 foot to fall below 100 mRem/hour for the large activated components, including the limiting component.
    - Used the results of the additional investigation in this Five-Year Review in assessing the feasibility of shortening the decay period.
- The following conclusions from this evaluation were reached:
    - The predicted time for when the large limiting activated component (i.e., thermal shield) will decay to 100 mRem/hour is in 65 years from 2007 (the safe storage decay period was determined based on the radiological inventory and radiation levels in 2007), or in the year 2072.
    - This predicted time was calculated based on activation analysis, and the calculations were supported by measurements of actual dose rates, most recently in 2020.
    - Radiation levels from the small highly activated components (transition plate and anti-critical grid) were within the bounds of expected levels when measured in a reactor vessel internal survey in 2009.
    - When the control rod blades were removed from the reactor, radiation levels and curie contents were in close agreement with the predicted levels.
    - Based on this close agreement between actual and predicted radiation levels, the calculated dose rates for the large activated components are also expected to be reasonably accurate. Therefore, there is no justification to change the safe storage (decay) period of 65 years.

HFBR Expected Progress in Meeting RAOs

- In accordance with the ROD, the removal and disposal of contaminated components, structures (including the stack), water, and soil at the HFBR complex is complete. Based on sampling results, continued monitoring and surveillance of the facility, groundwater monitoring downgradient of potential source areas, and visual inspections of remediated areas, those projects completed to date continue to meet the remedial action objectives identified in the ROD.
    - A portion of the radiological inventory at the HFBR complex has been either removed or stabilized as a result of the cleanup actions.
    - The ALARA principle was extensively used to help protect workers while implementing the cleanup actions.
    - Long-term monitoring, maintenance, and institutional controls continue to be performed for the HFBR.
- The remaining remedial action to be implemented for removal of the reactor vessel is also expected to meet the overall ROD remedial action objectives.

HFBR Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

No newly identified risks, impacts from natural disasters or land use changes have been found within the HFBR complex. No additional information has come to light that calls into question the protectiveness of the HFBR remedy.

7.11 Technical Assessment Summary

Currently, nine RODs have been signed at BNL. The first was signed in 1996 and the last was signed in 2009. In addition, four ESDs were signed documenting changes to the OU III and BGRR RODs. With the exception of the HFBR reactor vessel removal, all selected remedies for the RODs and ESDs have been implemented. This includes the excavation and off-site disposal of contaminated soil, sediment, and tanks, and the installation and operation of groundwater treatment systems. All closeout reports, with the exception of the HFBR stack demolition, were submitted to the regulators and approved. The stack closeout report is scheduled for submittal in the fall 2021. Possible remedies for PFAS and 1,4-dioxane will be documented in the OU VIII ROD.

Remedies have been implemented in accordance with the RODs and the ESDs, based on the data presented in the closeout reports and the annual BNL Groundwater Status Reports, site inspections, and regulatory interviews. Soil cleanup levels were met and groundwater pump and treat systems have been functioning as intended by the RODs. The cleanup performed continues to meet the remedial action objectives identified in each ROD.

For soil excavation/disposal remedies, work was performed in accordance with the ROD, applicable design documents, and Remedial Action Work Plans. Soil cleanup levels were met for these areas. The remaining work at the HFBR will be implemented in accordance with the ROD and the final remedy for PFAS and 1,4-dioxane will be documented in an OU VIII ROD. There have been no changes in the physical conditions of the site that would affect the protectiveness of the remedies. Soil and groundwater applicable or relevant and appropriate requirements in the RODs and ESDs have either been met or are expected to be met. There is no other information that calls into question the protectiveness of the remedies.

8.0 Issues

Issues are identified in **Section 9**, **Table 9-1**.

9.0 Recommendations and Follow-up Actions

The following table summarizes key recommendations developed in the Technical Assessment section of this document. These recommendations are subject to regulatory review, and implementation will be based on the availability of funding.

Table 9-1: Recommendations and Follow-up Actions

Issue	Recommendations/ Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Y/N)	
					Current	Future
Sr-90 in OU I Former HWMF Groundwater	Continue to track Sr-90 plume attenuation. Enhance monitoring network with temporary and/or permanent wells as necessary. Monitor plume attenuation progress with 2021 groundwater model predictions and report in annual Groundwater Status Report.	BNL	DOE, EPA, NYSDEC, SCDHS	June 2026	N	N
OU III Building 96 Source Removal Effectiveness	Monitor plume and source area. Evaluate and/or implement a liquid carbon in-situ treatment for the source area soils if groundwater concentrations do not decline to below the system capture goal.	BNL	DOE, EPA, NYSDEC, SCDHS	October 2023	N	N
OU III Middle Road VOC contamination	Conduct a pre-design characterization of VOCs in groundwater between monitoring well 104-37 and the site boundary by installing several temporary vertical profile wells. Install new extraction well(s) based on data and groundwater modeling.	BNL	DOE, EPA, NYSDEC, SCDHS	October 2024	N	N
OU III South Boundary VOC contamination	Conduct a pre-design characterization of VOCs in groundwater upgradient and downgradient of monitoring well 121-54 and the site boundary by installing several temporary vertical profile wells. Install new extraction well(s) based on data and groundwater modeling.	BNL	DOE, EPA, NYSDEC, SCDHS	October 2024	N	N
Continuing Sr-90 sources at BGRR, WCF, and Building 801	Monitor plume and continued degradation of source areas. Perform intermittent pulsed pumping of extraction wells SR-1, SR-2, and SR-3. Evaluate during next Five-Year Review.	BNL	DOE, EPA, NYSDEC, SCDHS	June 2026	N	N

Issue	Recommendations/ Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Y/N)	
					Current	Future
OU VI EDB contamination	Update the groundwater model framework based on latest geologic and groundwater quality data. Modify the system to meet ROD cleanup goals and ensure capture of deeper EDB.	BNL	DOE, EPA, NYSDEC, SCDHS	October 2024	N	N
OU VIII PFAS	Begin operation of the TCRA groundwater treatment systems for current and former firehouses' PFAS plumes.	BNL	DOE, EPA, NYSDEC, SCDHS	2022	Y	Y
Peconic River Remedy Optimization	Complete federally-required vegetation monitoring at Area PR-WC-06	BNL	DOE, EPA, NYSDEC, SCDHS	September 2022	N	N
HFBR	Issue final stack demolition closeout report	BNL	DOE, EPA, NYSDEC, SCDHS	Fall 2021	N	N
HFBR	Explore the feasibility of reducing the 65-year safe storage (decay) period and completing the removal of large activated components earlier.	BNL	DOE, EPA, NYSDEC, SCDHS	Recurring	N	N
OUs III & VI – Maintain terms of groundwater treatment system property access agreements	Record property access agreements with County Clerk, continue to manage existing access agreements.	BNL	DOE, EPA, NYSDEC, SCDHS	Ongoing	N	Y
Building 650	Update Building 650 LUIC fact sheet based on as left conditions documented in final D&D closeout report.	BNL	DOE, EPA, NYSDEC, SCDHS	Fall 2021	N	N

Notes:
Recommendations are subject to regulatory review; implementation will be based on the availability of funding
BGRR = Brookhaven Graphite Research Reactor
DOE = U.S. Department of Energy
EPA = U.S. Environmental Protection Agency
HFBR = High Flux Beam Reactor
NYSDEC = New York State Department of Environmental Conservation
SCDHS = Suffolk County Department of Health Services
VOCs = Volatile Organic Compounds

10.0 Protectiveness Statements

Individual Protectiveness Statements

Protectiveness statement for the individual OUs, the BGRR, HFBR, and g-2/BLIP/USTs are presented below.

Operable Unit I: The remedy is expected to be protective of human health and the environment upon attainment of groundwater cleanup goals, and in the interim, exposure pathways that could result in unacceptable risks are being controlled.

- All soil cleanup actions are complete and the groundwater treatment system was approved for closure in 2019. The attainment of groundwater cleanup goals for VOCs is expected to require 30 years or less to achieve (by 2030). Strontium-90 in groundwater is expected to attenuate to near the DWS at the site boundary. In the interim, exposure pathways that could result in unacceptable risks are being controlled. Institutional controls are preventing exposure to, or the ingestion of, contaminated groundwater and soil.
- Long-term protectiveness of the remedy will be verified by monitoring the movement and remediation of the plume. Current monitoring data indicate that the remedies are effective and they are functioning as required to achieve the groundwater cleanup goals.

Operable Unit II/VII: Remedial actions for the AOCs in this OU are documented in the OU I and OU III RODs, except for BLIP and the g-2 tritium plume, which are documented in another ROD. Since there is no ROD or remedial action for this OU, a protectiveness statement cannot be prepared. A protectiveness statement for the g-2/BLIP/UST AOCs is identified below.

Operable Unit III: The remedy is expected to be protective of human health and the environment upon attainment of groundwater cleanup goals. In the interim, exposure pathways that could result in unacceptable risks are being controlled.

- All soil cleanup actions are complete and all groundwater treatment systems are operational, in standby mode, or decommissioned/closed. The attainment of groundwater cleanup goals is expected to require:
  - 30 years or less to achieve MCLs for VOCs and tritium in the Upper Glacial aquifer (by 2030).
  - 40 years and 70 years or less to achieve MCLs for Sr-90 at the former Chemical Holes plume and the BGRR/WCF plumes, respectively (by 2040 and 2070, respectively).
  - 65 years or less to achieve MCLs for VOCs in the Magothy aquifer (by 2065).
- Exposure pathways that could result in unacceptable risks are being controlled. Site-specific institutional controls are preventing exposure to contaminated groundwater and soil.
- Long-term protectiveness of the remedies will be verified by continuing to monitor the movement and remediation of the plumes. Current monitoring data indicate that the remedies are functioning as required to achieve the groundwater cleanup goals.

Operable Unit IV: The remedy is protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being controlled.

- The groundwater cleanup goals have been met for the VOCs/SVOCs present at the 1977 oil/solvent spill site and the treatment system has been dismantled. Institutional controls are preventing exposure to contaminated soil and groundwater. All threats at the site have been addressed through the installation of fencing and warning signs, and the implementation of institutional controls.
- Additional groundwater characterization performed in 2011 and 2015 (and updated groundwater modeling) verified that the remaining Sr-90 contamination in groundwater will remain in the central portion of the site and attenuate to below the 8 pCi/L MCL by 2034.

Operable Unit V: Following the 2017 supplemental sediment cleanup of Area PR-WC-06, sediment cleanup goals for the Peconic River have been met and the remedy is protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being controlled. Revegetation of remediated areas has been completed. The post-cleanup, long-term monitoring has demonstrated the effectiveness of the Peconic River cleanup to mitigate potential human and ecological effects.

- The soil cleanup goals for the STP filter beds/berms and the groundwater goals have been met.
- The 2004/2005 cleanups, as well as the 2011 and 2017 supplemental sediment cleanups of the Peconic River met the remediation goals of the ROD.
- Long-term monitoring has demonstrated the effectiveness of the Peconic River cleanup and further post-cleanup monitoring of the Peconic River was discontinued. However, in response to a NYSDEC request, BNL recommends sampling of fish for mercury and PCBs in on-site portions of the Peconic River as part of the site environmental surveillance monitoring program. Fish sampling would be limited to times, as determined byBNL, when river conditions allow adequate size, number, and fish mobility to ensure results accurately represent risk levels to human health and the environment. Details of the sampling plan will be documented in an updated Peconic River Fish Surveillance Monitoring Data Quality Objective.

Operable Unit VI: The remedy is expected to be protective of human health and the environment upon attainment of the groundwater cleanup goals. In the interim, exposure pathways that could result in unacceptable risks are being controlled.

- The EDB groundwater treatment system is operational. The attainment of groundwater cleanup goals is expected to require 30 years or less to achieve the MCL for EDB in the Upper Glacial aquifer (by 2030).
- Exposure pathways that could result in unacceptable risks (e.g., off-site potable water supply) are being controlled and site-specific institutional controls are preventing exposure to, or the ingestion of, contaminated groundwater.

BGRR: The remedy is protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being controlled.

- The remedy is protective since the graphite pile and bioshield were removed and the final engineered cap was installed. Institutional controls are preventing exposure to contaminated structures, soil, and groundwater.
- All threats at the site have been addressed through removal or stabilization of the radiological inventory, excavation of contaminated soil, infiltration management, installation of signs, building access controls, and the implementation of specific institutional controls for the structures, soil, and groundwater.
- Long-term protectiveness of the remedy will be verified by continuing to perform periodic structural inspections of Building 701, water intrusion monitoring, preventive maintenance of the infiltration management system, and groundwater monitoring required as part of the OU III ROD and the ESD.

g-2/BLIP/USTs: The remedy defined in the ROD is expected to be protective of human health and the environment upon attainment of groundwater cleanup goals. In the interim, exposure pathways that could result in unacceptable risks are being controlled.

- Groundwater monitoring in the downgradient portion of the plume is complete; however, monitoring of the source area continues.
- Institutional controls designed to prevent exposure to contaminated structures, soil, and groundwater are in place.
- Long-term protectiveness of the remedy will be verified by continuing inspections and maintenance of the g-2 and BLIP facilities' stormwater controls, and groundwater monitoring required by the ROD.

HFBR: The completed remedy is expected to be protective of human health and the environment, and in the interim, exposure pathways that could result in unacceptable risks are being controlled.

- The remedy is expected to be protective upon completion of the segmentation, removal, and disposal of the remaining HFBR structures, systems, and components (including the reactor vessel, internals, thermal shield and biological shield) following a safe storage decay period (not to exceed 65 years). In the interim, exposure pathways that could result in unacceptable risks are being controlled. Institutional controls are preventing exposure to contaminated structures, soil, and groundwater.
- All threats at the site are being addressed through removal or stabilization of the radiological inventory, excavation of contaminated soil, infiltration management, installation of signs, building access controls, and the implementation of specific institutional controls for the structures, soil and groundwater.
- Long-term protectiveness of the remedy will be verified by continuing to perform periodic structural inspections of the reactor confinement building, water intrusion monitoring, preventive maintenance of the infiltration management system, and groundwater monitoring required as part of the OU III ROD.
- The closeout report for the stack demolition will be submitted to the regulators in the fall of 2021.

Comprehensive Protectiveness Statement

- A comprehensive sitewide protectiveness determination covering all the OUs, BGRR, g-2/BLIP/USTs and HFBR must be reserved at this time because HFBR remedy implementation is not yet complete, including reactor vessel removal. A TCRA is underway for PFAS groundwater contamination downgradient of the firehouses. A ROD has not yet been issued.

11.0 Next Review

The fifth sitewide Five-Year Review for BNL will be submitted within five years of issuance of this final report. This will include all OUs, including the g-2 Tritium Plume, the BLIP, and USTs ROD (AOCs 16T, 16K, and 12, respectively), and the BGRR and HFBR RODs. A comprehensive sitewide protectiveness determination may be included at that time.

_____ _____

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Date

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Figures

(Figures 4-1 through 7-1)

BGRR
WCF
Sr-90

OU IV
AOC 5

Bldg 452
Freon-11

Carbon
Tetrachloride

Bldg
96

HFBR
Tritium

Chem
Holes
Sr-90

Waste
Management
Area - AOC 1

Middle Road

OU I South
Boundary

OU III

South Boundary

Industrial
Park
East

Western
South
Boundary

Industrial Park

North
Street
East EDB

North
Street
East

OU VI
EDB

LIPA

North
Street

Brookhaven Airport

OU V

LEGEND

- 32 — BNL GRID NUMBER
- EW-12 — BNL REMEDIATION WELL
- BNL-12 — BNL SUPPLY / PROCESS WELL
- RA V — RECHARGE BASIN OR OTHER SURFACE WATER FEATURE

- OPERATING REMEDIATION SYSTEMS
- REMEDIATION SYSTEM PLACED IN SHUTDOWN MODE
- DECOMMISSIONED REMEDIATION SYSTEM

REMEDIATION WELL STATUS
(AS OF DECEMBER 2020)

- RTW-4A — ON FULL TIME
- RTW-3A — PULSED PUMPING
- RTW-5A — STANDBY-OFF

- 2020 TVOC PLUME UNLESS SPECIFIED. CONCENTRATION AS INDICATED. (DASHED WHERE INFERRED)
- 2020 TRITIUM PLUME. OUTLINE IS 20,000 pCi/L.
- 2020 STRONTIUM-90 PLUME. OUTLINE IS 8 pCi/L.
- 2020 NORTH STREET EAST AND OU VI EDB PLUMES. OUTLINE IS 0.05 µg/L.

Notes:
Treatment system status and plume extents represent December 2020 conditions/data.

µg/L - micrograms per liter
pCi/L - picocuries per liter
EDB - ethylene dibromide
TVOCs - total volatile organic compounds

SCALE
0 500 1000 FEET

05/06/21 FIGURE: 4 -1
GROUNDWATER REMEDIATION SYSTEMS
& OPERATIONAL STATUS OF WELLS

BROOKHAVEN NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

2021 BNL FIVE-YEAR REVIEW

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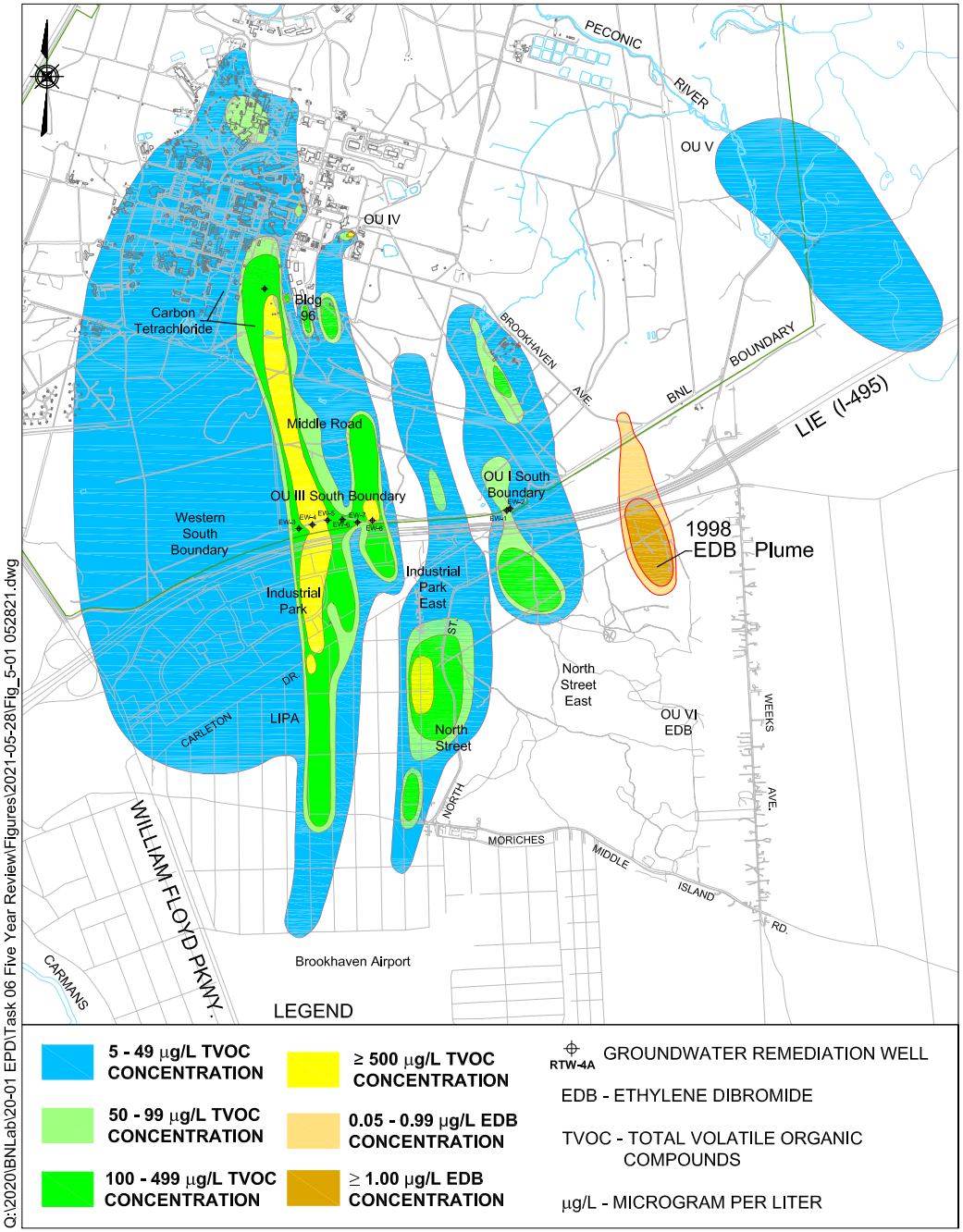
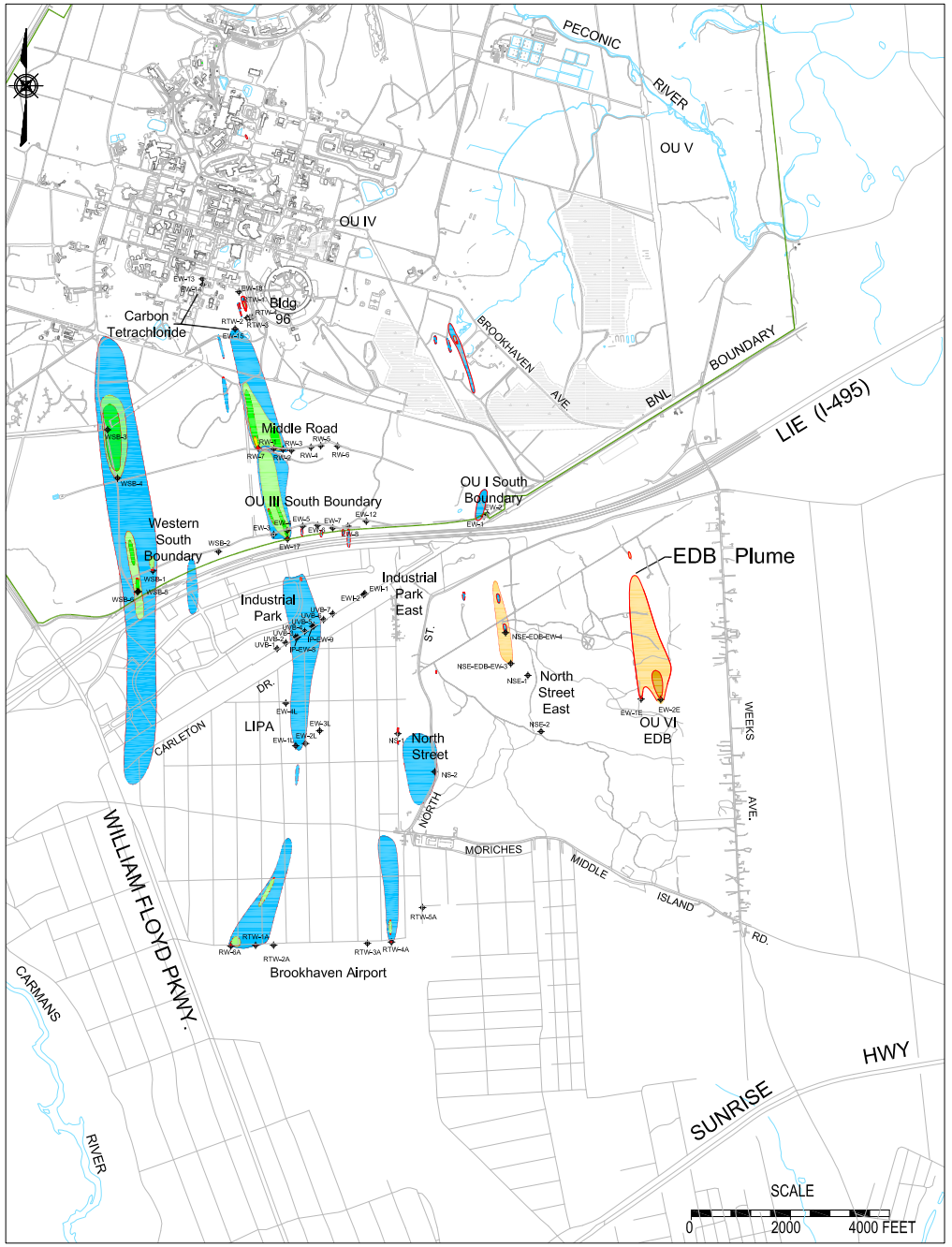
1997 TVOC/EDB PLUME DISTRIBUTION



2020 TVOC/EDB PLUME DISTRIBUTION



LEGEND

- 5 - 49 µg/L TVOC CONCENTRATION
- 50 - 99 µg/L TVOC CONCENTRATION
- 100 - 499 µg/L TVOC CONCENTRATION
- ≥ 500 µg/L TVOC CONCENTRATION
- 0.05 - 0.99 µg/L EDB CONCENTRATION
- ≥ 1.00 µg/L EDB CONCENTRATION
- RTW-4A GROUNDWATER REMEDIATION WELL
- EDB - ETHYLENE DIBROMIDE
- TVOC - TOTAL VOLATILE ORGANIC COMPOUNDS
- µg/L - MICROGRAM PER LITER

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ENVIRONMENTAL PROTECTION DIVISION

TITLE:

TVOC/EDB PLUME COMPARISON 1997/1998 - 2020

2021 BNL FIVE-YEAR REVIEW

DWN:	VT:HZ.:	DATE:	PROJECT NO.:
AJZ	-	05/06/21	-
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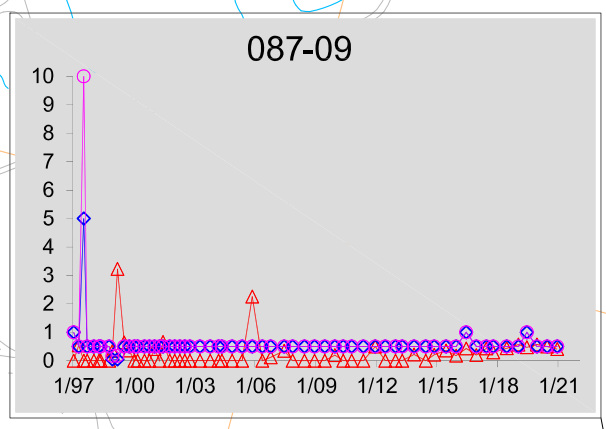
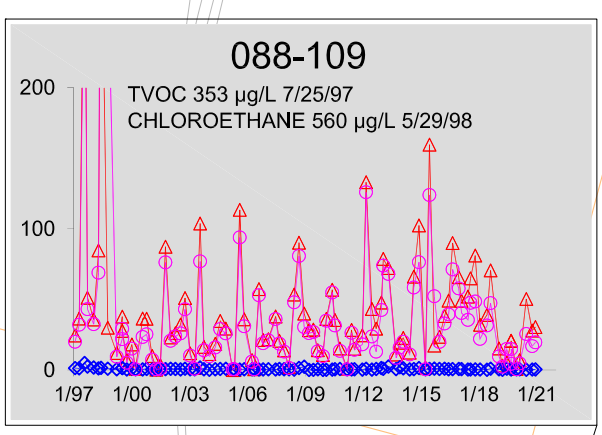
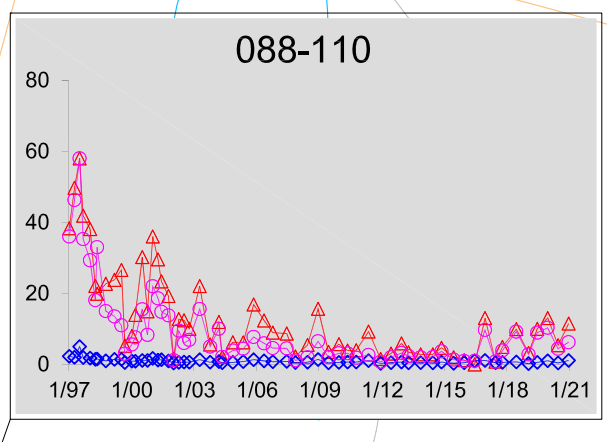
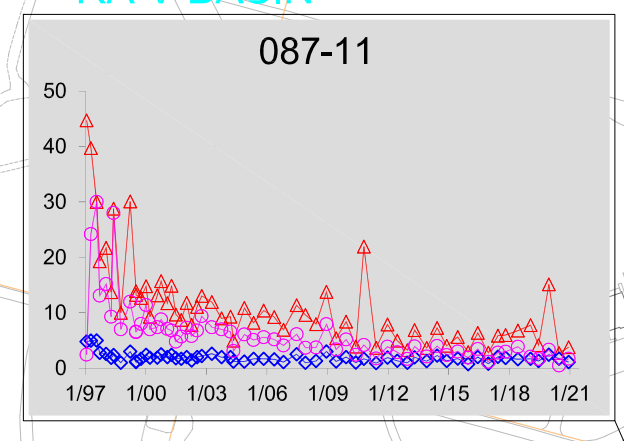
FIGURE NO.: 5-1

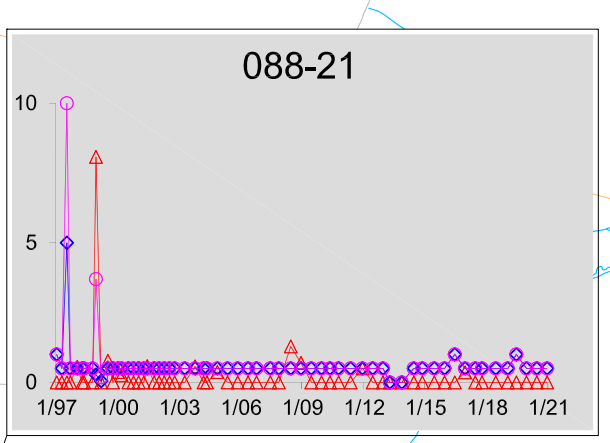


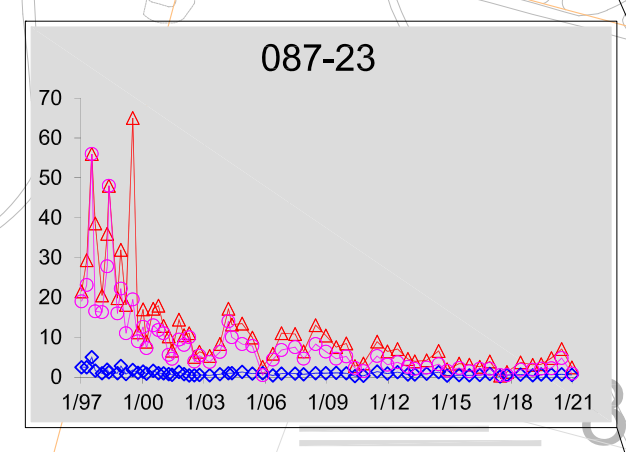


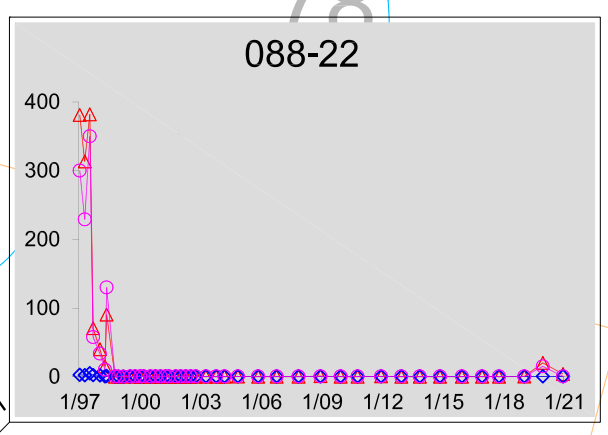


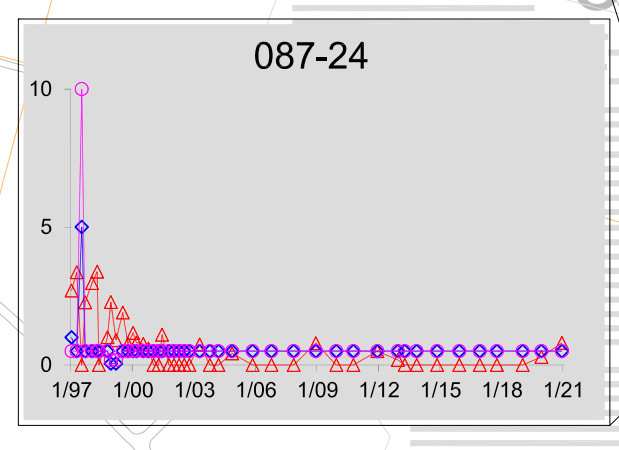
RA V BASIN

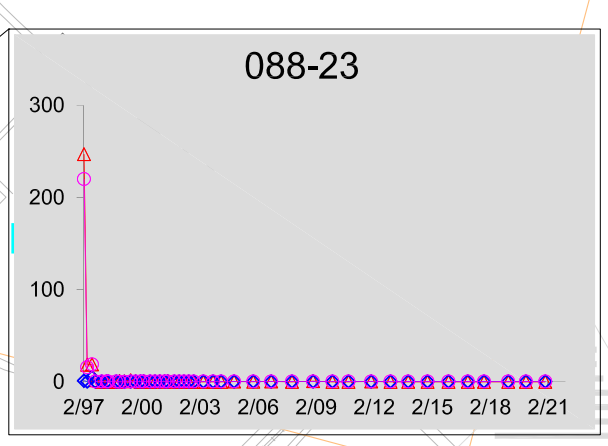


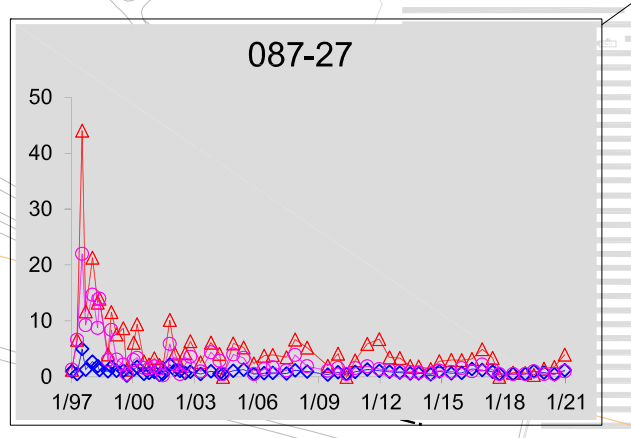


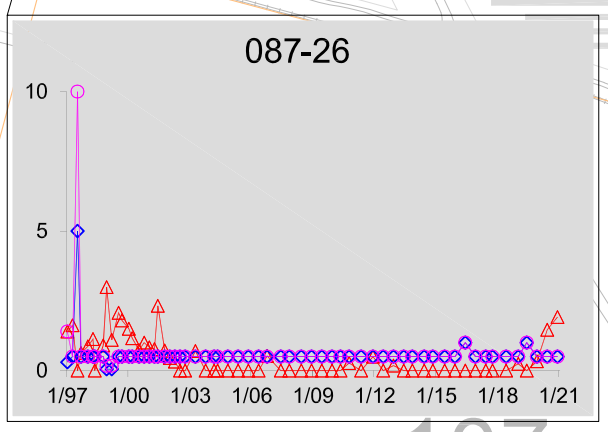


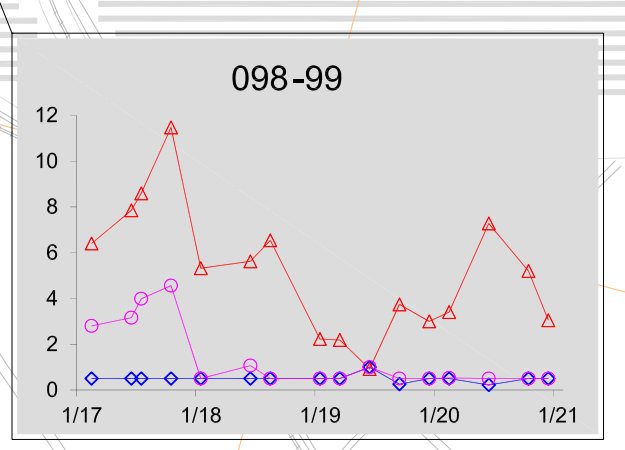












LEGEND

- 11 / 99 — MONITORING WELL & ID IN DIFFERENT MONITORING PROGRAMS
- ◇ Benzene (µG/L)
- ○ Chloroethane (µG/L)
- △ TVOC (µG/L)
- 32 — BNL GRID NUMBER
- RA V — BNL RECHARGE BASIN
- 087-09 — BACKGROUND
- 087-11 — DOWNGRADIENT
- SOLAR FARM PANELS

SCALE
0 500 FEET

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BROOKHAVEN NATIONAL LABORATORY
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TITLE:
OU I CURRENT LANDFILL
VOC TREND PLOTS
2021 BNL FIVE-YEAR REVIEW

DWN:	VT: HZ.:	DATE:	PROJECT NO.:
AJZ	–	05/06/21	–
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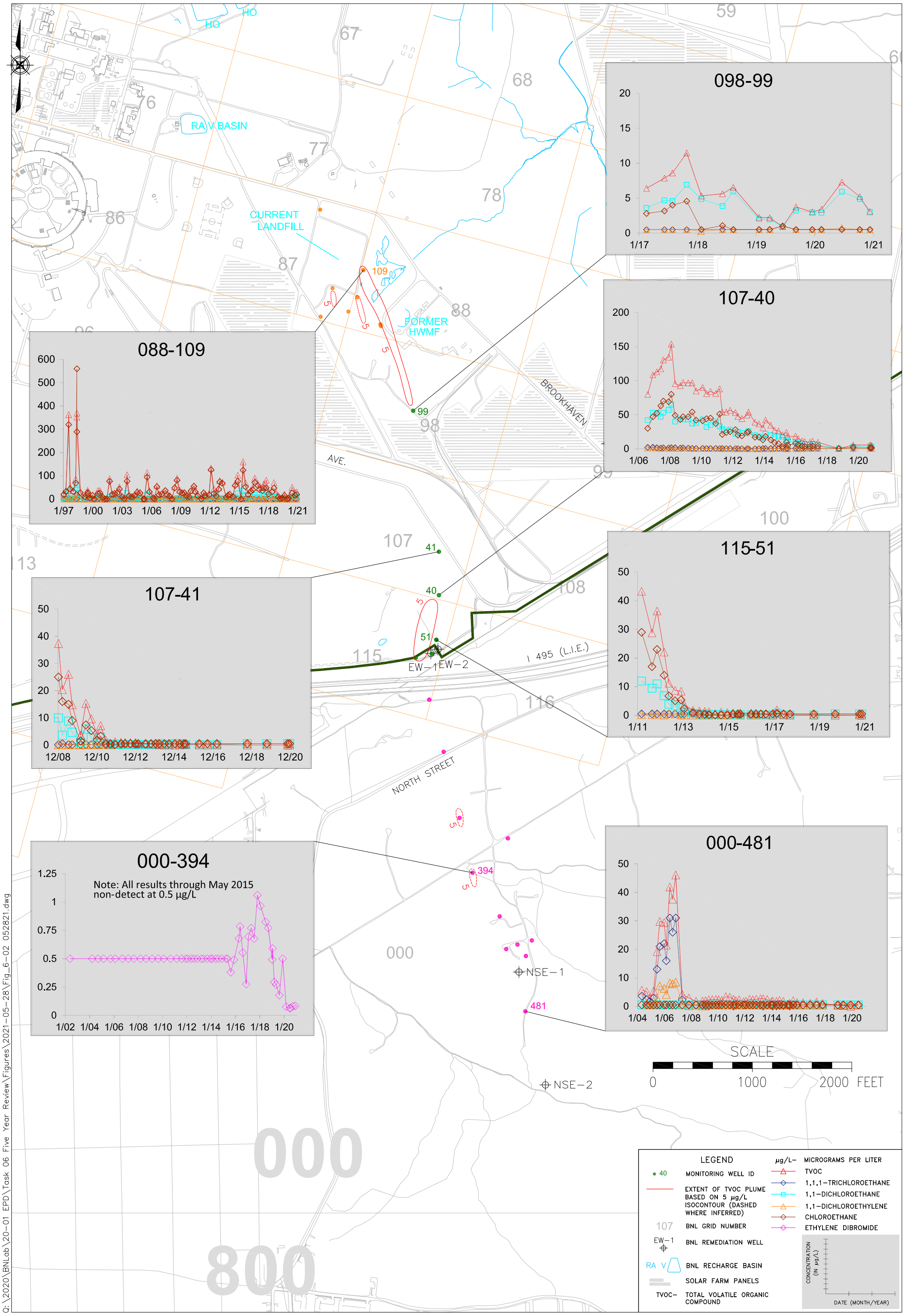

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BROOKHAVEN NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

TITLE:

OU I /CURRENT LANDFILL/ SOUTH BOUNDARY/ NORTH STREET EAST HISTORICAL VOC TRENDS

2021 BNL FIVE-YEAR REVIEW

DWN:	VT:HZ.:	DATE:	PROJECT NO.:
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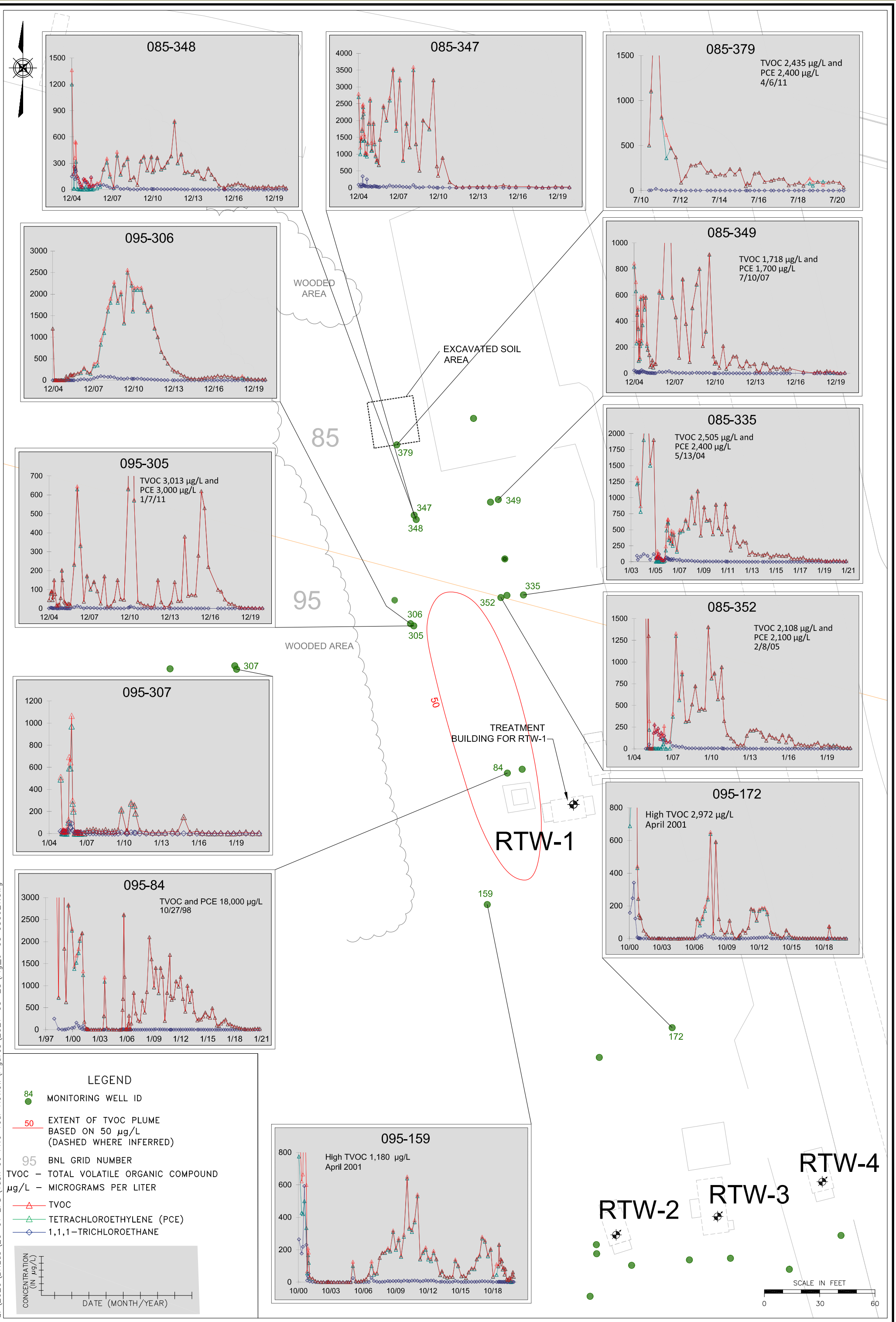

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BROOKHAVEN NATIONAL LABORATORY
ENVIRONMENTAL PROTECTION DIVISION

TITLE:

OU III BUILDING 96 AREA HISTORICAL VOC TRENDS

2021 BNL FIVE-YEAR REVIEW

DWN:	VS: HS.:	DATE:	PROJECT NO.:
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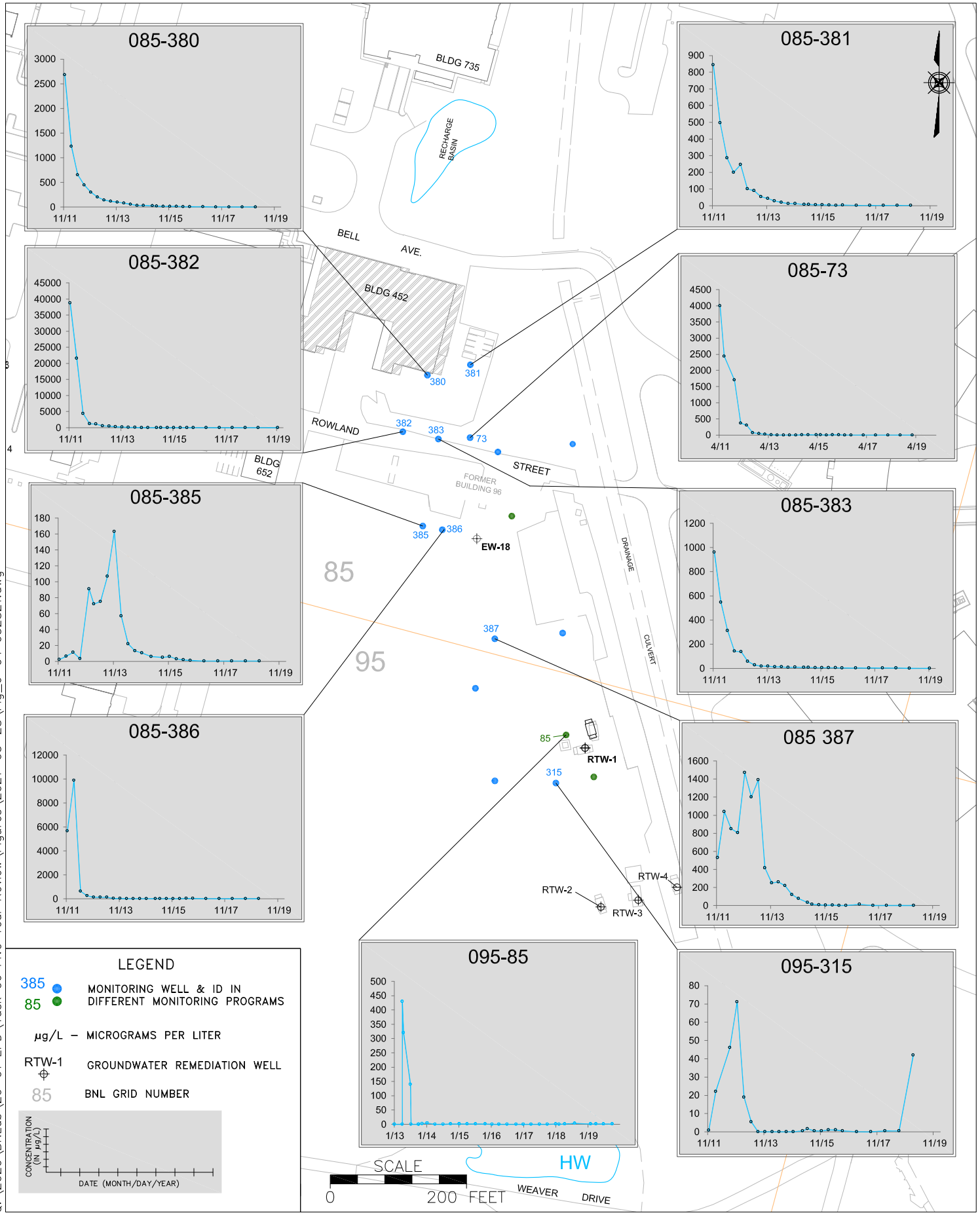
FIGURE NO.: 6–3



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BROOKHAVEN NATIONAL LABORATORY
ENVIRONMENTAL PROTECTION DIVISION

TITLE:

OU III BUILDING 452 AREA HISTORICAL FREON-11 TRENDS

2021 BNL FIVE-YEAR REVIEW

DWN:	VT: HZ.:	DATE:	PROJECT NO.:
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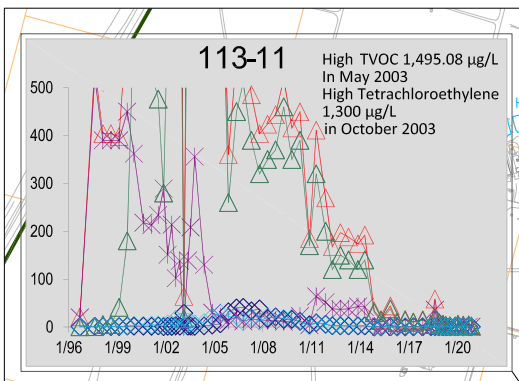

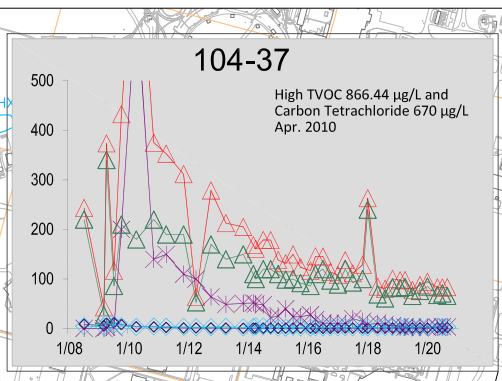

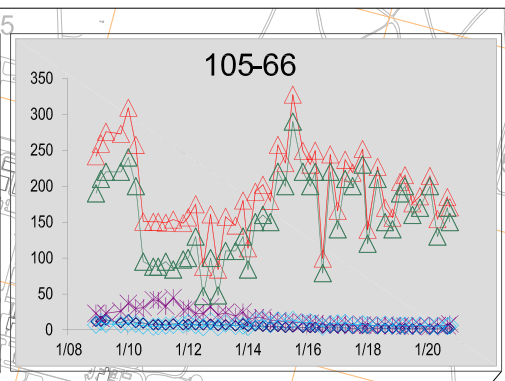

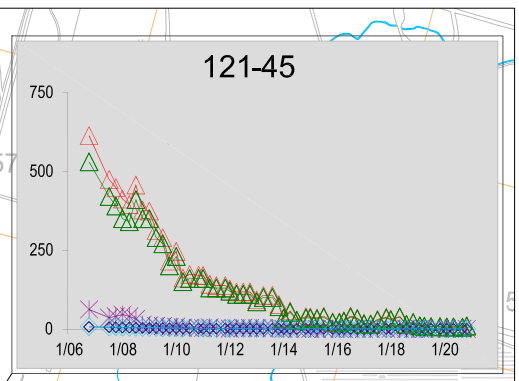

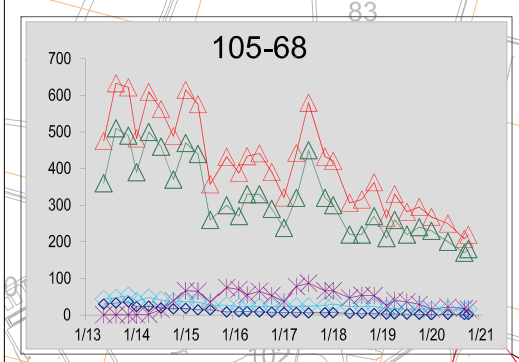

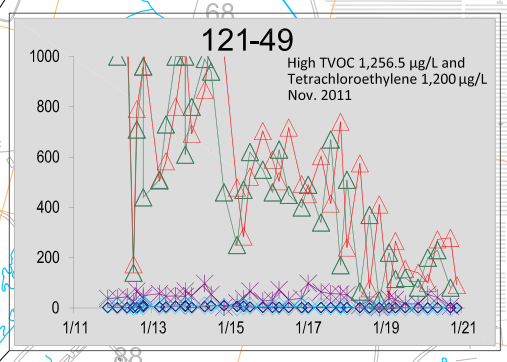

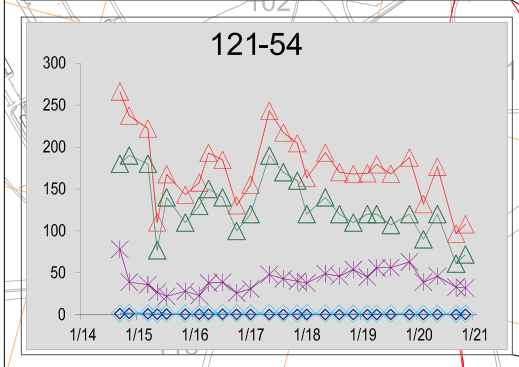

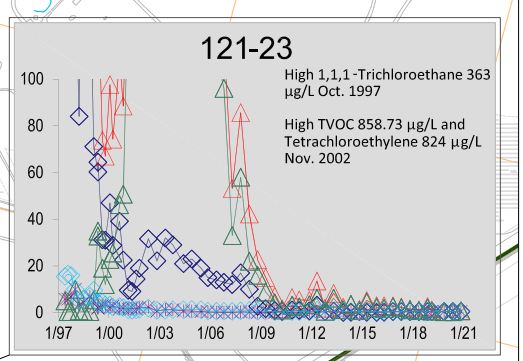

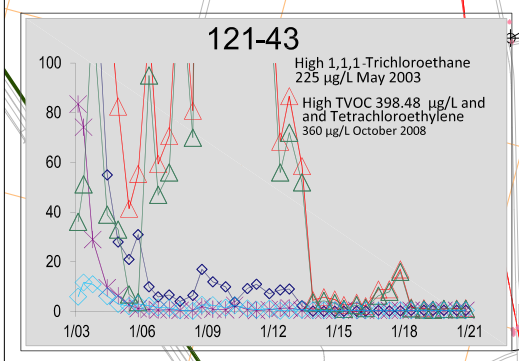

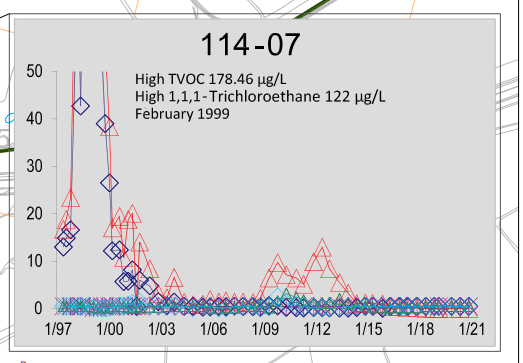

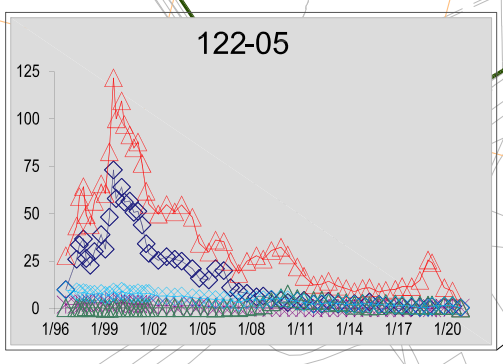

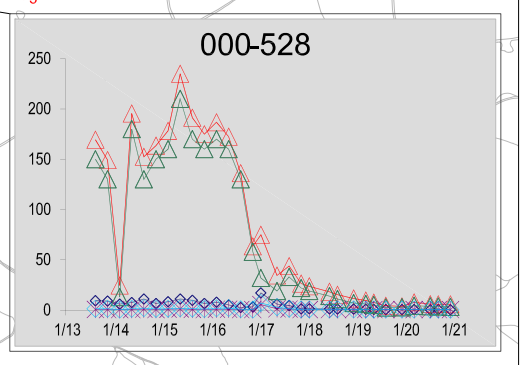

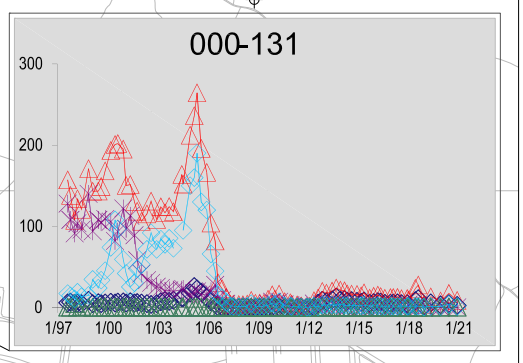

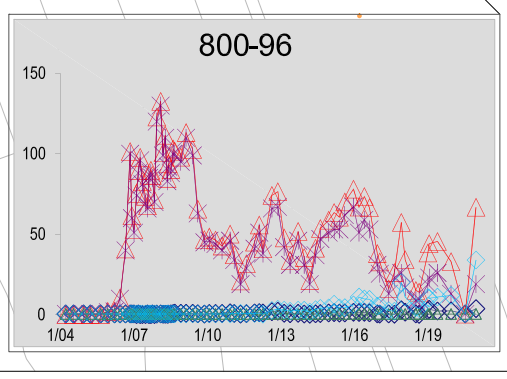

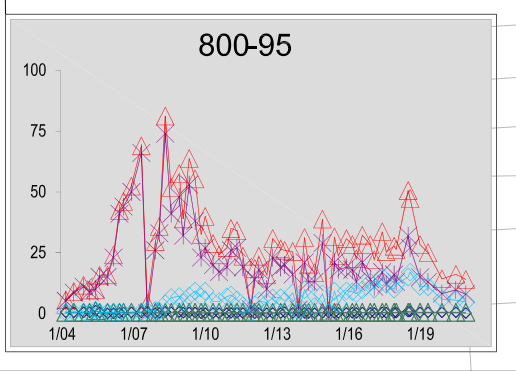

LEGEND

- 54 / 131 — MONITORING WELL & ID IN DIFFERENT MONITORING PROGRAM
- 5 — EXTENT OF TVOC PLUME BASED ON 5 µg/L ISOCONTOUR
- 105 — BNL GRID NUMBER
- EW-5 — BNL REMEDIATION WELL
- RA V — BNL RECHARGE BASIN
- SOLAR FARM PANELS
- TVOC – TOTAL VOLATILE ORGANIC COMPOUND
- µg/L – MICROGRAM PER LITER
- TVOC
- 1,1,1–TRICHLOROETHANE
- CARBON TETRACHLORIDE
- TETRACHLOROETHYLENE
- TRICHLOROETHYLENE

CONCENTRATION (N µg/L) — DATE (MONTH/YEAR)

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BROOKHAVEN NATIONAL LABORATORY
ENVIRONMENTAL PROTECTION DIVISION

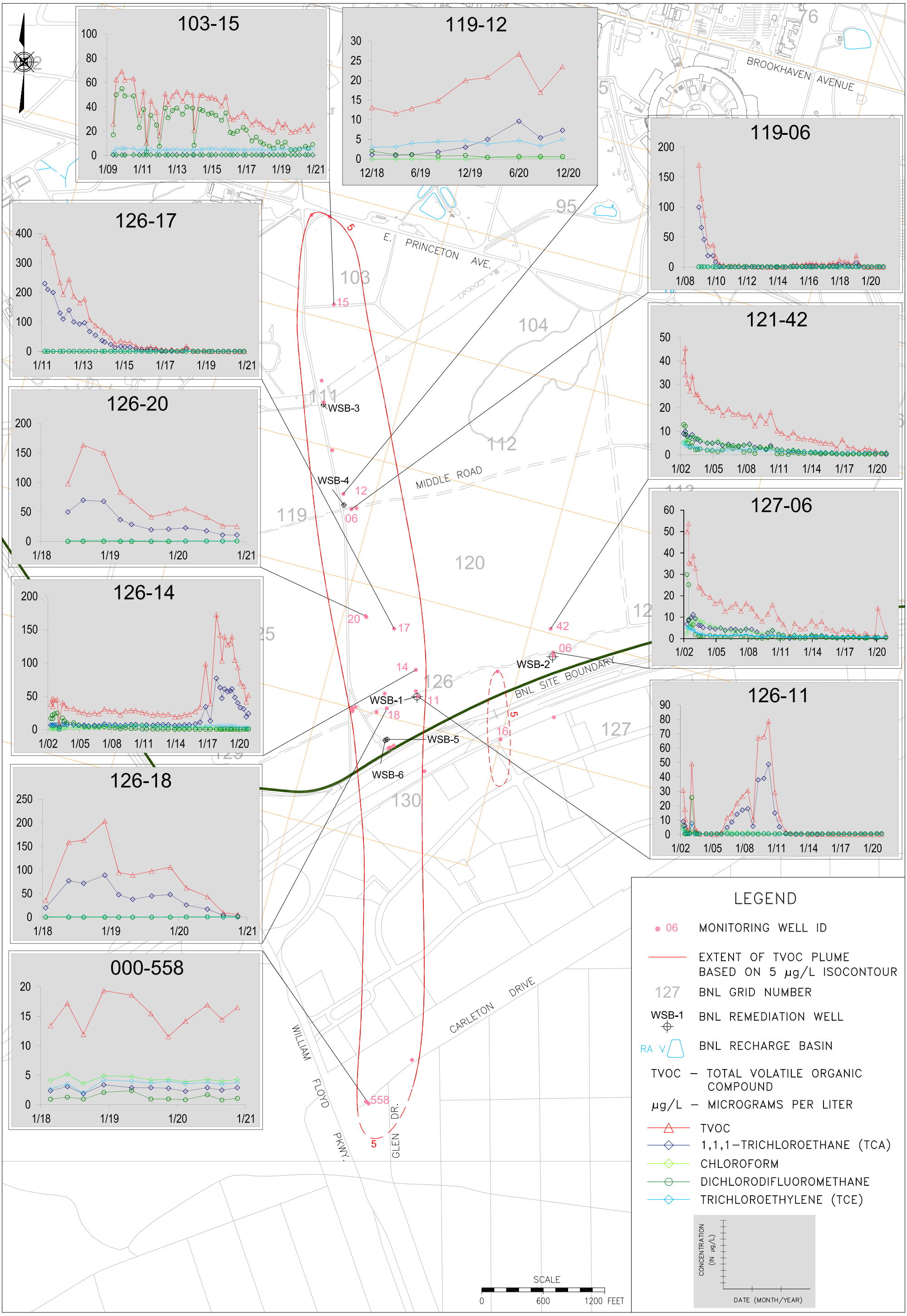
TITLE:

OU III SOUTH BOUNDARY AND OU IV PLUME(S) HISTORICAL VOC TRENDS

2021 BNL FIVE-YEAR REVIEW

DWN:	VT: HZ.:	DATE:	PROJECT NO.:
AJZ	–	05/06/21	–
CHKD:	APPD:	REV.:	NOTES:
WRD	WRD	–	–

FIGURE NO.: 6-5



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BROOKHAVEN NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

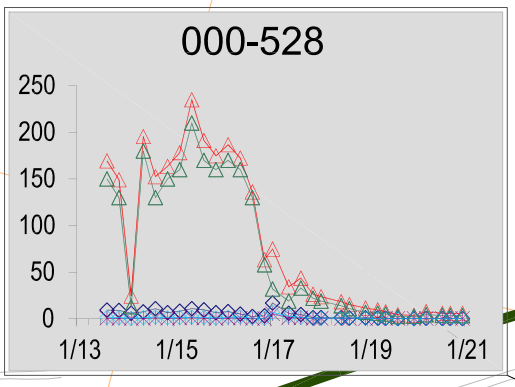
TITLE:

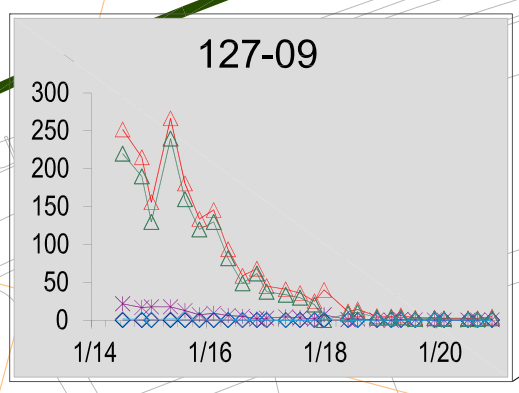
OU III WESTERN SOUTH BOUNDARY HISTORICAL VOC TRENDS

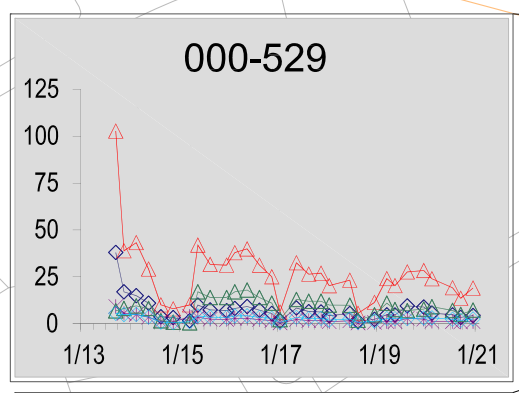
2021 BNL FIVE-YEAR REVIEW

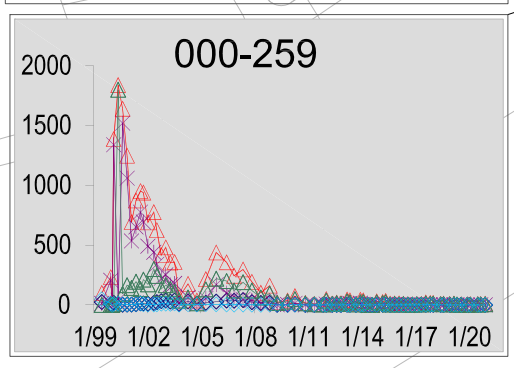
DWN:	VT: HZ.:	DATE:	PROJECT NO.:
AJZ	–	05/06/21	–
CHKD:	APPD:	REV.:	NOTES:
WRD	WRD	–	–

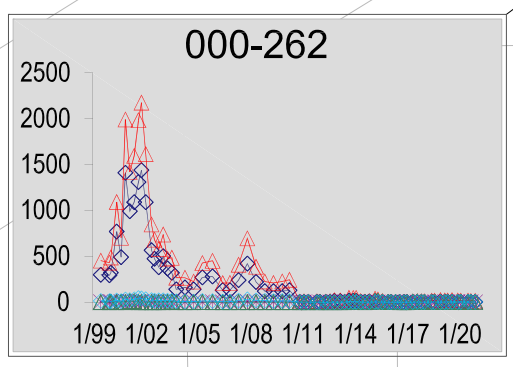
FIGURE NO.: 6–6

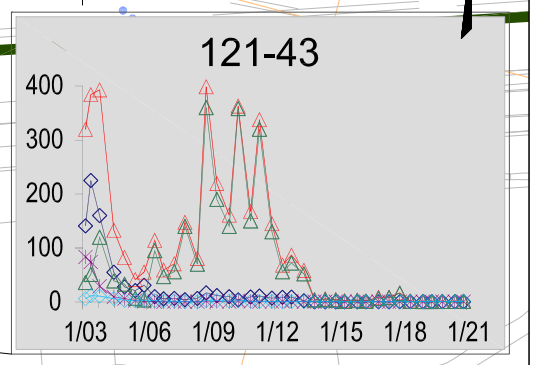


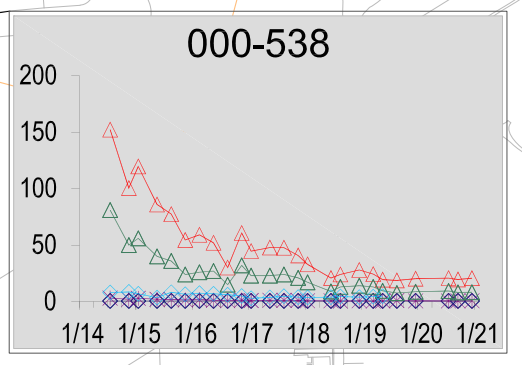


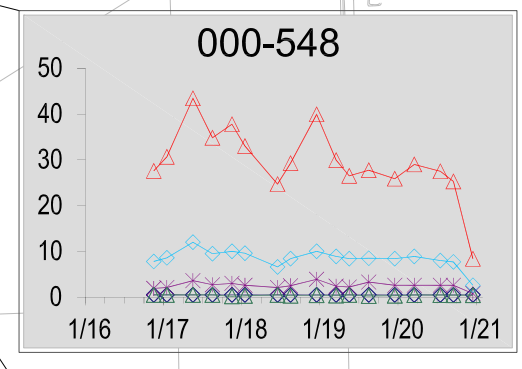


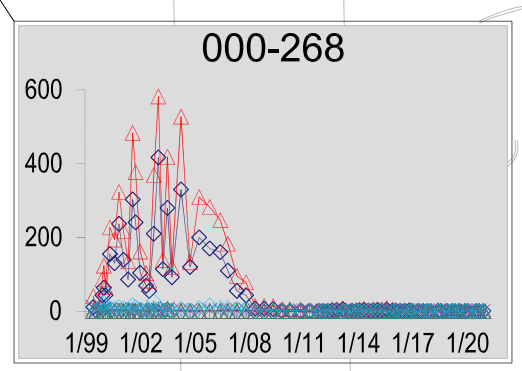










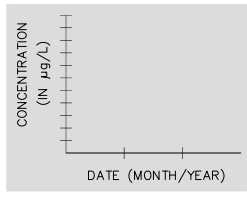


EW-3
EW-4
EW-17
EW-5
EW-6
EW-7
EW-8
EW-12
UVB-1
UVB-2
UVB-3
UVB-4
UVB-5
UVB-6
UVB-7
IP-EW-8
IP-EW-9
43
122
127
000
09
528
538
548
529
268
262
259
5
PRECISION DRIVE
RAMSAY DRIVE
LONG ISLAND RAILROAD
CARLETON DRIVE
MORICHES MIDDLE ISLAND ROAD

SCALE
0 300 600 FEET

LEGEND

- 268 MONITORING WELL ID
- EXTENT OF TVOC PLUME BASED ON 5 µg/L ISOCONTOUR
- 000 BNL GRID NUMBER
- UVB-5 BNL REMEDIATION WELL
- BNL RECHARGE BASIN
- TVOC – TOTAL VOLATILE ORGANIC COMPOUND
- µg/L – MICROGRAMS PER LITER
- TVOC
- 1,1,1–TRICHLOROETHANE (TCA)
- CARBON TETRACHLORIDE
- TETRACHLOROETHYLENE (PCE)
- TRICHLOROETHYLENE (TCE)



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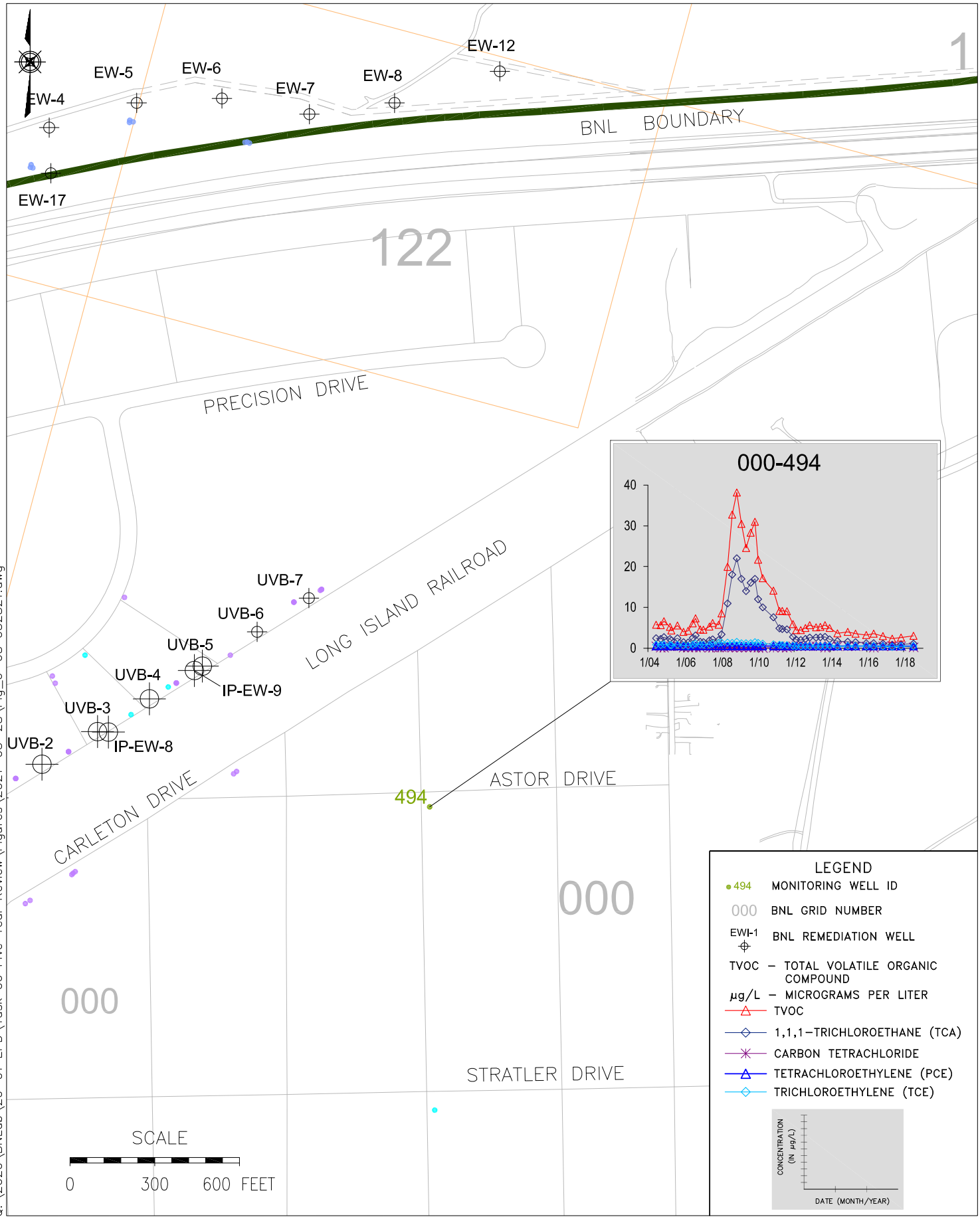
BROOKHAVEN NATIONAL LABORATORY
ENVIRONMENTAL PROTECTION DIVISION

TITLE:
OU III INDUSTRIAL PARK
HISTORICAL VOC TRENDS
2021 BNL FIVE-YEAR REVIEW

DWN:	VT: HZ.:	DATE:	PROJECT NO.:
AJZ	–	05/06/21	–
CHKD:	APPD:	REV.:	NOTES:
WRD	WRD	–	–

FIGURE NO.: 6–7



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BROOKHAVEN NATIONAL LABORATORY
ENVIRONMENTAL PROTECTION DIVISION

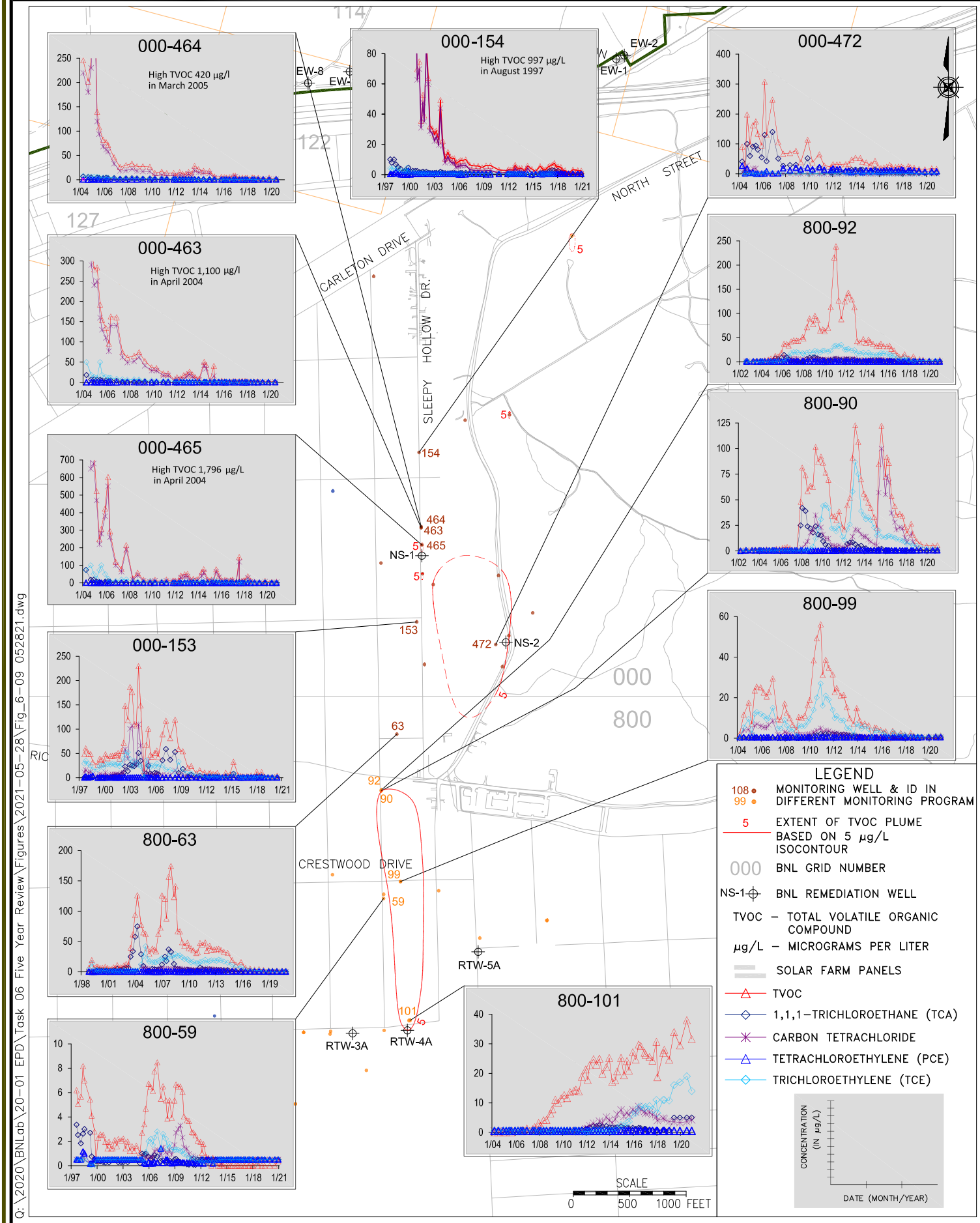
TITLE:

OU III INDUSTRIAL PARK EAST HISTORICAL VOC TRENDS

2021 BNL FIVE-YEAR REVIEW

DWN:	VT: HZ.:	DATE:	PROJECT NO.:
AJZ	–	05/06/21	–
CHKD:	APPD:	REV.:	NOTES:
WRD	WRD	–	–

FIGURE NO.: 6–8



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BROOKHAVEN NATIONAL LABORATORY
ENVIRONMENTAL PROTECTION DIVISION

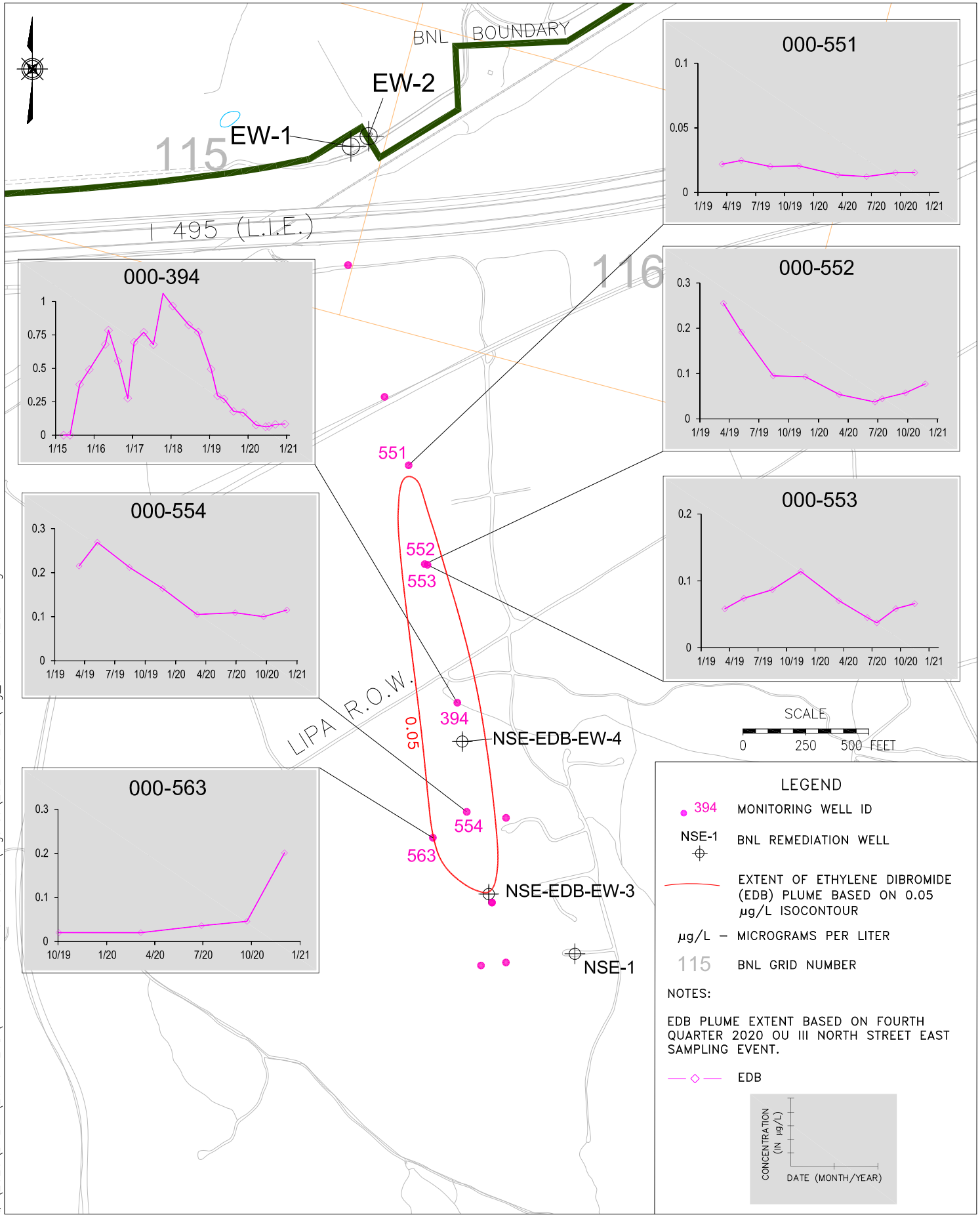
TITLE:

NORTH STREET HISTORICAL VOC TRENDS

2021 BNL FIVE-YEAR REVIEW

DWN:	VT:HZ.:	DATE:	PROJECT NO.:
AJZ	–	05/06/21	–
CHKD:	APPD:	REV.:	NOTES:
WRD	WRD	–	–

FIGURE NO.: 6–9



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BROOKHAVEN NATIONAL LABORATORY
ENVIRONMENTAL PROTECTION DIVISION

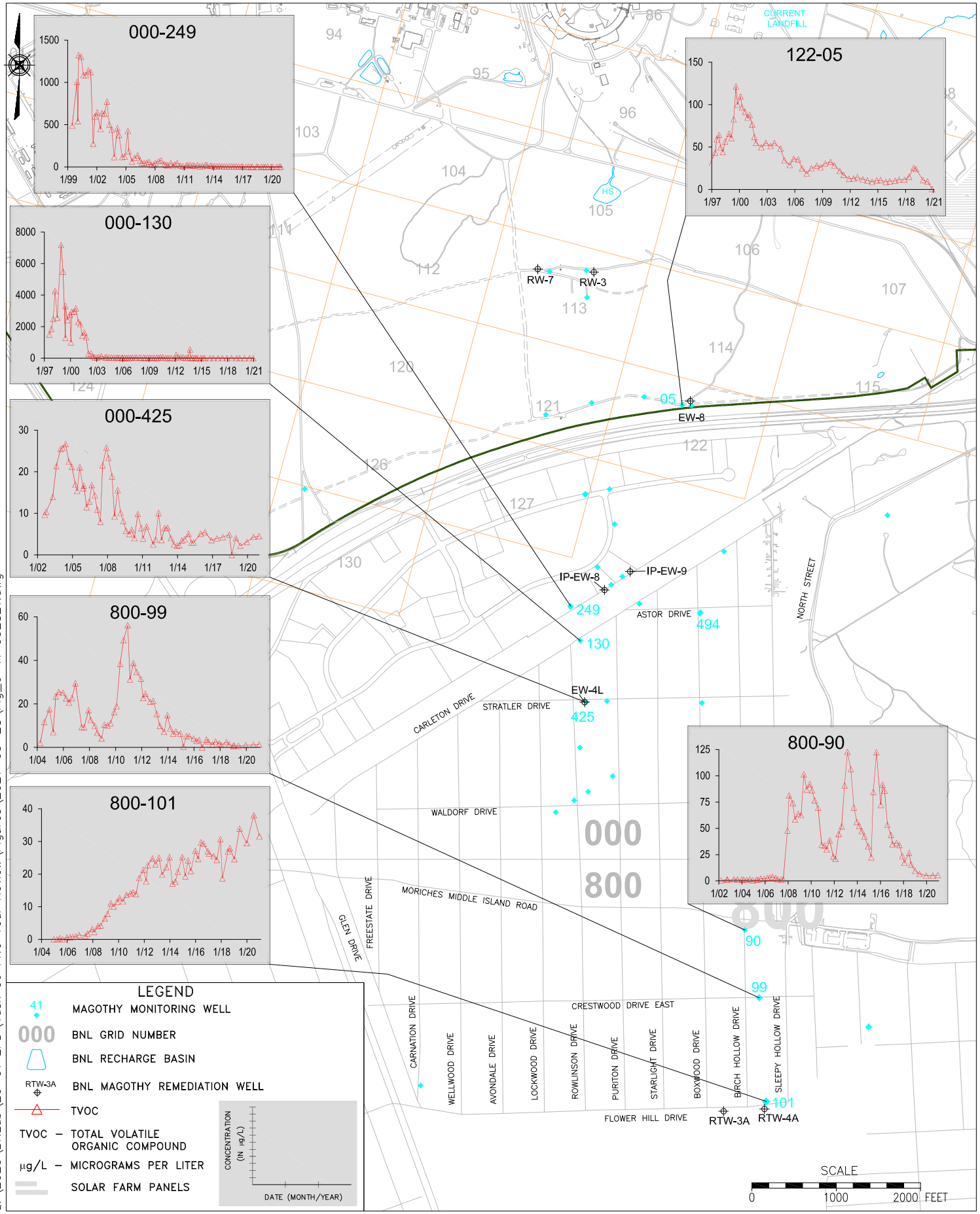
TITLE:

NORTH STREET EAST EDB TRENDS

2021 BNL FIVE-YEAR REVIEW

DWN:	VT: HZ.:	DATE:	PROJECT NO.:
AJZ	–	05/06/21	–
CHKD:	APPD:	REV.:	NOTES:
WRD	WRD		–

FIGURE NO.: 6-10



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BROOKHAVEN NATIONAL LABORATORY
ENVIRONMENTAL PROTECTION DIVISION

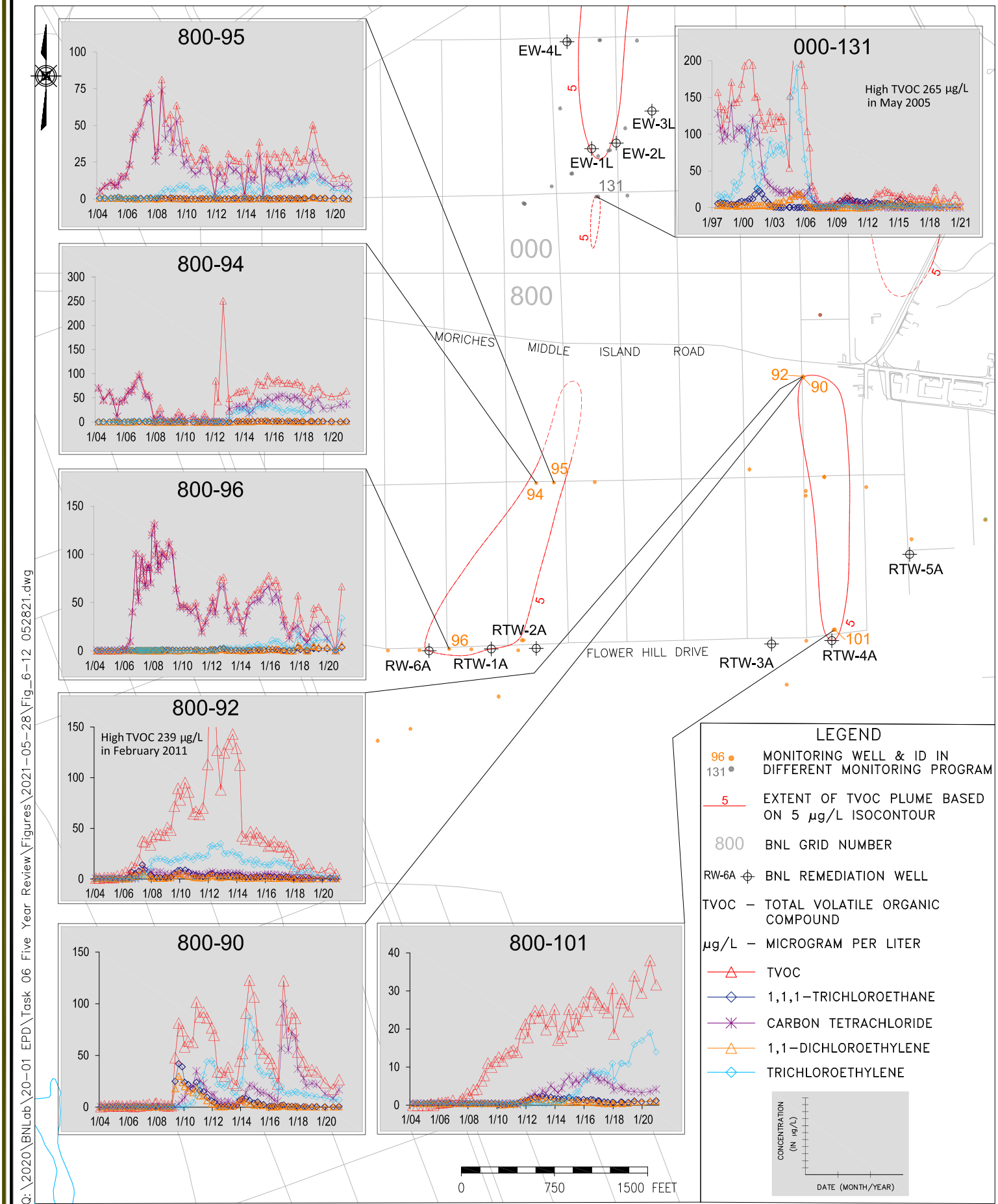
TITLE:

MAGOTHY HISTORICAL TVOC TRENDS

2021 BNL FIVE-YEAR REVIEW

DWN:	VT: HZ.:	DATE:	PROJECT NO.:
AJZ	–	05/06/21	–
CHKD:	APPD:	REV.:	NOTES:
WRD	WRD	–	–

FIGURE NO.: 6-11



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BROOKHAVEN NATIONAL LABORATORY
ENVIRONMENTAL PROTECTION DIVISION

TITLE:

OU III LIPA/AIRPORT HISTORICAL VOC TRENDS

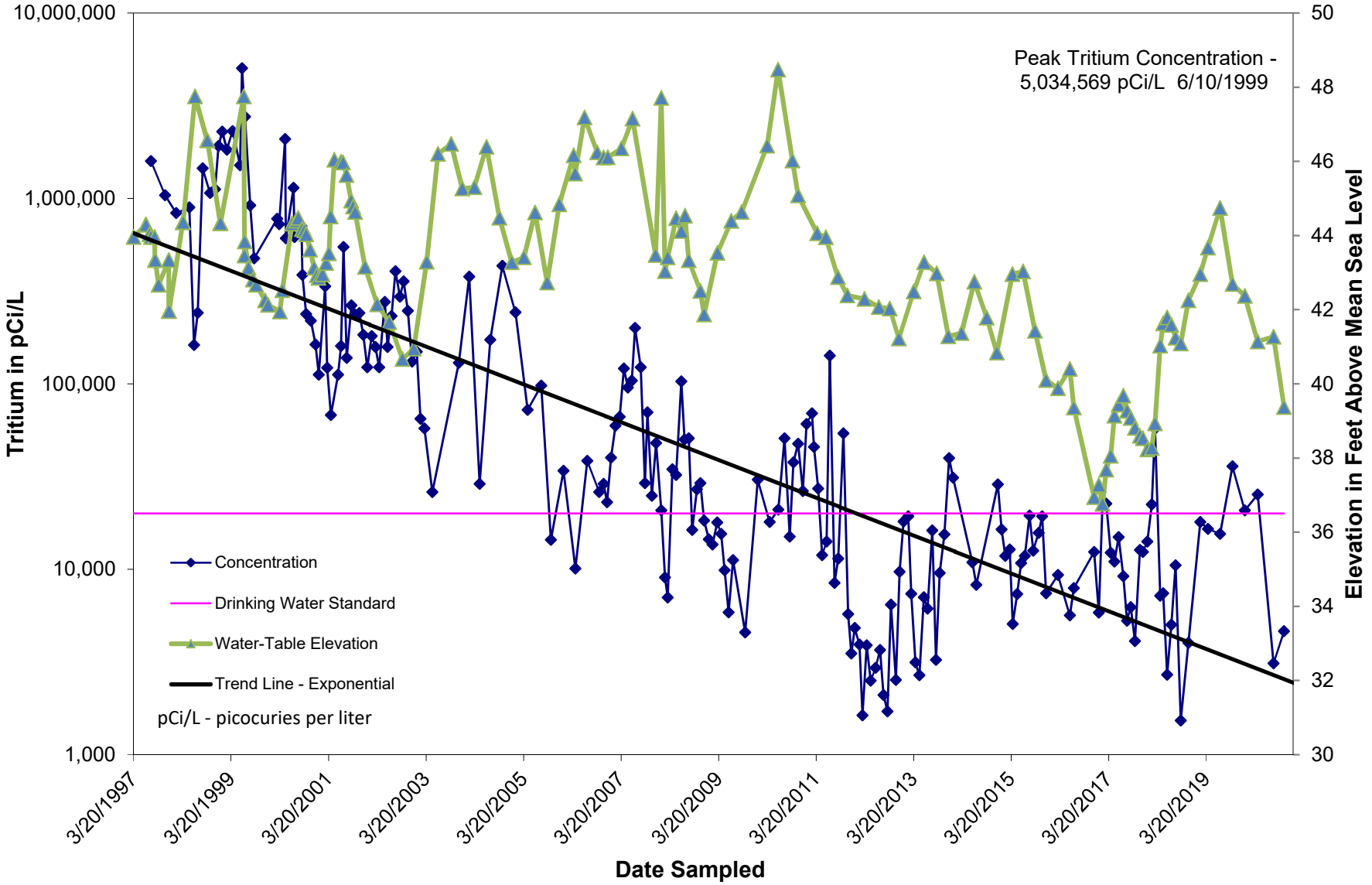
2021 BNL FIVE-YEAR REVIEW

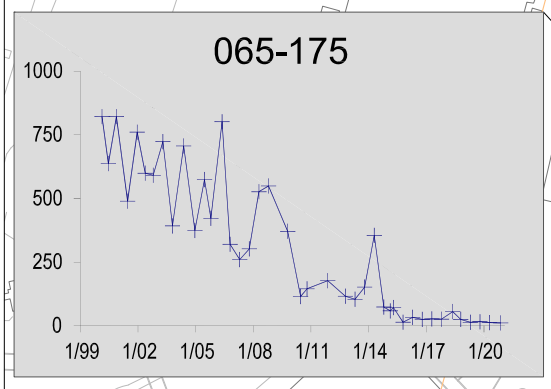
DWN:	VT:HZ.:	DATE:	PROJECT NO.:
AJZ	–	05/06/21	–
CHKD:	APPD:	REV.:	NOTES:
WRD	WRD	–	–

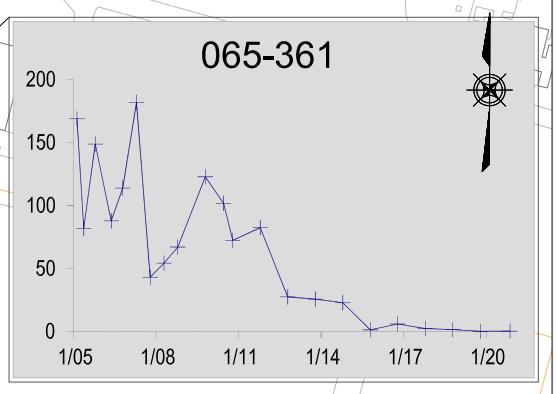
FIGURE NO.: 6-12

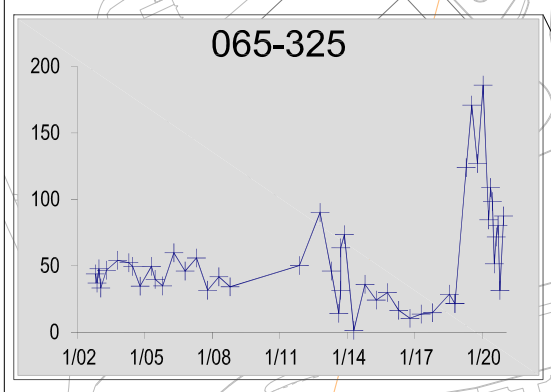
Figure 6-13
OU III HFBR
Peak Tritium Concentrations in Groundwater - HFBR to Cornell Avenue

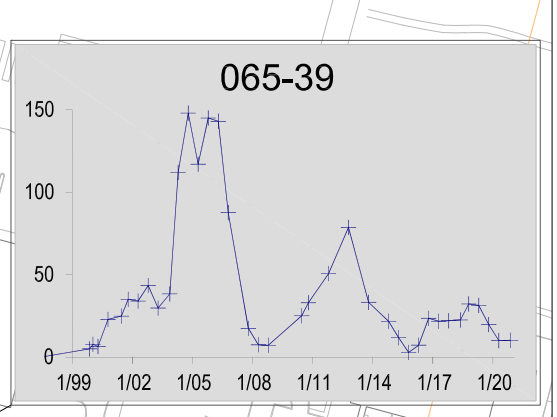
2021 BNL FIVE-YEAR REVIEW

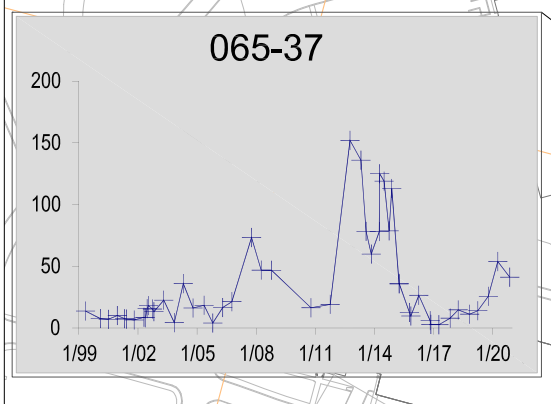


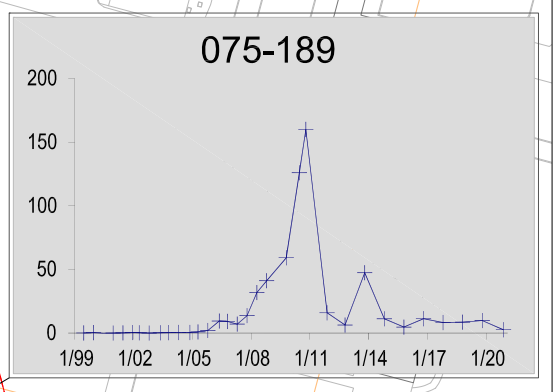


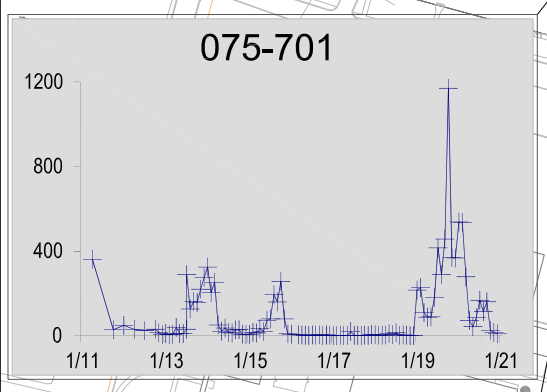


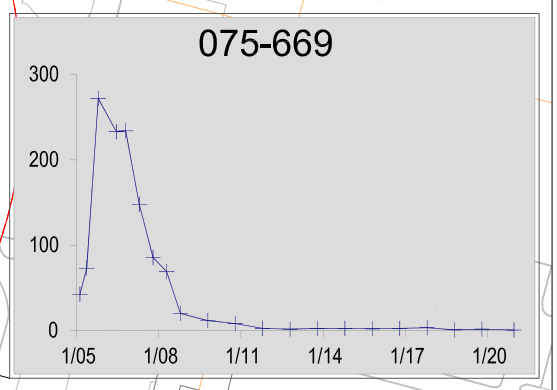


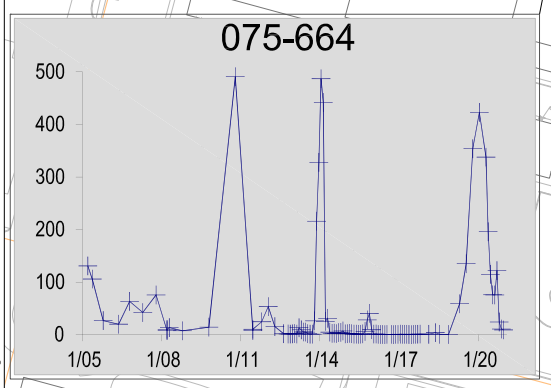


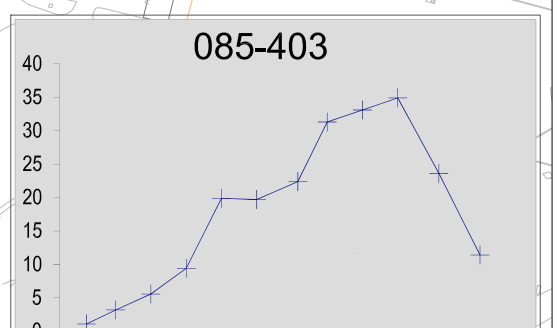












HENRY ST.
WASTE CONCENTRATION FACILITY
175
SR-1
SR-2
361
BGRR
325
39
37
65
701
664
SR-3
SR-6
HFBR
SR-5
SR-4
189
SR-7
SR-8
SR-9
CORNELL AVENUE
669
TEMPLE STREET
75
TECHNOLOGY
671
BROOKHAVEN AVENUE
85
403
ROCHESTER
ROWLAND STREET
SCALE
0 200 400 FEET

LEGEND

- 175 MONITORING WELL ID
- 8 EXTENT OF Sr-90 PLUME BASED ON 8 pCi/L ISOCONTOUR (DASHED WHERE INFERRED)
- 75 BNL GRID NUMBER
- pCi/L- PICOCURIES PER LITER
- WCF- WASTE CONCENTRATION FACILITY
- BGRR- BROOKHAVEN GRAPHITE RESEARCH REACTOR
- -+- STRONTIUM-90 (Sr-90) (pCi/L)

CONCENTRATION (IN pCi/L)
TIME (MONTH/YEAR)

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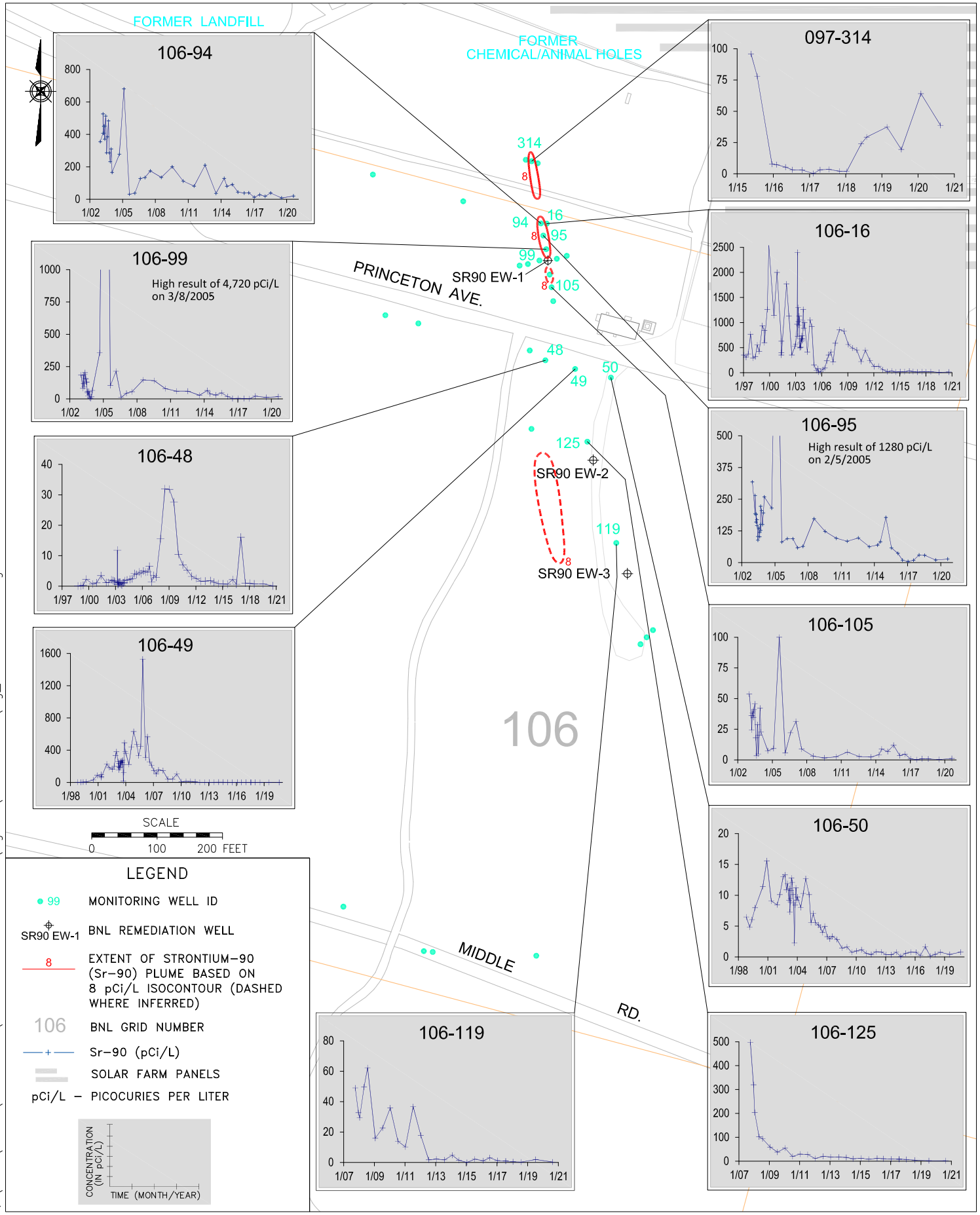
BROOKHAVEN NATIONAL LABORATORY
ENVIRONMENTAL PROTECTION DIVISION

TITLE:
OU III BGRR/WCF HISTORICAL Sr-90 TRENDS
2021 BNL FIVE-YEAR REVIEW

DWN:	VT: HZ.:	DATE:	PROJECT NO.:
AJZ	-	05/06/21	-
CHKD:	APPD:	REV.:	NOTES:
WRD	WRD	-	-

FIGURE NO.: 6-14



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BROOKHAVEN NATIONAL LABORATORY
ENVIRONMENTAL PROTECTION DIVISION

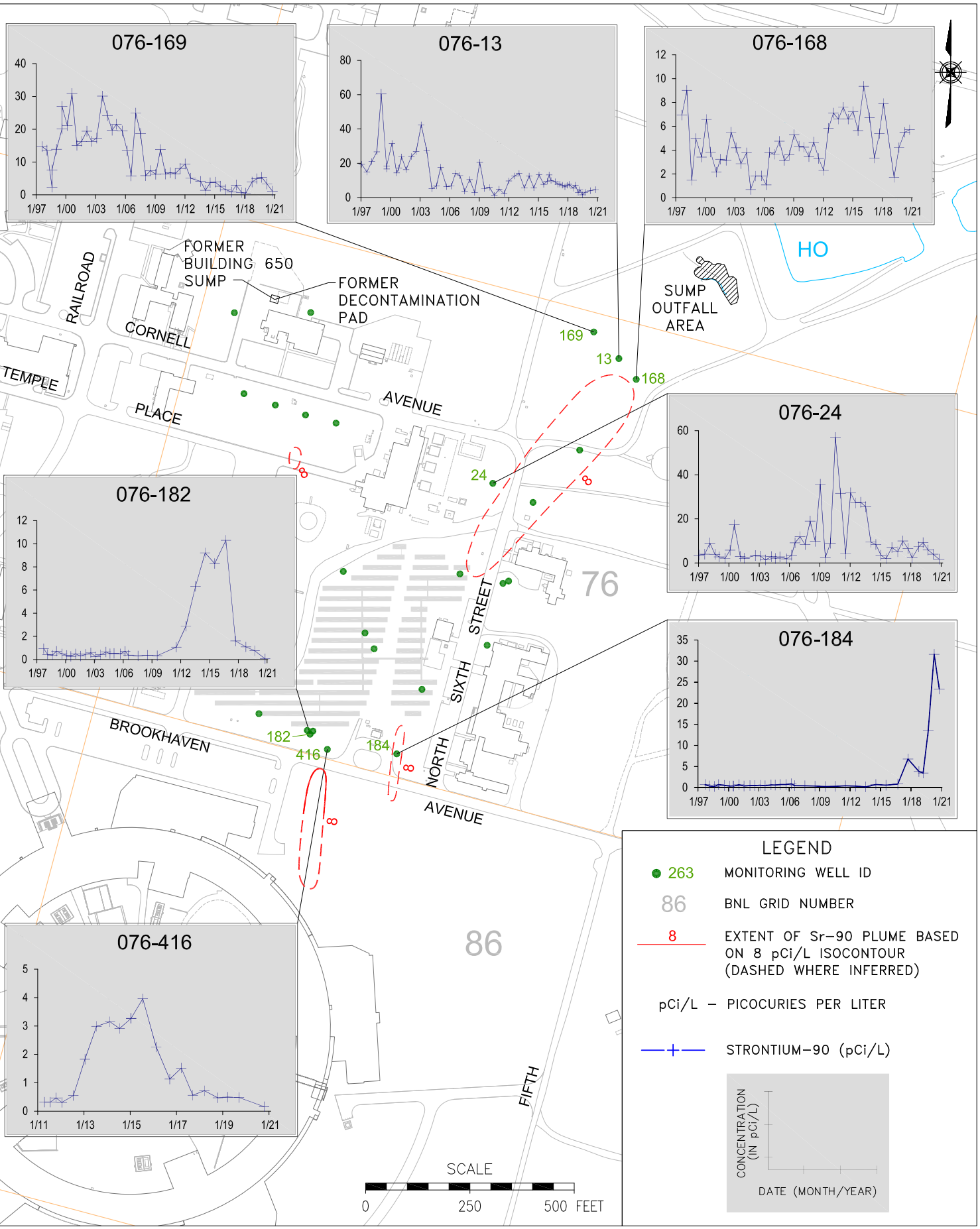
TITLE:

OU III CHEMICAL/ANIMAL HOLES HISTORICAL Sr-90 TRENDS

2021 BNL FIVE-YEAR REVIEW

DWN:	VT: HZ.:	DATE:	PROJECT NO.:
AJZ	–	05/06/21	–
CHKD:	APPD:	REV.:	NOTES:
WRD	WRD	–	–

FIGURE NO.: 6-15



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BROOKHAVEN NATIONAL LABORATORY
ENVIRONMENTAL PROTECTION DIVISION

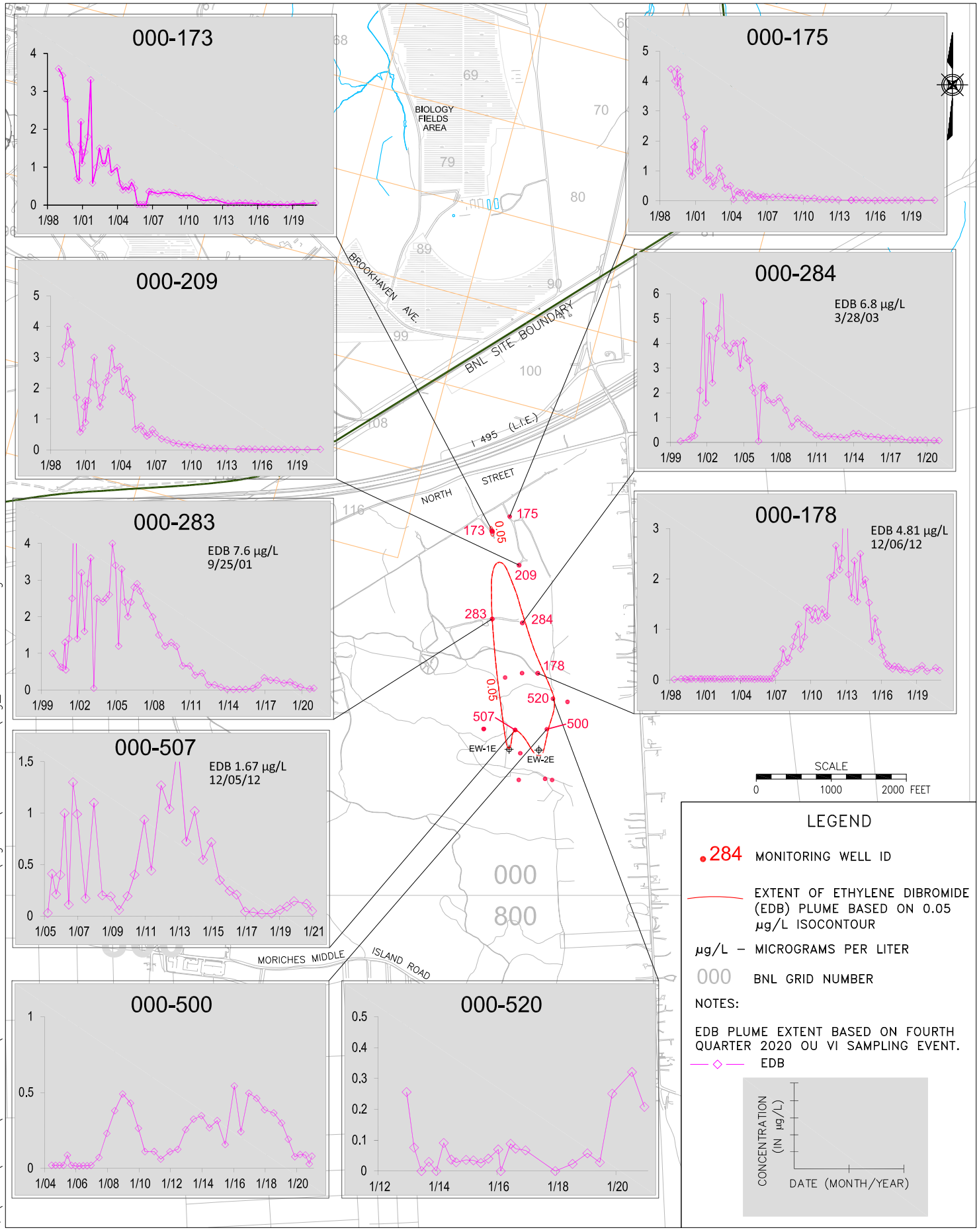
TITLE:

OU IV AOC 6
HISTORICAL Sr-90 TRENDS

2021 BNL FIVE-YEAR REVIEW

DWN:	VT: HZ.:	DATE:	PROJECT NO.:
AJZ	–	05/06/21	–
CHKD:	APPD:	REV.:	NOTES:
WRD	WRD	–	–

FIGURE NO.: 6-16



Q:\2020\BNLab\20-01 EPD\Task 06 Five Year Review\Figures\2021-05-28\Fig_6-17 052821.dwg

BROOKHAVEN NATIONAL LABORATORY
ENVIRONMENTAL PROTECTION DIVISION

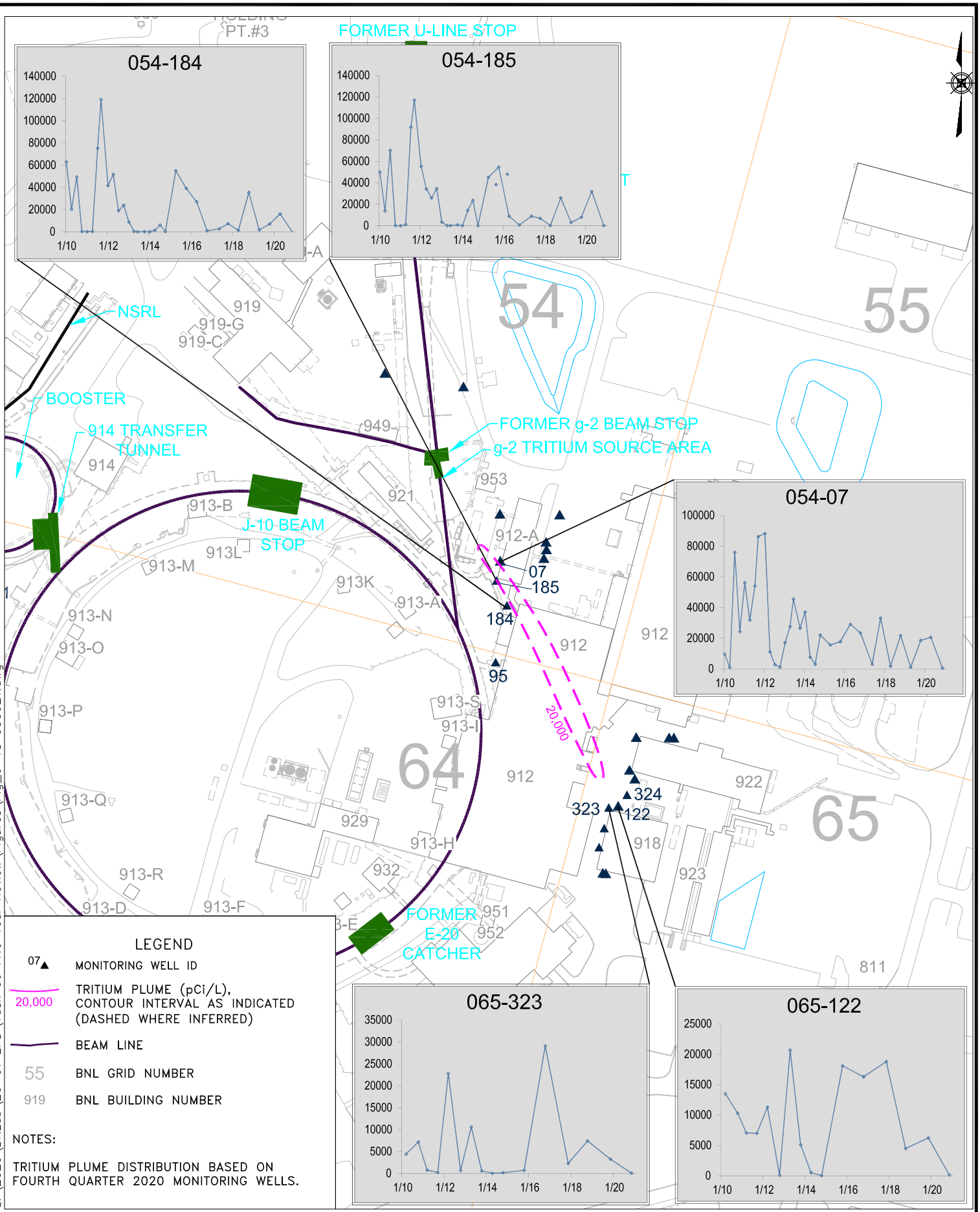
TITLE:

OU VI
HISTORICAL EDB TRENDS

2021 BNL FIVE-YEAR REVIEW

DWN:	VT: HZ.:	DATE:	PROJECT NO.:
AJZ	–	05/06/21	–
CHKD:	APPD:	REV.:	NOTES:
WRD	WRD	–	–

FIGURE NO.: 6-17



Q:\2020\BNLab\20-01 EPD\Task 06 Five Year Review\Figures\Fig_6-18 050621.dwg

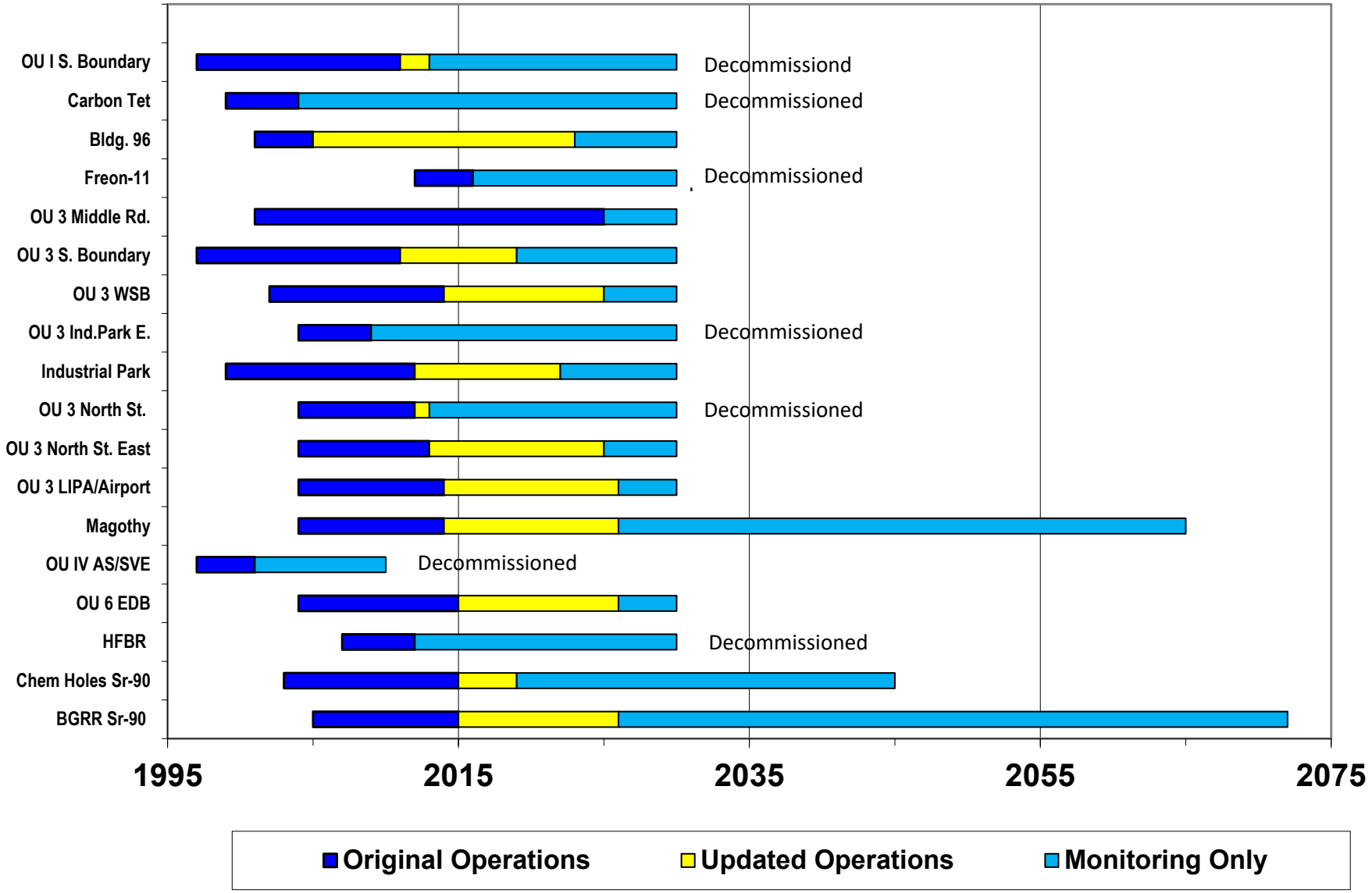
BROOKHAVEN NATIONAL LABORATORY
ENVIRONMENTAL PROTECTION DIVISION

TITLE:
FACILITY MONITORING PROGRAM, AOC 16T g-2 HISTORICAL TRITIUM TRENDS
2021 BNL FIVE-YEAR REVIEW

DWN:	VT: HZ.:	DATE:	PROJECT NO.:
AJZ	–	05/06/21	–
CHKD:	APPD:	REV.:	NOTES:
WRD	DEP	–	–

FIGURE NO.: 6-18

Figure 7-1
Groundwater Treatment System Status



X:\Five Year Review\2021 Five Year Review\Figures\Draft Figures\Figure 7-1 - GW System Timeline

Tables

(Tables 6-3 and 6-4)

Table 6-3
Permanent Monitoring and Extraction Wells Installed Since May 2015

Permant Well Identification	Temporary Identification	Well Type *	Installation Date
000-542	IP-MW-06-2014	MW	6/15/2015
000-549	EDB-MW01-2019	MW	1/8/2019
000-550	EDB-MW02-2019	MW	1/4/2019
000-551	NSE-MW01-2018	MW	11/15/2018
000-552	NSE-MW02-2018	MW	11/14/2018
000-553	NSE-MW03-2018	MW	11/8/2018
000-554	NSE-MW04-2018	MW	11/6/2018
000-555	NSE-MW05-2018	MW	11/1/2018
000-558	WSB-MW05-2017	MW	2/15/2018
000-559	WSB-MW06-2017	MW	2/13/2018
000-560	WSB-MW07-2017	MW	12/4/2018
000-563	NSE-EDB-MW01-2019	MW	8/22/2019
000-564	NSE-EDB-MW02-2019	MW	8/20/2019
000-565	NSE-EDB-MW03-2019	MW	8/30/2019
000-566	NSE-EDB-MW04-2019	MW	8/28/2019
000-567	OUVI-EDB MW01-2020	MW	10/6/2020
000-568	OUVI-EDB MW02-2020	MW	10/9/2020
075-802	HFBR-MW01-2018	MW	9/21/2018
075-803	HFBR-MW02-2018	MW	9/24/2018
075-804	HFBR-MW03-2018	MW	9/25/2018
075-805	HFBR-MW04-2018	MW	9/25/2018
075-806	HFBR-MW05-2018	MW	9/25/2018
075-807	HFBR-MW06-2018	MW	9/27/2018
075-808	HFBR-MW07-2018	MW	9/28/2018
076-418	B650-MW01-2020	MW	9/23/2020
076-419	B650-MW02-2020	MW	9/22/2020
076-420	B650-MW03-2020	MW	9/28/2020
076-421	B650-MW04-2020	MW	9/24/2020
085-403	BGRR-MW01-2015	MW	5/7/2015
095-325	B96-MW01-2019	MW	10/25/2019
095-326	BGRR-MW01-2020	MW	10/20/2020
097-313	CAH-MW01-2015	MW	5/6/2015
097-314	CAH-MW02-2015	MW	5/7/2015

Table 6-3
Permanent Monitoring and Extraction Wells Installed Since May 2015

Permant Well Identification	Temporary Identification	Well Type *	Installation Date
097-315	CAH-MW03-2015	MW	5/7/2015
098-100	OU1SB-MW01-2019	MW	10/29/2019
098-101	OU1SB-MW02-2019	MW	10/28/2019
098-102	OU1SB-MW03-2019	MW	10/28/2019
098-103	SB-MW01-2020	MW	9/29/2020
098-104	SB-MW02-2020	MW	9/30/2020
098-99	OUI-MW01-2017	MW	2/7/2017
103-18	WSB-MW01-2018	MW	3/30/2018
103-19	WSB-MW02-2018	MW	3/28/2018
106-136	CAH-MW04-2015	MW	6/3/2015
108-57	OU1-MW01-2018	MW	12/18/2018
108-58	OU1-MW02-2018	MW	12/20/2018
108-59	OU1-MW03-2018	MW	12/19/2018
111-15	WSB-MW02-2017	MW	5/2/2017
111-16	WSB-MW04-2018	MW	8/21/2018
119-11	WSB-MW01-2017	MW	2/17/2017
119-12	WSB-MW05-2018	MW	8/17/2018
126-18	WSB-MW03-2017	MW	5/4/2017
126-19	WSB-MW04-2017	MW	5/8/2017
126-20	WSB-MW03-2018	MW	3/26/2018
126-21	WSB-MW06-2018	MW	8/15/2018
126-22	WSB-MW07-2018	MW	8/31/2018
130-09	WSB-MW08-2018	MW	9/6/2018
130-10	WSB-MW09-2018	MW	9/11/2018
130-11	WSB-MW10-2018	MW	10/26/2018
111-17	WSB-EW03	EW	8/13/2018
119-13	WSB-EW04	EW	8/24/2018
130-12	WSB-EW05	EW	7/11/2018
130-13	WSB-EW06	EW	7/26/2018
000-561	NSE-EDB-EW03	EW	8/26/2019
000-562	NSE-EDB-EW04	EW	8/14/2019

* MW = Monitoring Well, EW = Extraction Well

Table 6-4
Monitoring Wells Decommissioned Since October 2015

Permanent Well Identification	Project	Decommissioned Date
000-280	Ind. Park	2/18/2021
060-02	Peconic	7/18/2017
065-40	HFBR	10/25/2018
075-12	HFBR	9/26/2018
075-208	HFBR	10/26/2018
075-209	HFBR	10/26/2018
075-211	HFBR	10/26/2018
075-224	HFBR	9/27/2018
075-225	HFBR	9/27/2018
075-226	HFBR	9/27/2018
075-227	HFBR	9/27/2018
075-228	HFBR	9/27/2018
075-229	HFBR	9/27/2018
075-230	HFBR	9/27/2018
075-231	HFBR	9/27/2018
075-232	HFBR	9/27/2018
075-233	HFBR	9/27/2018
075-234	HFBR	9/27/2018
075-235	HFBR	9/27/2018
075-236	HFBR	9/27/2018
075-237	HFBR	9/27/2018
075-238	HFBR	9/27/2018
075-239	HFBR	9/27/2018
075-240	HFBR	9/27/2018
075-241	HFBR	9/27/2018
075-242	HFBR	9/27/2018
075-243	HFBR	9/27/2018
075-244	HFBR	9/27/2018
075-245	HFBR	9/27/2018
075-285	HFBR	9/27/2018
075-289	HFBR	11/17/2018
075-292	HFBR	10/26/2018

Table 6-4
Monitoring Wells Decommissioned Since October 2015

Permanent Well Identification	Project	Decommissioned Date
075-293	HFBR	10/26/2018
075-294	HFBR	11/17/2018
075-295	HFBR	11/17/2018
075-42	HFBR	9/26/2018
075-43	HFBR	9/26/2018
075-44	HFBR	9/26/2018
075-45	HFBR	9/26/2018
075-88	HFBR	10/26/2018
075-89	HFBR	10/26/2018
076-11	NA	8/2/2017
076-177	HFBR	10/25/2018
085-40	HFBR	10/25/2018
085-71	HFBR	11/6/2018
095-44	HFBR	10/26/2018
095-46	HFBR	10/26/2018
095-48	HFBR	10/26/2018
095-51	HFBR	11/6/2018
098-101	OU I FHWMF Sr-90	9/30/2020
098-102	OU I FHWMF Sr-90	9/30/2020
104-10	HFBR	10/26/2018
122-24	Water Level	2/18/2021
122-25	Ind. Park East	2/18/2021

Attachment 1

Poll from February 20, 2020 BNL Email Survey to the Community Advisory Council

From:	Sundin, Nora
To:	Howe, Robert F
Subject:	FW: CAC Five Year Review Survey
Date:	Thursday, February 20, 2020 12:31:59 PM
Attachments:	Five Year Review Survey CAC.pdf

Nora Sundin
Manager, Environmental Communications & Outreach
Brookhaven National Laboratory
PO Box 5000, Building 462
Upton, NY 11973
631-344-4458
nsundin@bnl.gov

From: McKay, Robyn <rmckay@bnl.gov>
Sent: Thursday, February 20, 2020 12:06 PM
To: Manning, David <dmanning@bnl.gov>
Cc: Genzer, Peter A <genzer@bnl.gov>; Sundin, Nora <nsundin@bnl.gov>; Mr. C. Reed Hodgin <rhodgin@alphatrac.com>
Subject: CAC Five Year Review Survey

Dear CAC members,

At the February 13, 2020 meeting it was announced during the Environmental Updates portion of the agenda that the next Five-Year Review, as required by CERCLA, would be due in 2021. As part of the Review, the CAC and others are being asked for input.

Please complete the enclosed questionnaire at your convenience.

Completed surveys will be collected at the March 12 meeting or you can email it back to rmckay@bnl.gov . You will have an opportunity to discuss your responses at the meeting.

Robyn McKay
Brookhaven National Laboratory
Stakeholder Relations Office, Bldg. 400C
Upton, NY 11973
(631) 344-4959
rmckay@bnl.gov

Community Advisory Council to Brookhaven National Laboratory
Bldg. 400C, P.O. Box 5000, Upton, New York 11973

Members

Five-Year Review Survey

Community Advisory Council
February 18, 2020

CAC members are requested to participate in a survey to gather information that will be appended to the 2021 Five-Year Review. Input is being sought on the following questions:

1. What is your overall impression of BNL's cleanup and do you feel well informed about the cleanup activities and progress?

2. Are there any specific aspects of the cleanup that you feel should be of particular focus during the review? (e.g. Records of Decision, cleanup goals, community input, etc.)

3. Do you feel confident in BNL and DOE's management of the long-term cleanup operations for the site?

4. Do you have any comments, suggestions, or recommendations regarding BNL / DOE's management and communications of the cleanup?

(Please use the reverse side should you require additional space for your responses)

RESPONDENTS: 4 of 4

QUESTION SUMMARIES | INSIGHTS AND DATA TRENDS | INDIVIDUAL RESPONSES

Respondent #1

Edit | Delet

COMPLETE

Collector:	Web Link 1 (Web Link)
Started:	Tuesday, March 31, 2020 10:26:54 AM
Last Modified:	Tuesday, March 31, 2020 10:37:10 AM
Time Spent:	00:10:16
IP Address:	24.185.98.66

Page 1: BNL Five-Year Review SurveyBNL Community Advisory Council (CAC)

Q1

What is your overall impression of BNL's cleanup, and do you feel well informed about the cleanup activities progress?

I believe BSA/BNL is doing a wonderful job with respect to cleanup efforts. Their sharing of status/information with the CAC l excellent .

Q2

Are there any specific aspects of the cleanup that you feel should be of particular focus during the review? (e of Decision, cleanup goals, community input, etc.)

Any RODs that are forthcoming; Continued updates with respect to the stack removal.

Q3

Do you feel confident in BNL and DOE's management of the long-term cleanup operations for the site?

Yes.

Q4

Do you have any comments, suggestions, or recommendations regarding BNL / DOE's management and communications of the cleanup?

Keep up the good work. Continue to update the CAC.

Q5

Is there anything else regarding the BNL Five-Year Review that you would like to share?

No.

Q6

About You:

Name	Mark Israel
Organization	BNL Retired Employees Association (BREA)

ENGLISH

RESPONDENTS: 4 of 4

QUESTION SUMMARIES | INSIGHTS AND DATA TRENDS | INDIVIDUAL RESPONSES

Respondent #4

COMPLETE

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Last Modified: Wednesday, April 01, 2020 5:56:35 PM
Time Spent: 00:20:17
IP Address: 24.190.40.95

Page 1: BNL Five-Year Review SurveyBNL Community Advisory Council (CAC)

Q1

What is your overall impression of BNL's cleanup, and do you feel well informed about the cleanup activities progress?

From the information we've received, it appears BNL's cleanup efforts continue to mitigate the various plumes. We are given presentations annually regarding cleanup activities and progress.

Q2

Are there any specific aspects of the cleanup that you feel should be of particular focus during the review? (e of Decision, cleanup goals, community input, etc.)

Progress towards meeting cleanup goals. Also, cleanup of the newer found substances (PFA/PFOAs and 1,4 dioxane)) should addressed.

Q3

Do you feel confident in BNL and DOE's management of the long-term cleanup operations for the site?

Yes, BNL management and DOE appear to be addressing the cleanup operations with conviction.

Q4

Do you have any comments, suggestions, or recommendations regarding BNL / DOE's management and communications of the cleanup?

They should be congratulated on responding quickly and openly to the discovery and testing of PFA/PFOAs from Lab operatic cooperation with local authorities.

Q5

Is there anything else regarding the BNL Five-Year Review that you would like to share?

I appreciate the positive effect of a formal review of the cleanup efforts on all involved parties.

Q6

About You:

Name	Ray Keenan
Organization	Affiliated Brookhaven Civic Organizations

RESPONDENTS: 4 of 4

QUESTION SUMMARIES | INSIGHTS AND DATA TRENDS | INDIVIDUAL RESPONSES

Respondent #3

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Time Spent:	00:08:39
IP Address:	69.118.142.17

Page 1: BNL Five-Year Review SurveyBNL Community Advisory Council (CAC)

Q1

What is your overall impression of BNL's cleanup, and do you feel well informed about the cleanup activities progress?

BNL takes the cleanup issue very seriously, and has been quite diligent in addressing it.

Q2

Are there any specific aspects of the cleanup that you feel should be of particular focus during the review? (e of Decision, cleanup goals, community input, etc.)

Cannot think of much. Sometimes the presentations are, er, a bit too fine grained.

Q3

Do you feel confident in BNL and DOE's management of the long-term cleanup operations for the site?

yes

Q4

Do you have any comments, suggestions, or recommendations regarding BNL / DOE's management and communications of the cleanup?

See above remark about presentations.

Q5

Is there anything else regarding the BNL Five-Year Review that you would like to share?

BNL's response to environmental issues is impressive. I am happy to make a tiny contribution to this effort by serving on the

Q6

About You:

Name	Reinhardt Schuhmann
Organization	American Physical Society

ENGLISH

RESPONDENTS: 4 of 4

QUESTION SUMMARIES | INSIGHTS AND DATA TRENDS | INDIVIDUAL RESPONSES

Respondent #2

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Time Spent:	00:01:54
IP Address:	69.113.178.29

Page 1: BNL Five-Year Review SurveyBNL Community Advisory Council (CAC)

Q1

What is your overall impression of BNL's cleanup, and do you feel well informed about the cleanup activities progress?

Excellent

Q2

Are there any specific aspects of the cleanup that you feel should be of particular focus during the review? (e of Decision, cleanup goals, community input, etc.)

Nothing special.

Q3

Do you feel confident in BNL and DOE's management of the long-term cleanup operations for the site?

Yes

Q4

Do you have any comments, suggestions, or recommendations regarding BNL / DOE's management and communications of the cleanup?

No.

Q5

Is there anything else regarding the BNL Five-Year Review that you would like to share?

No.

Q6

About You:

Name	David Sprintzen
Organization	Emeritus-to be determined.

ENGLISH

RESPONDENTS: 7 of 7

QUESTION SUMMARIES | INSIGHTS AND DATA TRENDS | INDIVIDUAL RESPONSES

Respondent #7

COMPLETE

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Started:	Monday, April 06, 2020 5:35:45 PM
Last Modified:	Monday, April 06, 2020 5:39:34 PM
Time Spent:	00:03:48
IP Address:	67.84.145.102

Page 1: BNL Five-Year Review SurveyBNL Community Advisory Council (CAC)

Q1

What is your overall impression of BNL's cleanup, and do you feel well informed about the cleanup activities progress?

I see from the frequent updates presented to the CAC that the clean-up is progressing very well.

Q2

Are there any specific aspects of the cleanup that you feel should be of particular focus during the review? (e of Decision, cleanup goals, community input, etc.)

No specifics, the reviews are sufficient

Q3

Do you feel confident in BNL and DOE's management of the long-term cleanup operations for the site?

Yes, both are doing a good job.

Q4

Do you have any comments, suggestions, or recommendations regarding BNL / DOE's management and communications of the cleanup?

No comments at this time.

Q5

Is there anything else regarding the BNL Five-Year Review that you would like to share?

No.

Q6

About You:

Name	Paul Ziems
Organization	Coram Civic

RESPONDENTS: 7 of 7

QUESTION SUMMARIES | INSIGHTS AND DATA TRENDS | INDIVIDUAL RESPONSES

Respondent #6

COMPLETE

Edit | Delet

Collector: Web Link 1 (Web Link)
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Last Modified: Monday, April 06, 2020 11:03:06 AM
Time Spent: 00:01:43
IP Address: 130.199.166.55

Page 1: BNL Five-Year Review SurveyBNL Community Advisory Council (CAC)

Q1

What is your overall impression of BNL's cleanup, and do you feel well informed about the cleanup activities progress?

Excellent job, and yes, they were very informative.

Q2

Are there any specific aspects of the cleanup that you feel should be of particular focus during the review? (e of Decision, cleanup goals, community input, etc.)

No

Q3

Do you feel confident in BNL and DOE's management of the long-term cleanup operations for the site?

Absolutely Yes.

Q4

Do you have any comments, suggestions, or recommendations regarding BNL / DOE's management and communications of the cleanup?

None.

Q5

Is there anything else regarding the BNL Five-Year Review that you would like to share?

No. Thank you

Q6

About You:

Name	Linda Rundlett
Organization	Wading River Civic Association, Alternate

RESPONDENTS: 7 of 7

QUESTION SUMMARIES | INSIGHTS AND DATA TRENDS | INDIVIDUAL RESPONSES

Respondent #5

COMPLETE

Edit | Delet

Collector:	Web Link 1 (Web Link)
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Last Modified:	Monday, April 06, 2020 10:56:48 AM
Time Spent:	00:03:43
IP Address:	24.47.255.121

Page 1: BNL Five-Year Review SurveyBNL Community Advisory Council (CAC)

Q1

What is your overall impression of BNL's cleanup, and do you feel well informed about the cleanup activities progress?

not a member long enough to judge

Q2

Are there any specific aspects of the cleanup that you feel should be of particular focus during the review? (e of Decision, cleanup goals, community input, etc.)

no

Q3

Do you feel confident in BNL and DOE's management of the long-term cleanup operations for the site?

don't know

Q4

Do you have any comments, suggestions, or recommendations regarding BNL / DOE's management and communications of the cleanup?

no

Q5

Is there anything else regarding the BNL Five-Year Review that you would like to share?

no

Q6

About You:

Name	Janis Rottkamp
Organization	Alternate - Town of Riverhead

ENGLISH

RESPONDENTS: 8 of 8

QUESTION SUMMARIES | INSIGHTS AND DATA TRENDS | INDIVIDUAL RESPONSES

Respondent #8

COMPLETE

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Last Modified: Tuesday, April 07, 2020 9:04:44 AM
Time Spent: 18:32:49
IP Address: 24.189.237.199

Page 1: BNL Five-Year Review SurveyBNL Community Advisory Council (CAC)

Q1

What is your overall impression of BNL's cleanup, and do you feel well informed about the cleanup activities progress?

Yes. A small percentage of the people I spoke with said that methods of communication could have been improved.

Q2

Are there any specific aspects of the cleanup that you feel should be of particular focus during the review? (e of Decision, cleanup goals, community input, etc.)

No.

Q3

Do you feel confident in BNL and DOE's management of the long-term cleanup operations for the site?

Yes.

Q4

Do you have any comments, suggestions, or recommendations regarding BNL / DOE's management and communications of the cleanup?

No.

Q5

Is there anything else regarding the BNL Five-Year Review that you would like to share?

No.

Q6

About You:

Name	Kenneth Casanova
Organization	Ridge Civic Association

RESPONDENTS: 11 of 11

SAVE AS

QUESTION SUMMARIES | INSIGHTS AND DATA TRENDS | INDIVIDUAL RESPONSES

Respondent #11

Edit | Delete | Export

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Last Modified: Friday, April 10, 2020 5:16:07 PM
Time Spent: 00:07:26
IP Address: 69.124.35.26

Page 1: BNL Five-Year Review SurveyBNL Community Advisory Council (CAC)

Q1

What is your overall impression of BNL's cleanup, and do you feel well informed about the cleanup activities and progress?

Yes. The update reports provide a clear picture of current conditions with adequate backup including historical reference to help understand the status of activities conducted for the cleanup.

Q2

Are there any specific aspects of the cleanup that you feel should be of particular focus during the review? (e.g. Records of Decision, cleanup goals, community input, etc.)

Yes cleanup goals and any adjustments made to the goals as appropriate.

Q3

Do you feel confident in BNL and DOE's management of the long-term cleanup operations for the site?

Yes

Q4

Do you have any comments, suggestions, or recommendations regarding BNL / DOE's management and communications of the cleanup?

None

Q5

Is there anything else regarding the BNL Five-Year Review that you would like to share?

None

Q6

About You:

Name	Henry Perez
Organization	Wading River Civic Association

ENGLISH

RESPONDENTS: 11 of 11

SAVE AS

QUESTION SUMMARIES | INSIGHTS AND DATA TRENDS | INDIVIDUAL RESPONSES

Respondent #10

Edit | Delete | Export

COMPLETE

Collector: Web Link 1 (Web Link)
Started: Friday, April 10, 2020 3:02:45 PM
Last Modified: Friday, April 10, 2020 3:14:31 PM
Time Spent: 00:11:45
IP Address: 130.199.251.4

Page 1: BNL Five-Year Review SurveyBNL Community Advisory Council (CAC)

Q1

What is your overall impression of BNL's cleanup, and do you feel well informed about the cleanup activities and progress?

BNL has been diligent to meet its obligations and generous in many instances to go beyond the minimum requirements. BNL keeps the CAC well informed about all its issues and approaches to solutions. So I feel very well informed.

Q2

Are there any specific aspects of the cleanup that you feel should be of particular focus during the review? (e.g. Records of Decision, cleanup goals, community input, etc.)

Nothing specific comes to mind.

Q3

Do you feel confident in BNL and DOE's management of the long-term cleanup operations for the site?

I don't have enough information to answer this question at this time.

Q4

Do you have any comments, suggestions, or recommendations regarding BNL / DOE's management and communications of the cleanup?

I believe that management and communications have been sufficient. They keep up with new issues (like PFAS) and they communicate progress effectively.

Q5

Is there anything else regarding the BNL Five-Year Review that you would like to share?

Not now.

Q6

About You:

Name	Biays Bowerman
Organization	Friends of Brookhaven

RESPONDENTS: 11 of 11

SAVE AS

QUESTION SUMMARIES | INSIGHTS AND DATA TRENDS | INDIVIDUAL RESPONSES

Respondent #9

Edit | Delete | Export

COMPLETE

Collector: Web Link 1 (Web Link)
Started: Friday, April 10, 2020 10:06:34 AM
Last Modified: Friday, April 10, 2020 10:19:24 AM
Time Spent: 00:12:50
IP Address: 130.199.251.4

Page 1: BNL Five-Year Review SurveyBNL Community Advisory Council (CAC)

Q1

What is your overall impression of BNL's cleanup, and do you feel well informed about the cleanup activities and progress?

I feel that the Lab has been a very good custodian of the site. It has been quite proactive about locating contaminated sites, assessing them, proposing remediation options, and working with regulators for their input and approval.

Q2

Are there any specific aspects of the cleanup that you feel should be of particular focus during the review? (e.g. Records of Decision, cleanup goals, community input, etc.)

I think it's all important, especially info on specific contaminants, their effects on health, and regulatory exposure limits. History on their sources is also interesting to me.

Q3

Do you feel confident in BNL and DOE's management of the long-term cleanup operations for the site?

Yes, very.

Q4

Do you have any comments, suggestions, or recommendations regarding BNL / DOE's management and communications of the cleanup?

I think they do a great job. My only comment is that I feel a little guilty about all the high-quality paper/printing that is distributed.

Q5

Is there anything else regarding the BNL Five-Year Review that you would like to share?

Nope. Great job!

Q6

About You:

Name	Jean Jordan-Sweet
Organization	NSLS-II UEC

ENGLISH

RESPONDENTS: 15 of 15

SAVE AS

QUESTION SUMMARIES | INSIGHTS AND DATA TRENDS | INDIVIDUAL RESPONSES

Respondent #15

COMPLETE

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Collector: Web Link 1 (Web Link)
Started: Wednesday, April 15, 2020 9:33:15 AM
Last Modified: Wednesday, April 15, 2020 9:47:23 AM
Time Spent: 00:14:08
IP Address: 68.198.161.246

Page 1: BNL Five-Year Review SurveyBNL Community Advisory Council (CAC)

Q1

What is your overall impression of BNL's cleanup, and do you feel well informed about the cleanup activities and progress?

Remediation activities are going well and are on schedule. Yes, I feel well informed about clean up activities.

Q2

Are there any specific aspects of the cleanup that you feel should be of particular focus during the review? (e.g. Records of Decision, cleanup goals, community input, etc.)

They are all important.

Q3

Do you feel confident in BNL and DOE's management of the long-term cleanup operations for the site?

Yes, so far. But I also believe that all remediation plans are implemented better when there is transparency.

Q4

Do you have any comments, suggestions, or recommendations regarding BNL / DOE's management and communications of the cleanup?

Its been good.

Q5

Is there anything else regarding the BNL Five-Year Review that you would like to share?

Things are going well but it is critically important to continue public engagement and involvement. All government and private sector clean ups can stray from objectives if public engagement is not made a priority.

Q6

About You:

Name	Adrienne Esposito
Organization	Citizens Campaign for the Environment

Respondent #14

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COMPLETE

Collector: Web Link 1 (Web Link)
Started: Wednesday, April 15, 2020 7:07:52 AM
Last Modified: Wednesday, April 15, 2020 7:22:28 AM
Time Spent: 00:14:35
IP Address: 24.146.169.110

Page 1: BNL Five-Year Review SurveyBNL Community Advisory Council (CAC)

Q1

What is your overall impression of BNL's cleanup, and do you feel well informed about the cleanup activities and progress?

I am not a "founding member" of the CAC, when I started to participate, I was very impressed by the knowledge of my fellow members. It was very obvious that the Lab was very forthcoming about the clean-up efforts, for years. The current efforts are always reported in a well thought out manner, with plenty of time for questions and answers.

Q2

Are there any specific aspects of the cleanup that you feel should be of particular focus during the review? (e.g. Records of Decision, cleanup goals, community input, etc.)

I like the short review of past efforts, and of course there is always PHAS.

Q3

Do you feel confident in BNL and DOE's management of the long-term cleanup operations for the site?

I like the fact that the LAB is very trasnparent in it's efforts with the community, and it's willingness to partner with S.C. health dept.and other regulators on sampling, testing and analysis of the facts.

Q4

Do you have any comments, suggestions, or recommendations regarding BNL / DOE's management and communications of the cleanup?

Comtinue to collaborate with the local civic groups for concerns and inform them of the LAB's decisions and actions.. Continue the partnership with other levels of govenment, as everyone working together serves the public well.

Q5

Is there anything else regarding the BNL Five-Year Review that you would like to share?

I think that it's good to review the progress and the system of communicating the actions.

Q6

About You:

Name	Albert Krupski
Organization	S.C. Legislator

RESPONDENTS: 15 of 15

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QUESTION SUMMARIES | INSIGHTS AND DATA TRENDS | INDIVIDUAL RESPONSES

Respondent #13

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COMPLETE

Collector: Web Link 1 (Web Link)
Started: Tuesday, April 14, 2020 7:27:30 PM
Last Modified: Tuesday, April 14, 2020 7:36:32 PM
Time Spent: 00:09:02
IP Address: 24.146.163.238

Page 1: BNL Five-Year Review SurveyBNL Community Advisory Council (CAC)

Q1

What is your overall impression of BNL's cleanup, and do you feel well informed about the cleanup activities and progress?

Yes I think the BNL cleanup has proceeded well but I'm concerned about the upcoming BGRR Stack removal & environmental & health implications from it.

Q2

Are there any specific aspects of the cleanup that you feel should be of particular focus during the review? (e.g. Records of Decision, cleanup goals, community input, etc.)

I'm somewhat concerned about any radionuclids left in the soil beneath the BGRR and other areas.

Q3

Do you feel confident in BNL and DOE's management of the long-term cleanup operations for the site?

I'm optimistic but reserved.

Q4

Do you have any comments, suggestions, or recommendations regarding BNL / DOE's management and communications of the cleanup?

Overall they have done a good job but seem to downplay some areas of concern such as the radionuclids from the BGRR legacy.

Q5

Is there anything else regarding the BNL Five-Year Review that you would like to share?

Not at this time

Q6

About You:

Name	Isidore Doroski
Organization	Town of Riverhead

RESPONDENTS: 15 of 15

SAVE AS

QUESTION SUMMARIES | INSIGHTS AND DATA TRENDS | INDIVIDUAL RESPONSES

Respondent #12

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COMPLETE

Collector: Web Link 1 (Web Link)
Started: Tuesday, April 14, 2020 12:34:58 PM
Last Modified: Tuesday, April 14, 2020 12:38:27 PM
Time Spent: 00:03:28
IP Address: 24.146.169.110

Page 1: BNL Five-Year Review SurveyBNL Community Advisory Council (CAC)

Q1

What is your overall impression of BNL's cleanup, and do you feel well informed about the cleanup activities and progress?

I think that they have done a very good job with the clean up and it is reviewed in our meetings.

Q2

Are there any specific aspects of the cleanup that you feel should be of particular focus during the review? (e.g. Records of Decision, cleanup goals, community input, etc.)

Just to make sure that there is follow up and that the main objectives of the cleanup are remaining true.

Q3

Do you feel confident in BNL and DOE's management of the long-term cleanup operations for the site?

yes

Q4

Do you have any comments, suggestions, or recommendations regarding BNL / DOE's management and communications of the cleanup?

no

Q5

Is there anything else regarding the BNL Five-Year Review that you would like to share?

Not at this time. You always give us time at meetings to bring things up in case we do have additional questions on any issue. Thank you.

Q6

About You:

Name	John Stype
Organization	Legislative Aide for Suffolk County Legislator Al Krupski

Attachment 2

2020 BNL Groundwater Status Report, BNL 2021 (USB Drive Version)

(To be included in public availability version)

Attachment 3

Inspection Checklists

BNL 2021 Five-Year Review Site Inspection Checklist

I. SITE INFORMATION

Site name: Brookhaven National Laboratory	**Date(s) of inspection:** 8/17/20 through 9/2/20
Location and Region: Upton, NY, EPA Region 2	**EPA ID:** NY7890008975
Agency, office, or company leading the five-year review: Brookhaven Science Associates (BSA) for the U.S. Department of Energy (DOE)	**Weather/temperature:** NA

Remedy Includes: (Check all that apply)

- ☒ Landfill cover/containment
- ☒ Access controls
- ☒ Institutional controls
- ☒ Groundwater pump and treatment
- ☐ Surface water collection and treatment
- ☒ Other_Annual private well testing
- ☒ Monitored natural attenuation
- ☒ Groundwater containment
- ☐ Vertical barrier walls

_____

_____

Attachments: ☒ Inspection team roster attached ☐ Site map attached

II. INTERVIEWS (Check all that apply)

1. **O&M site manager** _ Bill Dorsch, Groundwater Protection Group (GPG) Manager_
   Interviewed ☒ at site ☒ at office ☐ by phone Phone no. _344-5186
   Problems, suggestions; ☐ Report attached _Work with on a daily basis and discuss issues weekly. ___

2. **O&M staff** Vinnie Racaniello, Eric Kramer, Adrian Steinhauff, Project Manager and Field Engineers
   Interviewed ☒ at site ☒ at office ☐ by phone Phone no. 344-5436, x8226, x2363_____
   Problems, suggestions; ☐ Report attached Work with on a daily basis and discuss issues weekly.____

3. **Local regulatory authorities and response agencies** (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices, etc.) Fill in all that apply.

   Agency ___EPA, NYSDEC, NYSDOH, SCDHS, DOE _____
   Contact _____ _____ _____ _____
   Name Title Date Phone no.
   Problems; suggestions; ☒ Report attached See interview records.
   _____

   Agency _____
   Contact _____ _____ _____ _____
   Name Title Date Phone no.
   Problems; suggestions; ☐ Report attached _____
   _____

4. **Other interviews** (optional) ☐ Report attached.

III. ON-SITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)

1. **O&M Documents**

☒ O&M manual	☒ Readily available	☒ Up to date	☐ N/A
☒ As-built drawings	☒ Readily available	☒ Up to date	☐ N/A
☐ Maintenance logs	☐ Readily available	☐ Up to date	☐ N/A

Remarks: O&M Manuals have been updated and are available in the treatment buildings, Bldg. 462 Project File, and on the internal GPG website. However, the manuals were missing from one off-site and one on-site system during the inspection. They were immediately replaced. The as-built drawings are available electronically through the GPG and copies are available through Facility & Operations database.

2. **Site-Specific Health and Safety Plan** ☒ Readily available ☒ Up to date ☐ N/A
☒ Contingency plan/emergency response plan ☒ Readily available ☒ Up to date ☐ N/A

Remarks: The groundwater treatment systems have a contingency/emergency plan in their O&M Manuals. Project maintenance/repair on the remediation systems is performed in accordance with SBMS Work Planning and Control requirements. Contractors also perform work in accordance with their H&S Plan and Phase Hazard Analysis.

3. **O&M and OSHA Training Records** ☒ Readily available ☒ Up to date N/A

Remarks _Worker training records are available on the BNL training website database. __

4. **Permits and Service Agreements**

☒ Air discharge permit	☒ Readily available	☒ Up to date	☐ N/A
☒ Effluent discharge	☒ Readily available	☒ Up to date	☐ N/A
☐ Waste disposal, POTW	☐ Readily available	☐ Up to date	☐ N/A
☒ Other permits: Peconic	☒ Readily available	☒ Up to date	☐ N/A

Remarks: DEC air and SPDES equivalency permits in place for all treatment systems, as appropriate. Received NYSDEC concurrence on closure of the Peconic River Sediment Removal permit for Area WC-06. ____

5. **Gas Generation Records** ☐ Readily available ☐ Up to date ☒ N/A

Remarks: Passive gas venting only. Landfill gas testing results available in the Landfill Annual Reports._

6. **Groundwater Monitoring Records** ☒ Readily available ☒ Up to date ☐ N/A

Remarks: Groundwater monitoring data is made available via the Quarterly System Operations Reports, as well as the Annual Groundwater Status Report. _____

7. **Discharge Compliance Records**

☒ Air	☒ Readily available	☒ Up to date	☐ N/A
☒ Water (effluent)	☒ Readily available	☒ Up to date	☐ N/A

Remarks: Discharge Monitoring Reports (DMRs) for the treatment systems with SPDES equivalency permits are issued monthly to the DEC and are available in the GPG Project Files. Air compliance records are documented in the Annual Groundwater Status Reports. _____

8. **Daily Access/Security Logs** ☒ Readily available ☐ Up to date ☐ N/A

Remarks_Operating data sheets for the groundwater systems are available at the treatment buildings and the GPG Project files. The Daily Operating Sheet will be revised to reflect monthly instead of daily use. Remote daily monitoring of the system is performed in Bldg. 462. System maintenance is documented in the Daily Field Report and system sampling is documented on the share drive.

9. **Comments** _____

_____

_____

IV. O&M COSTS

1. **O&M Organization**

☐ State in-house ☐ Contractor for State
☐ PRP in-house ☐ Contractor for PRP
☐ Federal Facility in-house ☒ Contractor for Federal Facility
☐ Other: Responsibility for managing BNL's Long Term Stewardship lies with the Environmental Protection Division's (EPD) Groundwater Protection Group (GPG). ___

2. **O&M Cost Records**

☒ Readily available ☒ Up to date
☒ Funding mechanism/agreement in place

Total average annual O&M cost by year for review period if available

From	10/15 Date	To	9/16 Date	Avg. Annual of $149K Total cost	☒ Breakdown attached
From	10/16 Date	To	9/17 Date	Avg. Annual of $157K Total cost	☒ Breakdown attached
From	10/17 Date	To	9/18 Date	Avg. Annual of $274K Total cost	☒ Breakdown attached
From	10/18 Date	To	9/19 Date	Avg. Annual of $165K Total cost	☒ Breakdown attached
From	10/19 Date	To	9/20 Date	Avg. Annual of $143K Total cost	☒ Breakdown attached

3. **Unanticipated or Unusually High O&M Costs During Review Period**

Describe costs and reasons: No unusually high O&M costs identified. The annual cost for each system from FY 2016 through FY 2020 is identified in the Five-Year Review.

V. ACCESS AND INSTITUTIONAL CONTROLS ☒ Applicable ☐ N/A

A. Fencing

1. **Fencing damaged** ☐ Location shown on site map ☒ Gates secured ☐ N/A
Remarks: _

B. Other Access Restrictions

1. **Signs and other security measures** ☐ Location shown on site map ☐ N/A
Remarks: Identification signs are in place for all of the on-site and off-site groundwater treatment systems. DOE notification signs are in place for all treatment facilities located beyond BNL's property boundary. There are BNL security personnel on the BNL property 24 hours per day. For the systems located beyond the BNL boundaries, the buildings are secured with a lock and alarms. Outside of work hours, the alarms are transmitted to an alarm company, then BNL is notified. Restricted use signs are posted at former soil cleanup areas including the Former Hazardous Waste Management Facility, former Meadow Marsh, Landfills, Ash Pit, former Chemical Holes, Bldg. 96, Bldg. 650 Sump Outfall, and Bldg. 811. _____

C. Institutional Controls (ICs)

1. **Implementation and enforcement**
Site conditions imply ICs not properly implemented ☐ Yes ☒ No ☐ N/A
Site conditions imply ICs not being fully enforced ☐ Yes ☒ No ☐ N/A

Type of monitoring (*e.g.*, self-reporting, drive by): Routine walkdown inspections of landfills, former soil cleanup areas, and groundwater treatment systems.

_____
Frequency: Physical site visits vary from once per week to monthly for treatment systems, monthly for landfills, semi-annual former soil cleanup areas. Remote monitoring of all treatment systems is performed daily at Bldg. 462._____
Responsible party/agency: BSA under contract with DOE.

_____

	Name	Title	Date	Phone no.
Contact:	William Dorsch	BSA GPG Manager	9/11/20	(631) 344-5186
	Gerald Granzen	DOE Project Manager	9/11/20	(631) 344-4089

Reporting is up-to-date ☒ Yes ☐ No ☐ N/A
Reports are verified by the lead agency ☒ Yes ☐No ☐ N/A

Specific requirements in deed or decision documents have been met ☒ Yes ☐ No ☐ N/A
Violations have been reported ☐ Yes ☒ No ☐ N/A
Other problems or suggestions: ☐Report attached
Remarks: There are six access agreements in place among BSA/DOE and various property owners to allow for operation of BNL's groundwater remediation systems for plumes that have migrated beyond the BNL property. Each agreement has terms and conditions that must be adhered to. Two of the agreements expired in 2018 and BSA legal office is working to renew them. A license agreement is also in place among BSA/BHSO/Suffolk County for the supplemental sediment cleanup for the Peconic River in 2017._____

2. **Adequacy** ☒ ICs are adequate ☐ ICs are inadequate ☐ N/A
Remarks: The Land Use Controls Management Plan and institutional controls website and fact sheets continue to be updated, as needed to reflect the most recent IC's for each project. ___

D. General

1. **Vandalism/trespassing** ☒ Yes ☐ Location shown on site map ☐ No vandalism evident
Remarks_In mid-2015, during a routine surveillance inspection, the GPG Field Engineer noticed graffiti on the wall and door of the OU I well pump Building 645. This building, which is fenced and locked, is located in a wooded area near the BNL south property boundary. There was no other damage identified and the incident was reported to the BNL Police. No additional incidents have occurred since.

2. **Land use changes on site** ☒ N/A
Remarks: None_____

3. **Land use changes off site** ☒ N/A
Remarks: None_____

VI. GENERAL SITE CONDITIONS

A. Roads ☒ Applicable ☐ N/A

1. **Roads damaged** ☐ Location shown on site map ☒ Roads adequate ☐ N/A
Remarks_____

B. Other Site Conditions

Remarks: _____

VII. SOIL CLEANUP REMEDIES ☒ Applicable ☐ N/A

A. Project OU I AOC 2F Ash Pit 9/2/20

1. **Soil Excavation Complete** ☒ Yes ☐ No
   Remarks _____

2. **S&M Documents**
   ☒ S&M Plan ☒ Readily available ☒ Up to date ☐ N/A
   ☒ Completion/Closeout Report ☒ Readily available ☒ Up to date ☐ N/A
   ☐ Maintenance logs ☐ Readily available ☐ Up to date ☒ N/A
   Remarks: Final Closeout Report for the Ash Pit OU I AOC 2F, dated 2/5/04. Section 4.0 of the Closeout Report identifies LTS requirements (i.e., annual inspection). _

3. **Settlement** (Low spots) ☐ Location shown on site map ☒ Settlement not evident
   Areal extent _____ Depth_____
   Remarks: None
   _____

4. **Erosion** ☐ Location shown on site map ☒ Erosion not evident
   Areal extent_____ Depth_____
   Remarks: None.
   _____

5. **Vegetative Cover** ☒ Grass ☒ Cover properly established ☒ No signs of stress
   ☒ Trees/Shrubs (indicate size and locations on a diagram)
   Remarks: Trees surround the pit area. Excellent native grass growth on pits. See photos._____

6. **Wet Areas/Water Damage** ☒ Wet areas/water damage not evident
   ☐ Wet areas ☐ Location shown on site map Areal extent_____
   ☐ Ponding ☐ Location shown on site map Areal extent_____
   ☐ Seeps ☐ Location shown on site map Areal extent_____
   ☐ Soft subgrade ☐ Location shown on site map Areal extent_____
   Remarks: None.
   _____

7. **Monitoring Wells** (within the excavated area)
   ☒ Properly secured/locked ☒ Functioning ☐ Routinely sampled ☒ Good condition
   ☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A
   Remarks_____
   _____

8. **Other Site Conditions**

   Remarks: Inspection attendees include R. Howe
   The concrete and bucket that was holding the LUIC point of contact sign was found broken and on the ground. It was subsequently replaced.____

VII. SOIL CLEANUP REMEDIES ☒ Applicable ☐ N/A

A. Project OU I AOC 8 Meadow Marsh 9/2/20

1. **Soil Excavation Complete** ☒ Yes ☐ No
   Remarks

2. **S&M Documents**
   ☒ S&M Plan ☒ Readily available ☒ Up to date ☐ N/A
   ☒ Completion/Closeout Report ☒ Readily available ☒ Up to date ☐ N/A
   ☐ Maintenance logs ☐ Readily available ☐ Up to date ☒ N/A
   Remarks: Final Closeout Report for the Meadow Marsh OU I AOC 8, dated 2/6/04. Section 4.0 of the Closeout Report identifies LTS requirements (i.e., ecological monitoring and inspection for Tiger Salamanders). Institutional controls are also identified in the Report.

3. **Settlement** (Low spots) ☐ Location shown on site map ☒ Settlement not evident
   Areal extent_____ Depth_____
   Remarks

4. **Erosion** ☐ Location shown on site map ☒ Erosion not evident
   Areal extent_____ Depth_____
   Remarks

5. **Vegetative Cover** ☒ Grass ☒ Cover properly established ☒ No signs of stress
   ☒ Trees/Shrubs (indicate size and locations on a diagram)
   Remarks: Native grasses planted adjacent to the pond. The growth is significant.

6. **Wet Areas/Water Damage** ☐ Wet areas/water damage not evident
   ☐ Wet areas ☐ Location shown on site map Areal extent_____
   ☒ Ponding ☐ Location shown on site map Areal extent_____
   ☐ Seeps ☐ Location shown on site map Areal extent_____
   ☐ Soft subgrade ☐ Location shown on site map Areal extent_____
   Remarks: The remediated area is a pond for the Tiger Salamanders. Due to the overgrown vegetation, the pond could not be inspected at this time. During the November 2019 inspection, the pond had significant water.

7. **Monitoring Wells** (within the excavated area)
   ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
   ☐ Evidence of leakage at penetration ☐ Needs Maintenance ☒ N/A
   Remarks

8. **Other Site Conditions**
   Remarks: Inspection attendees include R. Howe
   The LUIC sign was visible on the gate._

VII. SOIL CLEANUP REMEDIES ☒ Applicable ☐ N/A

A. Project OU I AOC 6 Bldg. 650 Sump Outfall 9/2/20

1. **Soil Excavation Complete** ☒ Yes ☐ No
   Remarks: Demolition of Building 650 is being performed in the fall of 2020.

2. **S&M Documents**
   ☒ S&M Plan ☒ Readily available ☒ Up to date ☐ N/A
   ☒ Completion/Closeout Report ☒ Readily available ☐ Up to date ☐ N/A
   ☐ Maintenance logs ☐ Readily available ☐ Up to date ☒ N/A
   Remarks: Draft Final Closeout Report for AOC 6 Bldg. 650 Sump and Sump Outfall, dated 1/02.

3. **Settlement** (Low spots) ☐ Location shown on site map ☒ Settlement not evident
   Areal extent_____ Depth_____
   Remarks: The entire area is graded and a drainage swale exists that routes surface runoff to the ponded sump. The pond is dry at this time.

4. **Erosion** ☐ Location shown on site map ☒ Erosion not evident
   Areal extent_____ Depth_____
   Remarks:

5. **Vegetative Cover** ☒ Grass ☐ Cover properly established ☒ No signs of stress
   ☒ Trees/Shrubs (indicate size and locations on a diagram)
   Remarks: Significant number of pine trees and vegetation surround the sump.

6. **Wet Areas/Water Damage** ☒ Wet areas/water damage not evident
   ☐ Wet areas ☐ Location shown on site map Areal extent_____
   ☐ Ponding ☐ Location shown on site map Areal extent_____
   ☐ Seeps ☐ Location shown on site map Areal extent_____
   ☐ Soft subgrade ☐ Location shown on site map Areal extent_____
   Remarks: Pond is Tiger Salamander habitat

7. **Monitoring Wells** (within the excavated area)
   ☒ Properly secured/locked ☒ Functioning ☒ Routinely sampled ☒ Good condition
   ☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A
   Remarks:

8. **Other Site Conditions**
   Remarks: Inspection attendees include R. Howe. Previously installed fence partially surrounds the former sump outfall (no restrictions for entering area).

VII. SOIL CLEANUP REMEDIES ☒ Applicable ☐ N/A

A. Project OU I AOC 16S Landscape Soil Areas 9/2/20

1. **Soil Excavation Complete** ☒ Yes ☐ No
   Remarks _____

2. **S&M Documents**
   ☒ S&M Plan ☒ Readily available ☒ Up to date ☐ N/A
   ☒ Completion/Closeout Report ☒ Readily available ☐ Up to date ☐ N/A
   ☐ Maintenance logs ☐ Readily available ☐ Up to date ☒ N/A
   Remarks: Final Closeout Report for AOC 16 Landscape Soils, dated 4/10/01.

3. **Settlement** (Low spots) ☐ Location shown on site map ☒ Settlement not evident
   Areal extent_____ Depth_____
   Remarks_____

4. **Erosion** ☐ Location shown on site map ☒ Erosion not evident
   Areal extent_____ Depth_____
   Remarks_____

5. **Vegetative Cover** ☒ Grass ☒ Cover properly established ☒ No signs of stress
   G Trees/Shrubs (indicate size and locations on a diagram)
   Remarks_____

6. **Wet Areas/Water Damage** ☒ Wet areas/water damage not evident
   ☐ Wet areas ☐ Location shown on site map Areal extent_____
   ☐ Ponding ☐ Location shown on site map Areal extent_____
   ☐ Seeps ☐ Location shown on site map Areal extent_____
   ☐ Soft subgrade ☐ Location shown on site map Areal extent_____
   Remarks_____

7. **Monitoring Wells** (within the excavated area)
   ☒ Properly secured/locked ☒ Functioning ☒ Routinely sampled ☒ Good condition
   ☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A
   Remarks_____

8. **Other Site Conditions**

   Remarks: Inspection attendees include R. Howe.

VII. SOIL CLEANUP REMEDIES ☒ Applicable ☐ N/A

A. Project OU I AOC 1 Hazardous Waste Management Facility (HWMF)/Waste Loading Area 9/2/20

1. **Soil Excavation Complete** ☒ Yes ☐ No

Remarks: The Waste Loading Area will be used for the staging and loading of HFBR stack waste onto rail cars for off-site disposal starting in December 2020.

2. **S&M Documents**

☒ S&M Plan	☒ Readily available	☒ Up to date	☐ N/A
☒ Completion/Closeout Report	☒ Readily available	☐ Up to date	☐ N/A
☐ Maintenance logs	☐ Readily available	☐ Up to date	☒ N/A

Remarks: The Soil and Peconic River Surveillance and Maintenance Plan, dated March 2013.
The Final Closeout Report for the Former Hazardous Waste Management Facility, dated 9/29/05.
Final Completion Report for the HFBR Waste Loading Area, dated July 2009.

3. **Settlement** (Low spots) ☐ Location shown on site map ☒ Settlement not evident
Areal extent_____ Depth_____
Remarks:

4. **Erosion** ☐ Location shown on site map ☒ Erosion not evident
Areal extent_____ Depth_____
Remarks: __

5. **Vegetative Cover** ☒ Grass ☒ Cover properly established ☐ No signs of stress
☒ Trees/Shrubs (indicate size and locations on a diagram)
Remarks: Significant grass, shrubs, trees present. Fallen trees are blocking the path to several of the foundations. A work order was placed to have them removed.

6. **Wet Areas/Water Damage** ☒ Wet areas/water damage not evident

☐ Wet areas	☐ Location shown on site map	Areal extent_____
☐ Ponding	☐ Location shown on site map	Areal extent_____
☐ Seeps	☐ Location shown on site map	Areal extent_____
☐ Soft subgrade	☐ Location shown on site map	Areal extent_____

Remarks: Significant vegetation throughout the area. The wetland area immediately to the northwest of the FHWMF is dry. _____

7. **Monitoring Wells** (within the excavated area)

☒ Properly secured/locked	☒ Functioning	☒ Routinely sampled	☒ Good condition
☐ Evidence of leakage at penetration		☐ Needs Maintenance	☐ N/A

Remarks:

8. **Other Site Conditions**

Remarks: Inspection attendees include R. Howe
GPG is performing monitoring well installation in the FHWMF to track the Sr-90 groundwater plume. The fixed contamination signs on the foundations are in good condition and legible. The annual survey of the fixed contamination on several of the concrete foundations was last performed in September 2019 by BNL RadCon. No loose contamination detected. The Waste Loading Area (WLA) has good vegetative growth. The WLA will be used for the loading of HFBR stack demolition waste. All gates have signs and are locked.

VII. SOIL CLEANUP REMEDIES ☒ Applicable ☐ N/A

A. Project OU V AOC 30 Peconic River 9/2/20 and

1. **Soil Excavation Complete** ☒ Yes ☐ No

Remarks: The original 2004/2005 is complete, and supplemental sediment remediation of three small areas was also completed in 2010/2011. Supplemental remediation of Area WC-06 was completed in 2017.

_____

2. **S&M Documents**

☒ S&M Plan	☒ Readily available	☒ Up to date	☐ N/A
☒ Completion/Closeout Report	☒ Readily available	☒ Up to date	☐ N/A
☐ Maintenance logs	☐ Readily available	☐ Up to date	☒ N/A

Remarks: Fish monitoring requirements are identified in the BNL Environmental Monitoring Plan Data Quality Objectives titled *Peconic River Fish Surveillance Monitoring*.

Final Closeout Report for Peconic River Remediation Phases 1 and 2, 8/25/05, Supplemental Remediation Closeout Report, dated March 2012, and Completion Report Peconic River Supplemental Sediment Removal Area, PR-WC-06 Area, December 2017.

3. **Settlement** (Low spots) ☐ Location shown on site map ☒ Settlement not evident
Areal extent_____ Depth_____
Remarks: _____

4. **Erosion** ☐ Location shown on site map ☒ Erosion not evident
Areal extent_____ Depth_____
Remarks_____
_____

5. **Vegetative Cover** ☒ Grass ☒ Cover properly established ☒ No signs of stress
☒ Trees/Shrubs (indicate size and locations on a diagram)
Remarks:

6. **Wet Areas/Water Damage** ☒ Wet areas/water damage not evident

☐ Wet areas	☐ Location shown on site map	Areal extent_____
☒ Ponding	☐ Location shown on site map	Areal extent: Area B_____
☒ Seeps	☐ Location shown on site map	Areal extent_____
☒ Soft subgrade	☐ Location shown on site map	Areal extent_____

Remarks: The onsite portion of the river is dry from the STP to Station HQ. There is no flow upstream of the former STP outfall at station HE.

7. **Monitoring Wells** (within the excavated area)

☒ Properly secured/locked	☒ Functioning	☐ Routinely sampled	☒ Good condition
☐ Evidence of leakage at penetration		☒ Needs Maintenance	☐ N/A

Remarks: River piezometer near Area WC-06 was removed during the excavation in 2017.

8. **Other Site Conditions**

Remarks: Inspection attendees include R. Howe.
There is significant vegetation growth at all cleanup areas. Gates along E. Boundary path and gate at North Street/Z-Path are locked.

VII. SOIL CLEANUP REMEDIES ☒ Applicable ☐ N/A

A. Project OU I AOC 10 Building 811 UST and Soils 9/2/20_____

1. **Soil Excavation Complete** ☒ Yes ☐ No

Remarks: Excavation complete in 2005. Building 810/811 demolition and soil remediation was completed in 2015/2016. Supplemental soil remediation north of Bldg. 811 was completed in 2017.

_____

2. **S&M Documents**

☒ S&M Plan	☒ Readily available	☒ Up to date	☐ N/A
☒ Completion/Closeout Report	☒ Readily available	☐ Up to date	☐ N/A
☐ Maintenance logs	☐ Readily available	☐ Up to date	☒ N/A

Remarks: Final Closeout Report for AOC 10 Waste Concentration Facility, 9/05, Waste Concentration Facility (Bldg. 811 - Area Of Concern 10) and Surrounding Area, January 2017, and Addendum to the Closeout Report Waste Concentration Facility (Bldg. 811 – Area of Concern 10) and Surrounding Area. June 2019. The Soil and Peconic River Surveillance and Maintenance Plan, dated March 2013.

3. **Settlement** (Low spots) ☐ Location shown on site map ☒ Settlement not evident
Areal extent_____ Depth_____
Remarks: _____

4. **Erosion** ☐ Location shown on site map ☒ Erosion not evident
Areal extent_____ Depth_____
Remarks:

5. **Vegetative Cover** ☒ Grass ☒ Cover properly established ☒ No signs of stress
☐ Trees/Shrubs (indicate size and locations on a diagram)
Remarks: Significant vegetation established. _____

6. **Wet Areas/Water Damage** ☒ Wet areas/water damage not evident

☐ Wet areas	☐ Location shown on site map	Areal extent_____
☐ Ponding	☐ Location shown on site map	Areal extent_____
☐ Seeps	☐ Location shown on site map	Areal extent_____
☐ Soft subgrade	☐ Location shown on site map	Areal extent_____

Remarks_____
_____

7. **Monitoring Wells** (within the excavated area)

☒ Properly secured/locked	☒ Functioning	☒ Routinely sampled	☒ Good condition
☐ Evidence of leakage at penetration		☐ Needs Maintenance	☐ N/A

Remarks: All of the BNL monitoring wells are secured and locked.

8. **Other Site Conditions**

Remarks: Part of the fence between the former Bldg. 811 area and the scrapyard to the north is down. A Work Order was issued to have it repaired. One point of contact sign was found down, and repaired during the inspection. Inspection attendees include R. Howe.

VII. SOIL CLEANUP REMEDIES ☒ Applicable ☐ N/A

A. Project OU III AOC 26B Building 96 9/2/20_____

1. **Soil Excavation Complete** ☒ Yes ☐ No
   Remarks: PCB soil excavation complete in 2005. VOC source area excavation was completed in 2010.

2. **S&M Documents**
   ☒ S&M Plan ☒ Readily available ☐ Up to date ☐ N/A
   ☒ Completion/Closeout Report ☒ Readily available ☒ Up to date ☐ N/A
   ☐ Maintenance logs ☐ Readily available ☐ Up to date ☒ N/A
   Remarks: OU III Building 96 PCB Soil (AOC 26B) Excavation Closeout Report, March 2005.
   Building 96 Soil Excavation and Disposal Closure Report, January 2011.
   The Soil and Peconic River Surveillance and Maintenance Plan, March 2013.

3. **Settlement** (Low spots) ☐ Location shown on site map ☒ Settlement not evident
   Areal extent_____ Depth_____
   Remarks:
   _____

4. **Erosion** ☐ Location shown on site map ☒ Erosion not evident
   Areal extent_____ Depth_____
   Remarks: _____

5. **Vegetative Cover** ☒ Grass ☒ Cover properly established ☒ No signs of stress
   ☐ Trees/Shrubs (indicate size and locations on a diagram)
   Remarks: Good vegetative growth. _____

6. **Wet Areas/Water Damage** ☒ Wet areas/water damage not evident
   ☐ Wet areas ☐ Location shown on site map Areal extent_____
   ☐ Ponding ☐ Location shown on site map Areal extent_____
   ☐ Seeps ☐ Location shown on site map Areal extent_____
   ☐ Soft subgrade ☐ Location shown on site map Areal extent_____
   Remarks_____
   _____

7. **Monitoring Wells** (within the excavated area)
   ☒ Properly secured/locked ☒ Functioning ☒ Routinely sampled ☐ Good condition
   ☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A
   Remarks: All of the BNL monitoring wells are secured and locked.

8. **Other Site Conditions**
   Remarks:
   Inspection attendees include R. Howe.

VII. SOIL CLEANUP REMEDIES ☒ Applicable ☐ N/A

A. Project OU I AOC 2B,C Chemical/Animal/Glass Holes 9/2/20_____

1. **Soil Excavation Complete** ☒ Yes ☐ No
   Remarks: Soil excavation complete in 2005.

2. **S&M Documents**
   ☒ S&M Plan ☒ Readily available ☒ Up to date ☐ N/A
   ☒ Completion/Closeout Report ☒ Readily available ☐ Up to date ☐ N/A
   ☐ Maintenance logs ☐ Readily available ☐ Up to date ☒ N/A
   Remarks: Animal/Chemical Pits and Glass Holes Remedial Action Closure Report, 10/97.
   Animal/Chemical Pits and Glass Holes Remedial Action Closure Report Addendum, 9/05.
   The Soil and Peconic River Surveillance and Maintenance Plan, March 2013.

3. **Settlement** (Low spots) ☐ Location shown on site map ☒ Settlement not evident
   Areal extent_____ Depth_____
   Remarks: None.

4. **Erosion** ☐ Location shown on site map ☒ Erosion not evident
   Areal extent_____ Depth_<1 foot_____
   Remarks: None._____

5. **Vegetative Cover** ☒ Grass ☒ Cover properly established ☒ No signs of stress
   ☐ Trees/Shrubs (indicate size and locations on a diagram)
   Remarks: Significant vegetation throughout area. _____

6. **Wet Areas/Water Damage** ☒ Wet areas/water damage not evident
   ☐ Wet areas ☐ Location shown on site map Areal extent_____
   ☐ Ponding ☐ Location shown on site map Areal extent_____
   ☐ Seeps ☐ Location shown on site map Areal extent_____
   ☐ Soft subgrade ☐ Location shown on site map Areal extent_____
   Remarks_____

7. **Monitoring Wells** (within the excavated area)
   ☒ Properly secured/locked ☒ Functioning ☒ Routinely sampled ☒ Good condition
   ☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A
   Remarks: None.

8. **Other Site Conditions**
   Remarks:
   Inspection attendees include R. Howe.

Location (AOC): Sewage Treatment Plant
Date of Inspection: 9/2/20
Name of Inspector(s): R. Howe
Purpose of Inspection: ☒ Routine (Scheduled Freq. of 2x/yr) ☐ Heavy Rainfall ☐ Reported Incident

A. Inspection Checklist

Component	Observed Condition				Further Action Req'd	
	Excell.	Fair	Poor	Not Applic.	Yes (describe)	No
1. Soil Covers/Wetlands:						
Vegetation (e.g. grass)	X					X
Soil (Cap/Cover/Fill)	X				No erosion evident	X
Other: _____						
2. Drainage Structures:						
Standing Water				X		X
Toe Drain				X		X
Drainage Channels				X		X
French Drains/Outfalls				X		X
Subsurface Drainage Pipes/Outfalls		X				X
Manholes				X		X
Filter Berms	X					X
Roof Drains				X		X
Recharge Areas	X					X
Other: _____						
3. Monitoring System:						
Soil Gas Wells				X		X
Groundwater Wells	X					X
Gas Vents				X		X
Other: _____						
4. Site Access:						
Asphalt Access Road				X		X
Crushed-concrete Access Road		X				X
Fence				X		X
Gates/locks				X		X
Radiological Postings				X		X
Other:						

5. Evidence of unauthorized work activities and/or unauthorized access has occurred? ☐ Yes ☒ No
If yes, describe evidence: _____

B. Description of Other Observations
Observed Conditions/Recommendations: There was no flow upstream at station HE. No erosion of soil cover is evident on the sand filter berms or sludge drying beds remediated areas. No unauthorized work visible at the abandoned sewer line area.

Location (AOC): Current Landfill and Wooded Wetland
Date of Inspection: 9/2/20
Name of Inspector(s): R. Howe
Purpose of Inspection: ☒ Routine (Scheduled Freq. of 2x/yr) ☐ Heavy Rainfall ☐ Reported Incident

A. Inspection Checklist

Component	Observed Condition				Further Action Req'd	
	Excell.	Fair	Poor	Not Applic.	Yes (describe)	No
1. Landfill Cap/Wetlands:						
Vegetation (e.g. grass)		X			Needs mowing	
Soil (Cap/Cover/Fill)	X				No burrows evident	X
Other:						
2. Drainage Structures:						
Standing Water	X				Dry	X
Toe Drain	X					X
Drainage Channels	X				Some vegetation	
French Drains/Outfalls				X		X
Subsurface Drainage Pipes/Outfalls		X				X
Manholes				X		X
Berms				X		X
Roof Drains				X		X
Recharge Areas	X					X
Other:						
3. Monitoring System:						
Soil Gas Wells		X			Need Vegetation Cut	
Groundwater Wells	X					X
Gas Vents	X				No nests or damage	X
Other: __						
4. Site Access:						
Asphalt Access Road		X				X
Crushed-concrete Access Road				X		X
Fence	X					X
Gates/locks	X					X
Radiological Postings				X		X
Other: Stairs access to cap	X					X

5. Evidence of unauthorized work activities and/or unauthorized access has occurred? ☐ Yes ☒ No
If yes, describe evidence: _

B. Description of Other Observations

Observed Conditions/Recommendations: The grass on the cap needs to be cut. Vegetation in the south culvert needs to be sprayed. The Wooded Wetland appears dry. Signs in place and all gates locked.

Location (AOC): Former Landfill Area (includes the former and interim landfills and slit trench)
Date of Inspection: 9/2/20
Name of Inspector(s): R. Howe
Purpose of Inspection: ☒ Routine (Scheduled Freq. of 2x/yr) ☐ Heavy Rainfall ☐ Reported Incident

A. Inspection Checklist

Component	Observed Condition				Further Action Req'd	
	Excell.	Fair	Poor	Not Applic.	Yes (describe)	No
1. Landfill Cap/Wetlands:						
Vegetation (e.g. grass)	X				Grass recently cut	X
Soil (Cap/Cover/Fill)	X				Cut pine, Interim LF	
Other: _____						
2. Drainage Structures:						
Standing Water	X				No water	X
Toe Drain	X					X
Drainage Channels		X			Remove vegetation	
French Drains/Outfalls	X					X
Subsurface Drainage Pipes/Outfalls	X					X
Manholes				X		X
Berms				X		X
Roof Drains				X		X
Recharge Areas	X				Significant vegetation	X
Other: _____						
3. Monitoring System:						
Soil Gas Wells	X					X
Groundwater Wells	X					X
Gas Vents	X					X
Other: _____	X					X
4. Site Access:						
Asphalt Access Road		X				X
Crushed-concrete Access Road		X				X
Fence				X		X
Gates/locks				X		X
Radiological Postings				X		X
Other: LUIC Signs	X				All signs in place	X

5. Evidence of unauthorized work activities and/or unauthorized access has occurred? ☐ Yes ☒ No
If yes, describe evidence: _____

B. Description of Other Observations

Observed Conditions/Recommendations: Former Landfill, Interim Landfill, and Slit Trench caps are in good condition. The grass on all three landfills was recently cut. No animal burrows are evident. A Work Order was issued for removal of the pine tree on the north edge of the Interim Landfill and spray or mechanically cut vegetation growing in all drainage channels.

Location (AOC): Former Hazardous Waste Management Facility Perimeter Soils
Date of Inspection: 9/2/20
Name of Inspector(s): R. Howe
Purpose of Inspection: ☒ Routine (Sched Freq of 2x/yr) ☐ Heavy Rainfall ☐ Reported Incident

A. Inspection Checklist

Component	Observed Condition				Further Action Req'd	
	Excell.	Fair	Poor	Not Applic.	Yes (describe)	No
1. Soil Covers/Wetlands:						
Vegetation (e.g. grass)	X					X
Soil (Cap/Cover/Fill)	X					X
Other: _____						
2. Drainage Structures:						
Standing Water	X				None	X
Toe Drain				X		X
Drainage Channels				X		X
French Drains/Outfalls				X		X
Subsurface Drainage Pipes/Outfalls				X		X
Manholes				X		X
Berms				X		X
Roof Drains				X		X
Recharge Areas				X		X
Other: __						
3. Monitoring System:						
Soil Gas Wells				X		X
Groundwater Wells				X		X
Gas Vents				X		X
Other: _____						
4. Site Access:						
Asphalt Access Road				X		X
Crushed-concrete Access Road				X		X
Fence				X		X
Gates/locks				X		X
Radiological Postings				X		X
Other:						

5. Evidence of unauthorized work activities and/or unauthorized access has occurred? ☐ Yes ☒ No
If yes, describe evidence: _____

B. Description of Other Observations

Observed Conditions/Recommendations: The soil cover for all three phases of the cleanup areas is excellent and no erosion was evident.

Location (AOC): Building 811 Former A/B Waste Transfer Lines
Date of Inspection: 9/2/20
Name of Inspector(s): R. Howe
Purpose of Inspection: ☒ Routine (Sched Freq of 2x/yr) ☐ Heavy Rainfall ☐ Reported Incident

A. Inspection Checklist

Component	Observed Condition				Further Action Req'd	
	Excell.	Fair	Poor	Not Applic.	Yes (describe)	No
1. Soil Covers/Wetlands:						
Vegetation (e.g. grass)	X					X
Soil (Cap/Cover/Fill)	X				No erosion evident	X
Other:						
2. Drainage Structures:						
Standing Water				X		X
Toe Drain				X		X
Drainage Channels				X		X
French Drains/Outfalls				X		X
Subsurface Drainage Pipes/Outfalls				X		X
Manholes				X		X
Berms				X		X
Roof Drains				X		X
Recharge Areas				X		X
Other:						
3. Monitoring System:						
Soil Gas Wells				X		X
Groundwater Wells	X					X
Gas Vents				X		X
Other:						
4. Site Access:						
Asphalt Access Road	X					X
Crushed-concrete Access Road				X		X
Fence				X		X
Gates/locks				X		X
Radiological Postings				X		X
Other: LUIC POC Signs				X		X

5. Evidence of unauthorized work activities and/or unauthorized access has occurred? ☐ Yes ☒ No

B. Description of Other Observations
Observed Conditions/Recommendations: Good vegetation growth and no erosion evident.

Location (AOC): Old Incinerator Facility
Date of Inspection: 9/2/20
Name of Inspector(s): R. Howe
Purpose of Inspection: ☒ Routine (Scheduled Freq. of 2x/yr) ☐ Heavy Rainfall ☐ Reported Incident

A. Inspection Checklist

Component Req'd	Observed Condition				Further Action	
	Excell.	Fair	Poor	Not Applic.	Yes (describe)	No
1. Landfill Cap/Soil Covers:						
Vegetation (e.g. grass)	X					X
Soil (Cap/Cover/Fill)	X				No erosion visible	X
Other: _____						
2. Drainage Structures:						
Standing Water				X		X
Toe Drain				X		X
Drainage Channels				X		X
French Drains/Outfalls				X		X
Subsurface Drainage Pipes/Outfalls				X		X
Manholes				X		X
Berms				X		X
Roof Drains				X		X
Recharge Areas				X		X
Other: _____						
3. Monitoring System:						
Soil Gas Wells				X		X
Groundwater Wells	X					X
Gas Vents				X		X
Other: _____						
4. Site Access:						
Asphalt Access Road				X		X
Crushed-concrete Access Road				X		X
Fence				X		X
Gates/locks				X		X
Radiological Postings				X		X
Other: _____				X		X

5. Evidence of unauthorized work activities and/or unauthorized access has occurred? ☐ Yes ☒ No
If yes, describe evidence: _____

B. Description of Other Observations
Observed Conditions/Recommendations: Excellent vegetative growth, no erosion evident.

Location (AOC): Low Mass Criticality Facility
Date of Inspection: 9/2/20
Name of Inspector(s): R. Howe
Purpose of Inspection: ☒ Routine (Scheduled Freq. of 1x/yr) ☐ Heavy Rainfall ☐ Reported Incident

A. Inspection Checklist

Component	Observed Condition				Further Action Req'd	
	Excell.	Fair	Poor	Not Applic.	Yes (describe)	No
1. Soil Covers/Wetlands:						
Vegetation (e.g. grass)	X					X
Soil (Cap/Cover/Fill)				X		X
Other: _____						
2. Drainage Structures:						
Standing Water	X				Little water in basin	X
Toe Drain				X		X
Drainage Channels				X		X
French Drains/Outfalls				X		X
Subsurface Drainage Pipes/Outfalls	X					X
Manholes	X					X
Berms				X		X
Roof Drains	X					X
Recharge Areas		X			Phragmites in basin	X
Other: _____				X		X
3. Monitoring System:						
Soil Gas Wells				X		X
Groundwater Wells	X					X
Gas Vents				X		X
Other: _____				X		X
4. Site Access:						
Asphalt Access Road				X		X
Crushed-concrete Access Road		X				X
Fence				X		X
Gates/locks				X		X
Radiological Postings				X		X
Other: _____						

5. Evidence of unauthorized work activities and/or unauthorized access has occurred? ☐ Yes ☒ No
If yes, describe evidence:

_____

B. Description of Other Observations
Observed Conditions/Recommendations: No institutional control issues.

Location (AOC): AGS Storage Yards (1 and 2)
Date of Inspection: 9/2/20
Name of Inspector(s): R. Howe
Purpose of Inspection: ☒ Routine (Scheduled Freq. of 1x/yr) ☐ Heavy Rainfall ☐ Reported Incident

A. Inspection Checklist

Component	Observed Condition				Further Action Req'd	
	Excell.	Fair	Poor	Not Applic.	Yes (describe)	No
1. Soil Covers/Wetlands:						
Vegetation (e.g. grass)		X				X
Soil (Cap/Cover/Fill)				X		X
Other: _____						
2. Drainage Structures:						
Standing Water				X		X
Toe Drain				X		X
Drainage Channels				X		X
French Drains/Outfalls				X		X
Subsurface Drainage Pipes/Outfalls				X		X
Manholes				X		X
Berms				X		X
Roof Drains				X		X
Recharge Areas				X		X
Other: _____				X		X
3. Monitoring System:						
Soil Gas Wells				X		X
Groundwater Wells		X				X
Gas Vents				X		X
Other: _____				X		X
4. Site Access:						
Asphalt Access Road				X		X
Crushed-concrete Access Road				X		X
Fence		X			No fence in Yard 2	X
Gates/locks		X			No gate in Yard 2	X
Radiological Postings		X			RMA postings good	X
Other: _____						X

5. Evidence of unauthorized work activities and/or unauthorized access has occurred? ☐ Yes ☒ No
If yes, describe evidence:

B. Description of Other Observations

Observed Conditions/Recommendations: The Bldg. 912 Steel Yard (Yard 1A) is a Radioactive Material Area (RMA). It is fenced, rad posted with a chain, and C-AD contact sign. The Bldg. 912 Former Lead Storage Yard (Yard 1B), is also identified as a RMA, is rad posted as an RMA, and the area is fenced but the gate is open. Yard 2 is a vacant field to the east of Bldg. 811 with no rad postings. A work order was issued to have the snow fence repaired that demarcates between Yard 1B and the former Building 811 Area.

Location (AOC): Bubble Chamber
Date of Inspection: 9/2/20
Name of Inspector(s): R. Howe
Purpose of Inspection: ☒ Routine (Scheduled Freq. of 1x/yr) ☐ Heavy Rainfall ☐ Reported Incident

A. Inspection Checklist

Component	Observed Condition				Further Action Req'd	
	Excell.	Fair	Poor	Not Applic.	Yes (describe)	No
1. Soil Covers/Wetlands:						
Vegetation (e.g. grass)		X				X
Soil (Cap/Cover/Fill)				X		X
Other: _____						
2. Drainage Structures:						
Standing Water	X					X
Toe Drain				X		X
Drainage Channels				X		X
French Drains/Outfalls				X		X
Subsurface Drainage Pipes/Outfalls				X		X
Manholes				X		X
Berms				X		X
Roof Drains				X		X
Recharge Areas				X		X
Other: _____				X		X
3. Monitoring System:						
Soil Gas Wells				X		X
Groundwater Wells		X				X
Gas Vents				X		X
Other: _____				X		X
4. Site Access:						
Asphalt Access Road		X				X
Crushed-concrete Access Road				X		X
Fence	X					X
Gates/locks	X				B960 gate locked	X
Radiological Postings	X				C-AD Rad Storage	X
Other: _____						

5. Evidence of unauthorized work activities and/or unauthorized access has occurred? ☐ Yes ☒ No
If yes, describe evidence:

B. Description of Other Observations

Observed Conditions/Recommendations: The fenced area is controlled by Collider-Accelerator Dept. (C-AD) and is designated as the Bldg. 960 Waste Yard. It is used for outdoor storage of rad materials. It is fenced, locked, with rad postings, and paved. The remainder of the area to the north is open and consists of grass, pavement, and concrete slabs (no postings).

Location (AOC): Bldg. 830 USTs and Pipe Leak
Date of Inspection: 9/2/20
Name of Inspector(s): R. Howe
Purpose of Inspection: ☒ Routine (Scheduled Freq. of 1x/yr) ☐ Heavy Rainfall ☐ Reported Incident

A. Inspection Checklist

Component	Observed Condition				Further Action Req'd	
	Excell.	Fair	Poor	Not Applic.	Yes (describe)	No
1. Soil Covers/Wetlands:						
Vegetation (e.g. grass)				X		X
Soil (Cap/Cover/Fill)				X		X
Other: _____						
2. Drainage Structures:						
Standing Water				X		X
Toe Drain				X		X
Drainage Channels				X		X
French Drains/Outfalls				X		X
Subsurface Drainage Pipes/Outfalls				X		X
Manholes				X		X
Berms				X		X
Roof Drains				X		X
Recharge Areas				X		X
Other: _____				X		X
3. Monitoring System:						
Soil Gas Wells				X		X
Groundwater Wells		X				X
Gas Vents				X		X
Other: _____				X		X
4. Site Access:						
Asphalt Access Road	X					X
Crushed-concrete Access Road				X		X
Fence				X		X
Gates/locks				X		X
Radiological Postings	X				For Rad Storage Area	X
Other: _____						

5. Evidence of unauthorized work activities and/or unauthorized access has occurred? ☐ Yes ☒ No
If yes, describe evidence: Digging proposed for the area would be reviewed by the Groundwater Protection Group via the digging permit process.

B. Description of Other Observations
Observed Conditions/Recommendations: The area currently consists of Bldg. 830 (occupied) by the Nonproliferation and National Security Department. Outdoor connex storage, waste collection area, and rad waste storage areas are present.

VIII. GROUNDWATER REMEDIES ☒ Applicable ☐ N/A 8/17/20

A. System OU III LIPA/Airport. Inspection attendees include R. Howe, E. Kramer

1. **Construction Complete/System Operating** ☒ Yes ☐ No

Remarks: System operating. Airport wells RTW-2, RTW-3 and RTW-5 are off in standby mode, and all LIPA wells EW-1L, EW-2L, EW-3L and EW-4L are in standby.

B. Groundwater Extraction Wells, Pumps, and Pipelines ☒ Applicable ☐ N/A

1. **Pumps, Wellhead Plumbing, and Electrical**
☒ Good condition ☒ All required wells properly operating ☐ Needs Maintenance
Remarks: No repairs needed.

2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances**
☒ Good condition ☐ Needs Maintenance
Remarks_____

3. **Spare Parts and Equipment**
☒ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks_____

C. Treatment System ☒ Applicable ☐ N/A

1. **Treatment Train** (Check components that apply)
☐ Metals removal ☐ Oil/water separation ☐ Bioremediation
☐ Air stripping ☒ Carbon adsorbers
☐ Filters_____
☐ Additive (*e.g.*, chelation agent, flocculent):
☐ Others_____
☒ Good condition ☐ Needs Maintenance
☒ Sampling ports properly marked and functional
☐ Sampling/maintenance log displayed and up to date (See remarks)
☒ Equipment properly identified
☒ Quantity of groundwater treated annually_____
☐ Quantity of surface water treated annually_____
Remarks_Current Current O&M Manual and SPDES Equivalency Permit are displayed.
Daily Operating Sheet will be revised to reflect monthly use. Remote monitoring of the system is performed in Bldg. 462. System maintenance is documented in the Daily Field Report and system sampling is documented on the share drive._____

2. **Electrical Enclosures and Panels** (properly rated and functional)
☐ N/A ☒ Good condition ☐ Needs Maintenance
Remarks:

3. **Tanks, Vaults, Storage Vessels**
☐ N/A ☒ Good condition ☐ Proper secondary containment ☐ Needs Maintenance
Remarks:

4. **Discharge Structure and Appurtenances**
☐ N/A ☒ Good condition ☒ Needs Maintenance
Remarks: Injection and recirculation wells require routine maintenance to prevent clogging.

System OU III LIPA/Airport (cont'd).

5. **Treatment Building(s)**
☐ N/A ☒ Good condition (esp. roof and doorways) ☒ Needs repair
☐ Chemicals and equipment properly stored
Remarks: _Area around building and transformer yard need weed whacking._____

6. **Monitoring Wells** (pump and treatment remedy)
☐ Properly secured/locked ☒ Functioning ☒ Routinely sampled ☒ Good condition
☒ All required wells located ☐ Needs Maintenance ☐ N/A
Remarks
_____

D. Monitoring Data

1. Monitoring Data
☒ Is routinely submitted on time ☒ Is of acceptable quality

2. Monitoring data suggests:
☒ Groundwater plume is effectively contained ☒ Contaminant concentrations are declining
Remarks: VOC concentrations in all four LIPA extraction wells have remained low and these wells are in standby mode. VOCs in Airport EWs have been low and stable, while VOCs in RW-6A are slightly higher.

VIII. GROUNDWATER REMEDIES ☒ Applicable ☐ N/A 8/17/20

A. System OU III North Street/North Street East. Inspection attendees include R. Howe

1. **Construction Complete/System Operating** ☒ Yes ☐ No

Remarks: The original NSE VOC system has been administratively closed per the 2019 Groundwater Status Report. The NS system was approved for closure in March 2020. A modification to the NSE system was completed in July 2020 with the addition of two additional extraction wells to remediate the EDB plume.

B. Groundwater Extraction Wells, Pumps, and Pipelines ☒ Applicable ☐ N/A

1. **Pumps, Wellhead Plumbing, and Electrical**

☒ Good condition ☒ All required wells properly operating ☐ Needs Maintenance ☐ N/A

Remarks: NSE EDB extraction wells NSE-EDB-EW-1 and NSE-EDB-EW-2 are operating.

2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances**

☒ Good condition ☐ Needs Maintenance

Remarks_____

3. **Spare Parts and Equipment**

☐ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided

Remarks_____

C. Treatment System ☒ Applicable ☐ N/A

1. **Treatment Train** (Check components that apply)

☐ Metals removal ☐ Oil/water separation ☐ Bioremediation
☐ Air stripping ☒ Carbon adsorbers
☐ Filters_____
☐ Additive (*e.g.*, chelation agent, flocculent):
☐ Others_____
☒ Good condition ☐ Needs Maintenance
☒ Sampling ports properly marked and functional
☐ Sampling/maintenance log displayed and up to date (See remarks)
☒ Equipment properly identified
☒ Quantity of groundwater treated annually_____
☐ Quantity of surface water treated annually_____

Remarks: Hazard info placard by main door and inside building needs updating of primary contact. The O&M Manual is not readily available in the building. The current SPDES Equivalency Permit (that includes the NSE EDB) is not posted in the building.
Daily Operating Sheet will be revised to reflect monthly use. Remote monitoring of the system is performed in Bldg. 462. System maintenance is documented in the Daily Field Report and system sampling is documented on the share drive._____

2. **Electrical Enclosures and Panels** (properly rated and functional)

☐ N/A ☒ Good condition ☐ Needs Maintenance

Remarks:

System OU III North Street/North Street East (cont'd)

3. **Tanks, Vaults, Storage Vessels**
☐ N/A ☒ Good condition ☐ Proper secondary containment ☐ Needs Maintenance
Remarks_____
_____

4. **Discharge Structure and Appurtenances**
☐ N/A ☒ Good condition ☐ Needs Maintenance
Remarks: Injection wells need routine maintenance due to fouling (every 6 to 12 months).

5. **Treatment Building(s)**
☐ N/A ☒ Good condition (esp. roof and doorways) ☒ Needs repair
☐ Chemicals and equipment properly stored
Remarks: Weeds growing in the east gutter need to be removed. _____
_____

6. **Monitoring Wells** (pump and treatment remedy)
☒ Properly secured/locked ☒ Functioning ☒ Routinely sampled ☒ Good condition
☒ All required wells located ☐ Needs Maintenance ☐ N/A
Remarks_____
_____

D. Monitoring Data

3. Monitoring Data
☒ Is routinely submitted on time ☒ Is of acceptable quality

4. Monitoring data suggests:
☒ Groundwater plume is effectively contained ☒ Contaminant concentrations are declining (except for NSE EDB)
Note: Original NSE VOC system and the NS system are closed.

VIII. GROUNDWATER REMEDIES ☒ Applicable ☐ N/A 8/17/20

A. System OU VI AOC 28 EDB. Inspection attendees include R. Howe

1. **Construction Complete/System Operating** ☒ Yes ☐ No

Remarks: System has been shut down since 8/15/20 due to repairs needed to PLC.

B. Groundwater Extraction Wells, Pumps, and Pipelines ☒ Applicable ☐ N/A

1. **Pumps, Wellhead Plumbing, and Electrical**

☒ Good condition ☒ All required wells properly operating ☐ Needs Maintenance ☐ N/A

Remarks:

2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances**

☒ Good condition ☐ Needs Maintenance

Remarks

3. **Spare Parts and Equipment**

☒ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided

Remarks

C. Treatment System ☒ Applicable ☐ N/A

1. **Treatment Train** (Check components that apply)

☐ Metals removal ☐ Oil/water separation ☐ Bioremediation
☐ Air stripping ☒ Carbon adsorbers
☐ Filters
☐ Additive (*e.g.*, chelation agent, flocculent):
☐ Others
☒ Good condition ☐ Needs Maintenance
☒ Sampling ports properly marked and functional
☐ Sampling/maintenance log displayed and up to date (See remarks)
☒ Equipment properly identified
☒ Quantity of groundwater treated annually
☐ Quantity of surface water treated annually

Remarks: Hazard info placard by main door needs updating of primary contact. The current SPDES Equivalency Permit is not posted in the building, but the O&M Manual is available.
Daily Operating Sheet will be revised to reflect monthly use. Remote monitoring of the system is performed in Bldg. 462. System maintenance is documented in the Daily Field Report and system sampling is documented on the share drive.

2. **Electrical Enclosures and Panels** (properly rated and functional)

☐ N/A ☒ Good condition ☒ Needs Maintenance

Remarks: Faulty fire alarm sensor was replaced 8/17/20.

3. **Tanks, Vaults, Storage Vessels**

☐ N/A ☒ Good condition ☐ Proper secondary containment ☐ Needs Maintenance

Remarks

4. **Discharge Structure and Appurtenances**

☐ N/A ☒ Good condition ☐ Needs Maintenance

Remarks:

System OU VI AOC 28 EDB (cont'd)

5. **Treatment Building(s)**
☐ N/A ☐ Good condition (esp. roof and doorways) ☒ Needs repair
☐ Chemicals and equipment properly stored
Remarks: Black mold is present on the east inside wall and ceiling due to excessive moisture and needs to be removed. The two air conditioners were not operating and had mold. Either repair or remove them. Water piping and flanges have significant rust. Evaluate and repaint if needed. The area around the building and transformer yard need weed whacking. The soffit at the southeast corner of the building needs repair.

6. **Monitoring Wells** (pump and treatment remedy)
☒ Properly secured/locked ☒ Functioning ☒ Routinely sampled ☒ Good condition
☒ All required wells located ☐ Needs Maintenance ☐ N/A
Remarks_ _____
_____

D. Monitoring Data

5. Monitoring Data
☒ Is routinely submitted on time ☒ Is of acceptable quality

6. Monitoring data suggests:
☒ Groundwater plume is effectively contained ☐ Contaminant concentrations are declining
Remarks: The plume is moving slower and the system is operating significantly longer than originally projected.

VIII. GROUNDWATER REMEDIES ☒ Applicable ☐ N/A 8/17/20

A. System OU III Deep VOCs in Industrial Park. Inspection attendees include R. Howe

1. **Construction Complete/System Operating** ☒ Yes ☐ No

Remarks: The Industrial Park East system was approved for closure in 2013, and the extraction wells and several monitoring wells were abandoned. Starting in late 2014, the building (OS-2) and associated utilities, the carbon units, and injection wells are being used to treat the deep VOC plume in the Industrial Park. The two extraction wells (EW-8 and EW-9) are currently in standby mode.

B. Groundwater Extraction Wells, Pumps, and Pipelines ☒ Applicable ☐ N/A

1. **Pumps, Wellhead Plumbing, and Electrical**
☒ Good condition ☒ All required wells properly operating ☐ Needs Maintenance ☐ N/A
Remarks:

2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances**
☒ Good condition ☐ Needs Maintenance
Remarks_____
_____

3. **Spare Parts and Equipment**
☒ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks_____
_____

C. Treatment System ☒ Applicable ☐ N/A

1. **Treatment Train** (Check components that apply)
☐ Metals removal ☐ Oil/water separation ☐ Bioremediation
☐ Air stripping ☒ Carbon adsorbers
☐ Filters_____
☐ Additive (*e.g.*, chelation agent, flocculent):
☐ Others_____
☒ Good condition ☐ Needs Maintenance
☒ Sampling ports properly marked and functional
☐ Sampling/maintenance log displayed and up to date
☒ Equipment properly identified
☒ Quantity of groundwater treated annually_____
☐ Quantity of surface water treated annually_____
Remarks: Hazard info placard by main door needs updating of primary contact. The current SPDES Equivalency Permit is not posted in the building, but the O&M Manual is available.
Daily Operating Sheet will be revised to reflect monthly use. Remote monitoring of the system is performed in Bldg. 462. System maintenance is documented in the Daily Field Report and system sampling is documented on the share drive._____
_____

2. **Electrical Enclosures and Panels** (properly rated and functional)
☐ N/A ☒ Good condition ☐ Needs Maintenance
Remarks:

3. **Tanks, Vaults, Storage Vessels**
☐ N/A ☒ Good condition ☐ Proper secondary containment ☐ Needs Maintenance
Remarks_
_____
_____

System	OU III Deep VOCs in Industrial Park (cont'd)
4.	**Discharge Structure and Appurtenances** ☐ N/A ☒ Good condition ☐ Needs Maintenance Remarks: The injection wells require periodic maintenance
5.	**Treatment Building(s)** ☐ N/A ☐ Good condition (esp. roof and doorways) ☒ Needs repair ☐ Chemicals and equipment properly stored Remarks: Gutter on east side of building is down and the one on the west side is hanging off. Either remove or repair. Significant vegetation around building and poison ivy around main door needs to be removed.
6.	**Monitoring Wells** (pump and treatment remedy) ☒ Properly secured/locked ☒ Functioning ☒ Routinely sampled ☒ Good condition ☒ All required wells located ☐ Needs Maintenance ☐ N/A Remarks:
D. Monitoring Data	
7.	Monitoring Data ☒ Is routinely submitted on time ☒ Is of acceptable quality
8.	Monitoring data suggests: ☒ Groundwater plume is effectively contained ☐ Contaminant concentrations are declining Remarks: Due to low levels of VOCs, the treatment system was placed in standby mode in July 2019.

VIII. GROUNDWATER REMEDIES ☒ Applicable ☐ N/A 8/17/20

A. System OU III Industrial Park. Inspection attendees include R. Howe

1. **Construction Complete/System Operating** ☒ Yes ☐ No

Remarks: The system is currently in stand-by mode.

B. Groundwater Extraction Wells, Pumps, and Pipelines ☒ Applicable ☐ N/A

1. **Pumps, Wellhead Plumbing, and Electrical**

☒ Good condition ☐ All required wells properly operating ☒ Needs Maintenance ☐ N/A

Remarks: All UVB treatment wells are shut down and remain in standby mode.

2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances**

☒ Good condition ☐ Needs Maintenance

Remarks_____

_____

3. **Spare Parts and Equipment**

☒ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided

Remarks_____

_____

C. Treatment System ☒ Applicable ☐ N/A

1. **Treatment Train** (Check components that apply)

☐ Metals removal ☐ Oil/water separation ☐ Bioremediation

☒ Air stripping ☒ Carbon adsorbers (vapor phase)

☐ Filters_____

☐ Additive (*e.g.*, chelation agent, flocculent):

☐ Others_____

☒ Good condition ☐ Needs Maintenance

☒ Sampling ports properly marked and functional

☐ Sampling/maintenance log displayed and up to date (See remarks)

☒ Equipment properly identified

☒ Quantity of groundwater treated annually_____

☐ Quantity of surface water treated annually_____

Remarks: Hazard info placard by main door needs updating of primary contact. The current O&M Manual is readily available in the building.

Daily Operating Sheet will be revised to reflect monthly use. Remote monitoring of the system is performed in Bldg. 462. System maintenance is documented in the Daily Field Report and system sampling is documented on the share drive._____

2. **Electrical Enclosures and Panels** (properly rated and functional)

☐ N/A ☒ Good condition ☐ Needs Maintenance

Remarks:

3. **Tanks, Vaults, Storage Vessels**

☐ N/A ☒ Good condition ☐ Proper secondary containment ☐ Needs Maintenance

Remarks_____

_____

4. **Discharge Structure and Appurtenances**

☐ N/A ☒ Good condition ☐ Needs Maintenance

Remarks: These wells are recirculation wells with two screens and require frequent cleaning to keep them operational

System	OU III Industrial Park (cont'd)
5.	**Treatment Building(s)** ☐ N/A ☒ Good condition (esp. roof and doorways) ☐ Needs repair ☐ Chemicals and equipment properly stored Remarks: The area around the building needs weed whacking._____
6.	**Monitoring Wells** (pump and treatment remedy) ☒ Properly secured/locked ☒ Functioning ☒ Routinely sampled ☒ Good condition ☒ All required wells located ☐ Needs Maintenance ☐ N/A Remarks_____ _____
D. Monitoring Data	
9.	Monitoring Data ☒ Is routinely submitted on time ☒ Is of acceptable quality
10.	Monitoring data suggests: ☒ Groundwater plume is effectively contained ☒ Contaminant concentrations are declining Remarks: All seven UVB treatment wells have remained in standby mode since 2017 due to low VOC concentrations in monitoring and extraction wells.

VIII. GROUNDWATER REMEDIES ☒ Applicable ☐ N/A 8/19/20

A. System OU III AOC 29 HFBR Tritium Pump and Recharge. Inspection attendees include R. Howe

1. **Construction Complete/System Operating** ☒ Yes ☐ No

Remarks: The system was approved for closure March 2019.

B. Groundwater Extraction Wells, Pumps, and Pipelines ☒ Applicable ☐ N/A

1. **Pumps, Wellhead Plumbing, and Electrical**

☒ Good condition ☐ All required wells properly operating ☐ Needs Maintenance ☐ N/A

Remarks: The four extraction wells are closed but will not be abandoned until emerging contaminant characterization is complete.

2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances**

☒ Good condition ☐ Needs Maintenance

Remarks

3. **Spare Parts and Equipment**

☒ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided

Remarks

C. Treatment System ☒ Applicable ☐ N/A

1. **Treatment Train** (Check components that apply)

☐ Metals removal ☐ Oil/water separation ☐ Bioremediation
☐ Air stripping ☒ Carbon adsorbers
☐ Filters_____
☐ Additive (*e.g.*, chelation agent, flocculent):
☐ Others_____
☒ Good condition ☐ Needs Maintenance
☒ Sampling ports properly marked and functional
☐ Sampling/maintenance log displayed and up to date (system closed)
☒ Equipment properly identified
☒ Quantity of groundwater treated annually_____
☐ Quantity of surface water treated annually_____

Remarks: The carbon was removed from the vessels in Sept. 2014 and not replaced. The vessels may be reused for treatment of PFAS from the former firehouse plume.

The Facility Project Manager on the two signs outside the building need to be changed. The current O&M Manual and SPDES equivalency permit is readily available in the building.

2. **Electrical Enclosures and Panels** (properly rated and functional)

☐ N/A ☒ Good condition ☐ Needs Maintenance

Remarks:

3. **Tanks, Vaults, Storage Vessels**

☐ N/A ☒ Good condition ☐ Proper secondary containment ☒ Needs Maintenance

Remarks: The camlock cap on the drainage line to the carbon vessels is missing._____

4. **Discharge Structure and Appurtenances**

☐ N/A ☒ Good condition ☐ Needs Maintenance

Remarks:

System: HFBR Tritium Pump and Recharge (cont'd)

5. **Treatment Building(s)**
☐ N/A ☒ Good condition (esp. roof and doorways) ☐ Needs repair
☐ Chemicals and equipment properly stored
Remarks: The inside of Bldg. 598 needs housekeeping. The last inspection date posted on the roll-up door is April 2015. Need to check required inspection frequency.

6. **Monitoring Wells** (pump and treatment remedy)
☒ Properly secured/locked ☐ Functioning ☒ Routinely sampled ☒ Good condition
☒ All required wells located ☐ Needs Maintenance ☐ N/A
Remarks

D. Monitoring Data

11. Monitoring Data
☒ Is routinely submitted on time ☒ Is of acceptable quality

12. Monitoring data suggests:
☒ Groundwater plume is effectively contained ☒ Contaminant concentrations are declining
Remarks: The system was shut down and placed in stand-by mode in May 2013, then approved for closure in March 2019.

VIII. GROUNDWATER REMEDIES ☒ Applicable ☐ N/A 8/19/20

A. System OU I South Boundary (Bldg. 598) Inspection attendees include R. Howe

1. **Construction Complete/System Operating** ☒ Yes ☐ No

Remarks: The system was approved for closure September 2019.

B. Groundwater Extraction Wells, Pumps, and Pipelines ☒ Applicable ☐ N/A

1. **Pumps, Wellhead Plumbing, and Electrical**

☒ Good condition ☐ All required wells properly operating ☐ Needs Maintenance ☐ N/A

Remarks: The extraction wells are closed but will not be abandoned until emerging contaminant characterization is complete.

2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances**

☒ Good condition ☐ Needs Maintenance

Remarks

3. **Spare Parts and Equipment**

☒ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided

Remarks_____

C. Treatment System ☒ Applicable ☐ N/A

1. **Treatment Train** (Check components that apply)

☐ Metals removal ☐ Oil/water separation ☐ Bioremediation
☒ Air stripping ☐ Carbon adsorbers
☐ Filters_____
☐ Additive (*e.g.*, chelation agent, flocculent)_sodium polyphosphate is not used_____
☐ Others_____
☒ Good condition ☐ Needs Maintenance
☒ Sampling ports properly marked and functional
☒ Sampling/maintenance log displayed and up to date
☒ Equipment properly identified
☐ Quantity of groundwater treated annually_____
☐ Quantity of surface water treated annually_____

Remarks: The current O&M Manual and SPDES equivalency permit is readily available in the building.
_____

2. **Electrical Enclosures and Panels** (properly rated and functional)

☐ N/A ☒ Good condition ☒ Needs Maintenance

Remarks_Repairs are being made on the electrical system and controllers that were damaged due to lightning strike in early July.
_____
_____

3. **Tanks, Vaults, Storage Vessels**

☐ N/A ☒ Good condition ☐ Proper secondary containment ☐ Needs Maintenance

4. **Discharge Structure and Appurtenances**

☐ N/A ☒ Good condition ☐ Needs Maintenance

Remarks: Recharge Basin is in good condition.

System: OU I South Boundary (cont'd)

5. **Treatment Building(s)**
☐ N/A ☒ Good condition (esp. roof and doorways) ☒ Needs repair
☐ Chemicals and equipment properly stored
Remarks: The inside of Bldg. 598 needs housekeeping. Part of the foam sound insulation on the outside portion of the blower needs to be repaired. Weeds growing in the southeast gutter need to be removed. Area around building was recently mowed.

6. **Monitoring Wells** (pump and treatment remedy)
☒ Properly secured/locked ☐ Functioning ☒ Routinely sampled ☐ Good condition
☒ All required wells located ☐ Needs Maintenance ☐ N/A
Remarks

D. Monitoring Data

13. Monitoring Data
☒ Is routinely submitted on time ☒ Is of acceptable quality

14. Monitoring data suggests:
☒ Groundwater plume is effectively contained ☒ Contaminant concentrations are declining
Remarks: The system was shut down and placed in stand-by mode in July 2013, then approved for closure in September 2019.

VIII. GROUNDWATER REMEDIES ☒ Applicable ☐ N/A 8/19/20

A. System OU III South Boundary Bldg. 517/518 (treatment building) and Bldg. 519 (pump house) Inspection attendees include R. Howe

1. **Construction Complete/System Operating** ☒ Yes ☐ No

Remarks: Well 17 is running and well 4 is pulsed pumping. EWs 3,5,6,7,8 and 12 are in standby due to low VOC concentrations.

B. Groundwater Extraction Wells, Pumps, and Pipelines ☒ Applicable ☐ N/A

1. **Pumps, Wellhead Plumbing, and Electrical**
☒ Good condition ☒ All required wells properly operating ☐ Needs Maintenance ☐ N/A
Remarks: Wells EWs 4 and 17 are operating.

2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances**
☒ Good condition ☐ Needs Maintenance
Remarks

3. **Spare Parts and Equipment**
☒ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks_____

C. Treatment System ☒ Applicable ☐ N/A

1. **Treatment Train** (Check components that apply)
☐ Metals removal ☐ Oil/water separation ☐ Bioremediation
☒ Air stripping ☐ Carbon adsorbers
☐ Filters_____
☐ Additive (*e.g.*, chelation agent, flocculent)_____
☐ Others_____
☒ Good condition ☐ Needs Maintenance
☒ Sampling ports properly marked and functional
☐ Sampling/maintenance log displayed and up to date
☒ Equipment properly identified
☒ Quantity of groundwater treated annually_____
☐ Quantity of surface water treated annually_____
Remarks: Daily Operating Sheet will be revised to reflect monthly use. Remote monitoring of the system is performed in Bldg. 462. System maintenance is documented in the Daily Field Report and system sampling is documented on the share drive. The current O&M Manual and SPDES equivalency permit are readily available in Buildings 517 and 519. The Facility Project Manager on the sign outside Buildings 517, 518 and 519 need to be updated.

2. **Electrical Enclosures and Panels** (properly rated and functional)
☐ N/A ☒ Good condition ☐ Needs Maintenance
Remarks_____
_____

3. **Tanks, Vaults, Storage Vessels**
☐ N/A ☒ Good condition ☐ Proper secondary containment ☐ Needs Maintenance

System: OU III South Boundary (cont'd)

4. **Discharge Structure and Appurtenances**
☐ N/A ☒ Good condition ☐ Needs Maintenance
Remarks: Recharge Basins are in good condition but require occasional scraping.

5. **Treatment Building(s)**
☐ N/A ☒ Good condition (esp. roof and doorways) ☐ Needs repair
☐ Chemicals and equipment properly stored
Remarks:

6. **Monitoring Wells** (pump and treatment remedy)
☒ Properly secured/locked ☐ Functioning ☒ Routinely sampled ☐ Good condition
☒ All required wells located ☐ Needs Maintenance ☐ N/A
Remarks

D. Monitoring Data

15. Monitoring Data
☒ Is routinely submitted on time ☒ Is of acceptable quality

16. Monitoring data suggests:
☒ Groundwater plume is effectively contained ☐ Contaminant concentrations are declining
Remarks: Two of the eight extraction wells are currently operating (EW-4 and EW-17). The remaining wells have met the cleanup goals.

VIII. GROUNDWATER REMEDIES ☒ Applicable ☐ N/A 8/19/20

A. System OU III Middle Road, Bldgs. 516 (pump house) and 517/518 (treatment system)
Inspection attendees include R. Howe

1. **Construction Complete/System Operating** ☒ Yes ☐ No

Remarks: Four extraction wells RW-1, RW-4, RW-5 and RW-6 are in standby and have met the Remedial Action Objectives for this project. Wells RW-2, RW-3 and RW-7 continue full time operation.

B. Groundwater Extraction Wells, Pumps, and Pipelines ☒ Applicable ☐ N/A

1. **Pumps, Wellhead Plumbing, and Electrical**
☒ Good condition ☒ All required wells properly operating ☐ Needs Maintenance ☐ N/A
Remarks: RW-2, 3, and 7 are operating.

2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances**
☒ Good condition ☐ Needs Maintenance
Remarks

3. **Spare Parts and Equipment**
☒ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks_____

C. Treatment System ☒ Applicable ☐ N/A

1. **Treatment Train** (Check components that apply)
☐ Metals removal ☐ Oil/water separation ☐ Bioremediation
☒ Air stripping ☐ Carbon adsorbers
☐ Filters_____
☐ Additive (*e.g.*, chelation agent, flocculent)_sodium polyphosphate is not used_____
☐ Others_____
☒ Good condition ☐ Needs Maintenance
☒ Sampling ports properly marked and functional
☐ Sampling/maintenance log displayed and up to date
☒ Equipment properly identified
☒ Quantity of groundwater treated annually_____
☐ Quantity of surface water treated annually_____
Remarks: Daily Operating Sheet will be revised to reflect monthly use. Remote monitoring of the system is performed in Bldg. 462. System maintenance is documented in the Daily Field Report and system sampling is documented on the share drive. The current O&M Manual and SPDES equivalency permit are readily available in Buildings 517 and 518. Building 516 has the SPDES equivalency permit posted. The Facility Project Manager on the signs outside Buildings 516, 517/518 need to be updated.

2. **Electrical Enclosures and Panels** (properly rated and functional)
☐ N/A ☒ Good condition ☐ Needs Maintenance
Remarks_____
_____

3. **Tanks, Vaults, Storage Vessels**
☐ N/A ☒ Good condition ☐ Proper secondary containment ☐ Needs Maintenance

4. **Discharge Structure and Appurtenances**
☐ N/A ☒ Good condition ☐ Needs Maintenance
Remarks: Recharge Basins are is in good condition.

System: OU III Middle Road (cont'd)	
5.	**Treatment Building(s)** ☐ N/A ☒ Good condition (esp. roof and doorways) ☒ Needs repair ☐ Chemicals and equipment properly stored Remarks: The Bldg. 516 door lock plate is broken and needs to be repaired.
6.	**Monitoring Wells** (pump and treatment remedy) ☒ Properly secured/locked ☐ Functioning ☒ Routinely sampled ☐ Good condition ☒ All required wells located ☐ Needs Maintenance ☐ N/A Remarks
D. Monitoring Data	
17.	Monitoring Data ☒ Is routinely submitted on time ☒ Is of acceptable quality
18.	Monitoring data suggests: ☒ Groundwater plume is effectively contained ☐ Contaminant concentrations are declining Remarks: Only the deeper extraction wells MR-2, MR-3, and Mr-7 are operating. The remaining extraction wells have met cleanup goals and are in standby.

VIII. GROUNDWATER REMEDIES ☒ Applicable ☐ N/A 8/19/20

A. System OU III Western South Boundary (Bldg. 517/518) Inspection attendees include R. Howe

1. **Construction Complete/System Operating** ☒ Yes ☐ No

Remarks: original extraction well WSB-1 is operating and WSB-2 is on standby. Four additional extraction wells were installed and became operating in 2019. Wells WSB-3, WSB-4, WSB-5 and WSB-6 are operating.

B. Groundwater Extraction Wells, Pumps, and Pipelines ☒ Applicable ☐ N/A

1. **Pumps, Wellhead Plumbing, and Electrical**
☒ Good condition ☒ All required wells properly operating ☐ Needs Maintenance ☐ N/A
Remarks:

2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances**
☒ Good condition ☐ Needs Maintenance
Remarks

3. **Spare Parts and Equipment**
☒ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks_____

C. Treatment System ☒ Applicable ☐ N/A

1. **Treatment Train** (Check components that apply)
☐ Metals removal ☐ Oil/water separation ☐ Bioremediation
☒ Air stripping ☐ Carbon adsorbers
☐ Filters_____
☐ Additive (*e.g.*, chelation agent, flocculent)_sodium polyphosphate is not used_____
☐ Others_____
☒ Good condition ☐ Needs Maintenance
☒ Sampling ports properly marked and functional
☐ Sampling/maintenance log displayed and up to date
☒ Equipment properly identified
☒ Quantity of groundwater treated annually_____
☐ Quantity of surface water treated annually_____
Remarks: Daily Operating Sheet will be revised to reflect monthly use. Remote monitoring of the system is performed in Bldg. 462. System maintenance is documented in the Daily Field Report and system sampling is documented on the share drive. The revised O&M Manual and SPDES equivalency permit are readily available in Building 517. As of March 2019, the Western South Boundary system is operating under the Middle Road/South Boundary equivalency permit___
_____

2. **Electrical Enclosures and Panels** (properly rated and functional)
☐ N/A ☒ Good condition ☐ Needs Maintenance
Remarks_____
_____

3. **Tanks, Vaults, Storage Vessels**
☐ N/A ☒ Good condition ☐ Proper secondary containment ☐ Needs Maintenance

4. **Discharge Structure and Appurtenances**
☐ N/A ☒ Good condition ☐ Needs Maintenance
Remarks: Recharge Basin is in good condition

System: OU III Western South Boundary (cont'd)

5. **Treatment Building(s)**
☐ N/A ☒ Good condition (esp. roof and doorways) ☐ Needs repair
☐ Chemicals and equipment properly stored
Remarks:

6. **Monitoring Wells** (pump and treatment remedy)
☒ Properly secured/locked ☐ Functioning ☒ Routinely sampled ☒ Good condition
☒ All required wells located ☐ Needs Maintenance ☐ N/A
Remarks

D. Monitoring Data

19. Monitoring Data
☒ Is routinely submitted on time ☒ Is of acceptable quality

20. Monitoring data suggests:
☒ Groundwater plume is effectively contained ☒ Contaminant concentrations are declining
Remarks: VOC concentrations in the original VOC plume have significantly declined. Remediation of the deeper VOCs began in early 2019.

VIII. GROUNDWATER REMEDIES ☒ Applicable ☐ N/A 8/19/20

A. System: OU III Building 96 (Bldg. TR-644, TR-854, TR-866, TR-867, TR-868) Inspection attendees include R. Howe

1. Construction Complete/System Operating ☒ Yes ☐ No

Remarks: Wells RTW-2, RTW-3 and RTW-4 are on standby mode due to low VOCs. Starting in July 2019, the flow from Bldg. 96 RTW-1 was increased to 60 gallons per minute and the water is now being treated at the Building 452 Freon-11 treatment system due to the larger capacity of that system. Beginning with the July DMR report, this discharge is now reported under the Freon-11 equivalency permit.

B. Groundwater Extraction Wells, Pumps, and Pipelines ☒ Applicable ☐ N/A

1. Pumps, Wellhead Plumbing, and Electrical
☐ Good condition ☒ All required wells properly operating ☐ Needs Maintenance ☐ N/A
Remarks: RTW-1 is operating.

2. Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances
☒ Good condition ☐ Needs Maintenance
Remarks

3. Spare Parts and Equipment
☒ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks_____

C. Treatment System ☒ Applicable ☐ N/A

1. Treatment Train (Check components that apply)
☐ Metals removal ☐ Oil/water separation ☐ Bioremediation
☒ Air stripping ☐ Carbon adsorbers
☒ Filters The air inlet port screens on the side of the buildings need to be cleaned of debris._____
☐ Additive (*e.g.*, chelation agent, flocculent)_____
☐ Others_____
☒ Good condition ☐ Needs Maintenance
☒ Sampling ports properly marked and functional
☐ Sampling/maintenance log displayed and up to date
☒ Equipment properly identified
☒ Quantity of groundwater treated annually_____
☐ Quantity of surface water treated annually_____
Remarks: Daily Operating Sheet will be revised to reflect monthly use. Remote monitoring of the system is performed in Bldg. 462. System maintenance is documented in the Daily Field Report and system sampling is documented on the share drive. The SPDES equivalency permit is available in the building. However, the Bldg. 96 O&M Manual is not available in Bldg. 644. The Facility Project Manager on the sign on all buildings need to be updated.

2. Electrical Enclosures and Panels (properly rated and functional)
☐ N/A ☒ Good condition ☐ Needs Maintenance
Remarks: The PLC in Bldg. 644 was updated to include Bldg. 96 RTW-1._____

_____

System: OU III Building 96 (cont'd)	
3.	Tanks, Vaults, Storage Vessels ☐ N/A ☒ Good condition ☐ Proper secondary containment ☐ Needs Maintenance Remarks: The hexavalent chromium treatment system was decommissioned in 2018 following regulatory approval.
4.	Discharge Structure and Appurtenances ☐ N/A ☒ Good condition ☐ Needs Maintenance Remarks:
5.	Treatment Building(s) ☐ N/A ☒ Good condition (esp. roof and doorways) ☒ Needs repair ☐ Chemicals and equipment properly stored Remarks: The intake air vent screens on the buildings need to be cleaned of insects and leaves. The roof on TR-845 needs to be repaired. Temporary plastic tarps were installed in the interim. Due to the leaky roof, there is mold and debris inside the building that needs to be cleaned. Due to in
6.	Monitoring Wells (pump and treatment remedy) ☒ Properly secured/locked ☐ Functioning ☒ Routinely sampled ☒ Good condition ☒ All required wells located ☐ Needs Maintenance ☐ N/A Remarks
D. Monitoring Data	
21.	Monitoring Data ☒ Is routinely submitted on time ☒ Is of acceptable quality
22.	Monitoring data suggests: ☒ Groundwater plume is effectively contained ☒ Contaminant concentrations are declining Remarks: PCE concentrations are declining but concentrations around 100 ug/L continue to persist downgradient of the former source area. A soil vapor extraction pilot study was conducted in 2018 which concluded that a full scale system is not feasible.

VIII. GROUNDWATER REMEDIES ☒ Applicable ☐ N/A 8/19/20

A. System OU III Freon-11 (Bldg. 644) Inspection attendees include R. Howe

1. **Construction Complete/System Operating** ☒ Yes ☐ No
Remarks: The system was closed in August 2019 following regulatory approval.

B. Groundwater Extraction Wells, Pumps, and Pipelines ☒ Applicable ☐ N/A

1. **Pumps, Wellhead Plumbing, and Electrical**
☒ Good condition ☒ All required wells properly operating ☐ Needs Maintenance ☐ N/A
Remarks: Extraction well EW-18 is closed but will not be abandoned until emerging contaminant characterization is complete.

2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances**
☒ Good condition ☐ Needs Maintenance
Remarks

3. **Spare Parts and Equipment**
☒ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks

C. Treatment System ☒ Applicable ☐ N/A

1. **Treatment Train** (Check components that apply)
☐ Metals removal ☐ Oil/water separation ☐ Bioremediation
☒ Air stripping ☐ Carbon adsorbers
☒ Filters_ The air inlet port screens on the side of the building needs to be cleaned of debris._____
☐ Additive (*e.g.*, chelation agent, flocculent)_____
☐ Others_____
☒ Good condition ☐ Needs Maintenance
☒ Sampling ports properly marked and functional
☐ Sampling/maintenance log displayed and up to date
☒ Equipment properly identified
☒ Quantity of groundwater treated annually_____
☐ Quantity of surface water treated annually_____
Remarks:

2. **Electrical Enclosures and Panels** (properly rated and functional)
☐ N/A ☒ Good condition ☐ Needs Maintenance
Remarks_____

3. **Tanks, Vaults, Storage Vessels**
☐ N/A ☒ Good condition ☐ Proper secondary containment ☐ Needs Maintenance

4. **Discharge Structure and Appurtenances**
☐ N/A ☒ Good condition ☐ Needs Maintenance
Remarks:

5. **Treatment Building(s)**
☐ N/A ☒ Good condition (esp. roof and doorways) ☒ Needs repair
☐ Chemicals and equipment properly stored
Remarks:

6. **Monitoring Wells** (pump and treatment remedy)
☒ Properly secured/locked ☐ Functioning ☒ Routinely sampled ☒ Good condition
☒ All required wells located ☐ Needs Maintenance ☐ N/A
Remarks

D. Monitoring Data

23. Monitoring Data
☒ Is routinely submitted on time ☒ Is of acceptable quality

24. Monitoring data suggests:
☒ Groundwater plume is effectively contained ☒ Contaminant concentrations are declining
Remarks: The system was shut down in March 2017 and approved for closure in August 2019.

VIII. GROUNDWATER REMEDIES ☒ Applicable ☐ N/A 8/19/20

A. System OU III Sr-90 Chemical Holes (Bldg. 670) Inspection attendees include R. Howe

1. **Construction Complete/System Operating** ☒ Yes ☐ No

Remarks: The system was placed in standby mode in March 2018 following regulatory approval of the Petition for Shutdown.

B. Groundwater Extraction Wells, Pumps, and Pipelines ☒ Applicable ☐ N/A

1. **Pumps, Wellhead Plumbing, and Electrical**
☒ Good condition ☒ All required wells properly operating ☐ Needs Maintenance ☐ N/A
Remarks:

2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances**
☒ Good condition ☐ Needs Maintenance
Remarks: _____
_____

3. **Spare Parts and Equipment**
☒ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks_____
_____

C. Treatment System ☒ Applicable ☐ N/A

1. **Treatment Train** (Check components that apply)
☐ Metals removal ☐ Oil/water separation ☐ Bioremediation
☐ Air stripping ☐ Carbon adsorbers
☒ Filters: ion exchange_____
☐ Additive (*e.g.*, chelation agent, flocculent)_____
☐ Others_____
☒ Good condition ☐ Needs Maintenance
☒ Sampling ports properly marked and functional
☐ Sampling/maintenance log displayed and up to date
☒ Equipment properly identified
☒ Quantity of groundwater treated annually_____
☐ Quantity of surface water treated annually_____
Remarks: Daily Operating Sheet will be revised to reflect monthly use. Remote monitoring of the system is performed in Bldg. 462. System maintenance is documented in the Daily Field Report and system sampling is documented on the share drive. The updated SPDES equivalency permit is available in the building, however the 2003 permit should be removed. The current O&M Manual is in the building.

2. **Electrical Enclosures and Panels** (properly rated and functional)
☐ N/A ☒ Good condition ☐ Needs Maintenance
Remarks: The electrical room is clear of boxes and debris._____
_____

3. **Tanks, Vaults, Storage Vessels**
☐ N/A ☒ Good condition ☒ Proper secondary containment ☐ Needs Maintenance
Remarks: Tanks used to store purge water are registered with SCDHS._____

4. **Discharge Structure and Appurtenances**
☐ N/A ☒ Good condition ☐ Needs Maintenance
Remarks: Drywells have never required maintenance.

System: OU III Sr-90 Chemical Holes (cont'd)

5. **Treatment Building(s)**
☐ N/A ☒ Good condition (esp. roof and doorways) ☐ Needs repair
☐ Chemicals and equipment properly stored
Remarks: Need weed whacking around building and tree trimming in rear of building. There are no inspection stickers visible on the overhead doors.

6. **Monitoring Wells** (pump and treatment remedy)
☒ Properly secured/locked ☐ Functioning ☒ Routinely sampled ☒ Good condition
☒ All required wells located ☐ Needs Maintenance ☐ N/A
Remarks_____
_____

D. Monitoring Data

25. Monitoring Data
☒ Is routinely submitted on time ☒ Is of acceptable quality

26. Monitoring data suggests:
☒ Groundwater plume is effectively contained ☒ Contaminant concentrations are declining
Remarks: Concentrations in all extraction wells have significantly declined. However, slightly elevated Sr-90 persist in a monitoring well in the former source area.

VIII. GROUNDWATER REMEDIES ☒ Applicable ☐ N/A 8/19/20

A. System OU III Sr-90 BGRR/WCF (Bldg. 855) Inspection attendees include R. Howe

1. **Construction Complete/System Operating** ☒ Yes ☐ No

Remarks: Wells SR-4, SR-5, SR-6 and SR-7 are in standby mode. Wells SR-1, SR-2, SR-3 and SR-9 are operating.

B. Groundwater Extraction Wells, Pumps, and Pipelines ☒ Applicable ☐ N/A

1. **Pumps, Wellhead Plumbing, and Electrical**
☒ Good condition ☒ All required wells properly operating ☐ Needs Maintenance ☐ N/A
Remarks_ Well SR-8 is pulsed pumping (one month on and one month off).

2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances**
☒ Good condition ☐ Needs Maintenance
Remarks:_

3. **Spare Parts and Equipment**
☒ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks_____

C. Treatment System ☒ Applicable ☐ N/A

1. **Treatment Train** (Check components that apply)
☐ Metals removal ☐ Oil/water separation ☐ Bioremediation
☐ Air stripping ☒ Carbon adsorbers
☒ Filters: ion exchange ___
☐ Additive (*e.g.*, chelation agent, flocculent)_____
☐ Others_____
☒ Good condition ☐ Needs Maintenance
☒ Sampling ports properly marked and functional
☐ Sampling/maintenance log displayed and up to date
☒ Equipment properly identified
☒ Quantity of groundwater treated annually_____
☐ Quantity of surface water treated annually_____
Remarks: Daily Operating Sheet will be revised to reflect monthly use. Remote monitoring of the system is performed in Bldg. 462. System maintenance is documented in the Daily Field Report and system sampling is documented on the share drive. The updated O&M Manual is in the building. The SPDES equivalency permit available in the building is outdated and needs to be replaced.

2. **Electrical Enclosures and Panels** (properly rated and functional)
☐ N/A ☒ Good condition ☐ Needs Maintenance
Remarks__

3. **Tanks, Vaults, Storage Vessels**
☐ N/A ☒ Good condition ☒ Proper secondary containment ☐ Needs Maintenance
Remarks

4. **Discharge Structure and Appurtenances**
☐ N/A ☒ Good condition ☐ Needs Maintenance
Remarks: Secondary containment tanks are registered with SCDHS as CERCLA exempt

System: OU III Sr-90 BGRR/WCF (cont'd)

5. **Treatment Building(s)**
☐ N/A ☒ Good condition (esp. roof and doorways) ☐ Needs repair
☐ Chemicals and equipment properly stored
Remarks_____
_____

6. **Monitoring Wells** (pump and treatment remedy)
☒ Properly secured/locked ☐ Functioning ☒ Routinely sampled ☒ Good condition
☐ All required wells located ☐ Needs Maintenance ☐ N/A
Remarks_____
_____

D. Monitoring Data

27. Monitoring Data
☒ Is routinely submitted on time ☒ Is of acceptable quality

28. Monitoring data suggests:
☒ Groundwater plume is effectively contained ☒ Contaminant concentrations are declining
Remarks: Sr-90 concentrations are generally declining, except for a recent spike downgradient of Bldg. 701. Removal of Bldg. 811 and associated contaminated soil at the Waste Concentration Facility area was completed in 2016 through 2018.

E. Monitored Natural Attenuation

1. **Monitoring Wells** (natural attenuation remedy)
☒Properly secured/locked ☒ Functioning ☒ Routinely sampled ☒ Good condition
☒All required wells located ☐ Needs Maintenance ☐ N/A
Remarks: A portion of each groundwater remedy relies on some natural attenuation._____

IX. OTHER REMEDIES

If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.

X. OVERALL OBSERVATIONS

A. Implementation of the Remedy

Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission, etc.).

With the exception of the HFBR reactor vessel removal, all soil, sediment, and groundwater remedies for the nine RODs at the site have been implemented and are functioned as designed. This includes the excavation and off-site disposal of contaminated soil, sediment, tanks, as well as the installation and operation of all groundwater treatment systems. All of the remedies are being implemented in accordance with the RODs and the ESDs. The remedies are expected to be protective upon attainment of groundwater cleanup goals.

BNL has been proactively characterizing the nature and extent of emerging contaminants PFOS, PFOA and 1,4-dioxane since 2018. Two areas with elevated concentrations of PFOS and PFOA in groundwater were identified downgradient of the current and former firehouses. In July 2020, BNL began detailed characterization of these areas with temporary wells with the goal of designing and constructing two treatment systems to address the elevated concentrations at these source areas. With New York State adoption of maximum contaminant levels in August 2020 for these contaminants, this work will be incorporated into the BNL CERCLA program. _____

B. Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

The VOC treatment systems operated without any significant down time or issues over the last five years and have consistently met the state equivalency discharge requirements. The treatment systems are routinely physically inspected and all of the systems are also monitored remotely via the wireless monitoring/alarm system. System O&M has been very effective.

_____

C. Early Indicators of Potential Remedy Problems

Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs, that suggest that the protectiveness of the remedy may be compromised in the future.

A potential concern is the implication of the new 1,4-dioxane MCL on the existing SPDES equivalency permits. If additional treatment is needed to address low levels of 1,4-dioxane that may be identified in the influent to the existing treatment systems, that could be become very expensive and possibly technically impracticable. See Five Year Review Section 7.0 for more information.

D.	Opportunities for Optimization
	Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy. Opportunities are routinely identified and documented in the Quarterly and Annual Status Reports. See Five Year Review Section 7.0 for more information.

Attachment 4

Interview Records

INTERVIEW RECORD

Site Name: Brookhaven National Laboratory		**EPA ID No.:** 02334497
Subject: 2021 Five-Year Review		**Time: 1:30** **Date: 3/20/20**
Type: ( ) Telephone ( ) Visit (x) Other **Location of Visit:**		(x) Incoming ( ) Outgoing
Contact Made By:		
Name: Nora Sundin	**Title:** Manager, Environmental Communications & Outreach	**Organization:** Environmental Protection Division, BNL
Individual Contacted:		
Name: Sharon Hartzell	**Title**: Remedial Project Manager	**Organization:** EPA II
Telephone No: 212-637-4132 **Fax No:** **E-Mail Address:** hartzell.sharon@epa.gov		**Street Address**: 290 Broadway **City, State, Zip:** New York, NY 10007-1866

- What is your overall impression of the cleanup at BNL?
  Overall the cleanup at BNL is proceeding in an effective and efficient manner. EPA is glad to see that most of the OUs at BNL have made significant progress and many are in O&M at this point.

- Are there any specific aspects of the cleanup that you feel should be of particular focus during the review?
  EPA is placing a priority on emerging contaminants (PFAS and 1,4-dioxane). Efforts to investigate and contain these issues should be a focus on the 5YR

- Do you feel well informed about BNL's cleanup activities and progress?
  BNL has done an excellent job of keeping EPA apprised of progress on the site. We feel well informed.

- Do you believe the public is sufficiently informed of the cleanup progress?
  BNL does an excellent job of keeping the public informed on the cleanup progress. Community Advisory Council meetings are held regularly and the public is kept up to date both on the progress of the environmental clean-up, and the general scientific progress made at the lab.

- Are you aware of any recent or upcoming changes to Federal, or New York State laws, regulations, or cleanup standards that may impact protectiveness of human health or the environment at BNL?
  BNL will need to be ready to respond to any upcoming changes in regulations and standards for emerging contaminants, particularly PFAS compounds. BNL is located in a sole source aquifer that provides drinking water, and the presence of emerging contaminants is a high priority for regulatory agencies.

- Do you believe the remedies are functioning as expected by the RODs?
  The remedies at BNL are functioning as expected. Some groundwater plumes at BNL continue to fluctuate and migrate, which will need to be an area of continued attention to make sure the remedies continue to function as intended.

- Are you aware of any particular component of the cleanup decisions that pose a higher degree of difficulty in achieving?
  The uncertainty in the status of emerging contaminants (PFAS and 1,4-dioxane), and the inherent complexity of managing the fluctuation and migration of groundwater plumes are two challenges that will remain at BNL.

- Do you believe there are current opportunities to optimize operations and maintenance, or sampling efforts at BNL that could result in cost savings or improved efficiency?
  None specifically

- What do you think are the biggest risks to achieving the soil and groundwater cleanup objectives at BNL
  -Uncertainty in status of emerging contaminants
  -Potential changes to groundwater plumes
  -Difficulties in public communication and work progress related to current global pandemic

-

INTERVIEW RECORD

Site Name: Brookhaven National Laboratory	**EPA ID No.:**	
Subject: 2021 Five-Year Review	**Time:**	**Date:** 3/11/2020
Type: ( ) Telephone ( ) Visit (X) Other **Location of Visit:**	( ) Incoming ( ) Outgoing	

Contact Made By:

Name: Nora Sundin	**Title:** Manager, Environmental Communications & Outreach	**Organization:** Environmental Protection Division, BNL

Individual Contacted:

Name: Brian Jankauskus	**Title**: Project Manager	**Organization:** NYSDEC
Telephone No: 518-402-9626 **Fax No:** **E-Mail Address:** brian.jankauskus@dec.ny.gov	**Street Address**: 625 Broadway, 11th Floor **City, State, Zip:** Albany, NY 12233	

1. What is your overall impression of the cleanup at BNL?
   Remedial actions performed (e.g. operation groundwater extraction systems and removal of contaminated soils and sediments) have significantly improved site conditions. Groundwater remediation continues to be effective and BNL is taking the necessary steps to meet the remedial action objectives.

   While the number of radiological remedial actions have been limited in the past several years, the efficiency and effectiveness of the cleanups have met or exceeded expectations.

2. Are there any specific aspects of the cleanup that you feel should be of particular focus during the review?
   While delays and deviations can occur with any project due to unforeseen circumstances, having terminal dates for RODs for complex engineering actions seems lofty and sets up the team for possible failure. Such as the current timetable for the HFBR stack removal (12/31/2020) which seems quite improbable.

   In 2004 and 2005, site contamination was removed from the Peconic River to achieve the cleanup goals that were expected to protect human health and the environment as required by the 2004 ROD. Subsequent monitoring of sediment was performed to assess the removal action and if subsequent action is necessary. In 2011, select areas of the Peconic River (e.g. PR-SS-38 and PR-SS-10) were permitted to contain site contamination above the post excavation cleanup goals. In July 2017, the last focused sediment removal action was performed (PR-WC-06). These removal actions have removed significant site contamination, which has reduced exposure to humans and wildlife. In September 2014, the sewage treatment plant discharge to the Peconic River was removed and the Peconic River has reverted to its natural state as an intermittent river that is reliant on precipitation and groundwater fluctuations. Due to the intermittent flow of the Peconic River, continued fish monitoring onsite is difficult and potentially impossible during drought conditions. In 2015, the last round of onsite fish samples were obtained, which detected mercury above the EPA fish tissue criteria of 0.3 mg/kg. This is concerning as the ROD indicates that the cleanup goals were expected to be protective of human health and the environment. In 2018 and 2019 wetland restoration evaluations of the Peconic River (PR-WC-06) documented significant water present that may support a fish habitat. The Peconic River should be a focus of this review as some site related contamination remains within portions of the river. If possible, fish samples should be obtained to complete this review as indicated in the Department's letter, dated April 4, 2018.

3. Do you feel well informed about BNL's cleanup activities and progress?
   Yes.

4. Do you believe the public is sufficiently informed of the cleanup progress?
   Yes, BNL is very proactive with public information sessions, etc.

5. Are you aware of any recent or upcoming changes to Federal, or New York State laws, regulations, or cleanup standards that may impact protectiveness of human health or the environment at BNL?
   New York is in the process of promulgating drinking water standards for PFOA, PFOS, and 1,4 dioxane. These chemicals have been detected at BNL and currently being investigated by BNL. After finalization of the drinking water standards, remedial action may be required to be protective of human health. Additional standards, criteria, and guidance values (SCGs) are anticipated for other media (e.g. soils, groundwater, wildlife) after the drinking water standards are finalized. Further investigation and remedial action at BNL are anticipated when the SCGs are released.

6. Do you believe the remedies are functioning as expected by the RODs?
   See response to question #2.

7. Are you aware of any particular component of the cleanup decisions that pose a higher degree of difficulty in achieving?
   See response to question #2.

8. Do you believe there are current opportunities to optimize operations and maintenance, or sampling efforts at BNL that could result in cost savings or improved efficiency?
   Not that we are aware of.

9. What do you think are the biggest risks to achieving the soil and groundwater cleanup objectives at BNL?
   The removal of the contaminated sediments from the Peconic River was a tremendous achievement. Due to the current conditions and available data, the fish tissue concentrations do not appear to be reducing to below the EPA criteria. Hopefully further fish monitoring will provide data that shows fish levels below the EPA criteria.

INTERVIEW RECORD

Site Name: Brookhaven National Laboratory	**EPA ID No.:**	
Subject: 2021 Five-Year Review	**Time:**	**Date:** 3/23/2020
Type: ( ) Telephone ( ) Visit (X) Other **Location of Visit:**	( ) Incoming ( ) Outgoing	

Contact Made By:

Name: Nora Sundin	**Title:** Manager, Environmental Communications & Outreach	**Organization:** Environmental Protection Division, BNL

Individual Contacted:

Name: Steven Karpinski	**Title**: Project Manager	**Organization:** NYSDOH
Telephone No: 518-402-9626 **Fax No:** **E-Mail Address:** brian.jankauskus@dec.ny.gov	**Street Address**: 625 Broadway, 11th Floor **City, State, Zip:** Albany, NY 12233	

1. What is your overall impression of the cleanup at BNL? *From a radiological perspective groundwater cleanup has been effective, this is made evident by several groundwater treatment systems for radiological contamination being shut down or placed in standby. BNL has also removed contaminated structures and soil during this time period. BNL's success in addressing non-radiological groundwater contamination has been effective and responsive to changing conditions.*
2. Are there any specific aspects of the cleanup that you feel should be of particular focus during the review? *BNL should address meeting the due dates for remediation listed in the ROD. It is questionable whether BNL will meet the due date set forward for the removal of the Stack set forward in the ROD. BNL should continue their ongoing activities to identify sources and sampling to comprehensively identify where BNL-associated emerging contaminants are located in groundwater.*

3. Do you feel well informed about BNL's cleanup activities and progress? *Yes.*
4. Do you believe the public is sufficiently informed of the cleanup progress?*Yes.*
5. Are you aware of any recent or upcoming changes to Federal, or New York State laws, regulations, or cleanup standards that may impact protectiveness of human health or the environment at BNL? *New York is in the process of promulgating drinking water standards for PFOA, PFOS, and 1,4 dioxane. These chemicals have been detected at BNL and currently being investigated by BNL. After finalization of the drinking water standards, remedial action may be required to be protective of human health. Additional standards, criteria, and guidance values (SCGs) are anticipated for other media (e.g. soils, groundwater, wildlife) after the drinking water standards are finalized. Further investigation and remedial action at BNL are anticipated when the SCGs are released.*
6. Do you believe the remedies are functioning as expected by the RODs? *See response to question #2*.
7. Do you believe there are current opportunities to optimize operations and maintenance, or sampling efforts at BNL that could result in cost savings or improved efficiency? *No*
8. Are you aware of any particular component of the cleanup decisions that pose a higher degree of difficulty in achieving?
   See response to question #2.
9. Do you believe there are current opportunities to optimize operations and maintenance, or sampling efforts at BNL that could result in cost savings or improved efficiency? *No.*
10. What do you think are the biggest risks to achieving the soil and groundwater cleanup objectives at BNL? *BNL has effective internal policies and procedures to address currently known environmental impacts to respond to the discovery of previously unknown impacts, and funding issues appear to be the most likely risk to achieving goals.*

INTERVIEW RECORD

Site Name: Brookhaven National Laboratory	**EPA ID No.:**	
Subject: 2021 Five-Year Review	**Time: 11:20**	**Date: 03/10/20**
Type: (ξ) Telephone ( ) Visit ( ) Other **Location of Visit:**	( ) Incoming (ξ) Outgoing	

Contact Made By:

Name: Nora Sundin	**Title:** Manager, Environmental Communications & Outreach	**Organization:** Environmental Protection Division, BNL

Individual Contacted:

Name: Gerald Granzen	**Title**: Environmental Engineer	**Organization:** BHSO
Telephone No: 631-344-4089 **E-Mail Address:** gerald.granzen@science.doe.gov	**Street Address**: Bell Avenue **City, State, Zip:** Upton, NY 11973	

1. What is your overall impression of the cleanup at BNL?
    - The cleanup has been effective and successful. The program has been managed with integrity. When issues arise, solutions are developed proactively.

2. Are there any specific aspects of the cleanup that you feel should be of particular focus during the review?
    - There is a need to come to a resolution on the Peconic River with NYSDEC and USEPA. It seems that core remedial action decisions have come into question by regulators who were involved in the Record of Decision. It is difficult to come to agreement on effectiveness if the basis for the evaluation is not well understood or agreed upon.

3. Do you feel well informed about BNL's cleanup activities and progress?
    - Yes.

4. Do you believe the public is sufficiently informed of the cleanup progress?
    - Yes.

5. Do you believe the remedies are functioning as expected by the RODs?
    - Yes.

6. Are you aware of any recent or upcoming changes to Federal, or New York State laws, regulations, or cleanup standards that may impact protectiveness of human health or the environment at BNL?
    - Emerging Contaminants, notably PFAS and 1,4-Dioxane. BNL has proactively addressed these regulatory concerns, and to some extent has progressed ahead of regulatory implementation.

7. What do you think are the biggest risks to achieving the soil and groundwater cleanup objectives at BNL?
    - Significant costs associated with emerging contaminant investigation and remediation are likely. In addition, there is a lack of direct funding mechanisms to fund this work.

Attachment 5

Technology and Standards Review Memos (Arcadis and S. Moss)

Robert F. Howe
William R. Dorsch, P.G.
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ENVIRONMENT

Subject:
Summary of Technical Assessment for 2021 Five-Year Review
Brookhaven National Laboratory, Upton, New York

Date:
October 30, 2020

Contact:
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Our ref:
30054719

Dear Mr. Howe and Mr. Dorsch:

The Environmental Protection Agency (EPA) requires as part of CERCLA a Five-Year Review be completed for Brookhaven National Lab (BNL)'s environmental remediation program. Arcadis is providing support for the technical assessment portion of the Five-Year Review. More specifically, Arcadis has reviewed each of the groundwater treatment systems selected by BNL and corresponding plumes using available documentation including the Groundwater Status Reports and previous Five-Year Review Report to assess each system. The technical assessment was completed for each system to determine if it is on track to meet cleanup goals in the specified timeframe, if there are any new or alternative cleanup technologies that should be considered, and if updated groundwater modeling is required to complete the assessment. The groundwater treatment systems reviewed include:

- OU III VOC Plume
  - Building 96
  - Middle Road
  - OU III South Boundary
  - Industrial Park
  - LIPA/Airport
  - Western South Boundary
- OU VI EDB
- BGRR/WCF Strontium-90

The assessment for each of these systems is described in the following sections. It should be noted that all references to Figures in this letter report are referring to the 2019 BNL Groundwater Status Report (BNL, June 12, 2020).

OU III VOC PLUME

BUILDING 96 TREATMENT SYSTEM

Introduction

The OU III Building 96 Treatment System began operation in February 2001. It is unique in comparison to the other treatment systems along the OU III volatile organic compound (VOC) plume path. This system is the first groundwater treatment system along the contaminated groundwater flow path and is relatively shallow in the Upper Glacial Aquifer compared to the other treatment systems further downgradient. The depth of the only operating source area extraction well (RTW-1) that is part of this system is approximately 60 feet below ground surface (ft bgs) (Figure 3.2.1-2). This is compared to other extraction wells for other treatment system along the plume path which are commonly 150 to more than 200 ft bgs (Figure 3.2-2).

It is of note that significant source area remediation (soil excavation) occurred in 2010. Figure 3.2.1-1 shows the extent of the excavated source area. The Building 96 source area is located approximately 250 to 300 ft upgradient of extraction well RTW-1. Following the source area remediation, groundwater contamination concentrations in the source area decreased significantly.

Review of Building 96 Treatment System

Most of the monitoring wells monitoring the effects of the treatment system are on track to achieve cleanup goals [5 micrograms per liter (ug/L)] by 2030. However, 2 monitoring wells (085-379 and 095-159) warrant further and more specific discussion.

085-379: Monitoring well 085-379 is located immediately downgradient of the source area (Figure 3.2.1-3) and is screened in the uppermost portion of the aquifer, approximately 30 ft below ground surface (bgs) (Figure 3.2.1-2). During the 2010 soil excavation, it was noted that there are interbedded silts and clays in the vadose zone. Contaminant concentrations have decreased from a maximum of 2,435 ug/L TVOCs on April 6, 2011 to less than 100 ug/L during 2019. However, contaminant concentrations have only decreased by a factor of 2 in the last 5 years (from approximately 200 ug/L in 2014 to 100 ug/L in 2019 of primarily PCE). The current rate of decrease will not achieve the cleanup goal for PCE of 5 ug/L by 2030 at this location.

The source area remediation removed the vast majority of the source area contaminant mass and the source area soils achieved the PCE soil cleanup objectives based on end-point sample results. However, the concentration trends at this source area well indicate a small amount of residual mass remains within the source area at the surface of the groundwater table and is resulting in the slowly declining contaminant concentrations at monitoring well 085-379. This residual mass likely exacerbates the groundwater contaminant concentrations when water levels are relatively high.

095-159: Monitoring well 095-159 is located approximately 60 ft southwest of extraction well RTW-1 (Figure 3.2.1-2). Contaminant concentrations have decreased from a maximum of 1,180 ug/L TVOCs in April 2001 to less than 100 ug/L during 2019. This well has exhibited fluctuating contaminant concentrations throughout its history. As shown on Figure 3.2.1-3, contaminant concentrations increased to over 500 ug/L in 2010 and 2011, likely associated with the dissolved mass released during the source area excavation. Contaminant concentrations then decreased from 2011 to 2015 before increasing again to over 200 ug/L in late 2017 and early 2018.

Extraction well RTW-1 likely has a significant influence on groundwater flow at monitoring well 095-159. The monitoring well is screened in a similar depth interval and is located only about 60 ft away, albeit slightly down and side gradient of the extraction well. Contaminated groundwater at 095-159 may have difficulty continuing to migrate at times because of the extraction well pulling groundwater at this location upgradient and preventing it from continuing to migrate downgradient. At some location downgradient of the extraction well, the hydraulic gradient is zero because of the opposite effects of the natural gradient and the upgradient pull of the extraction well.

In June 2019, the pumping rate of extraction well RTW-1 was increased from 30 gpm to 60 gpm to increase capture of VOCs in the western portion of the plume (including monitoring well 095-159).

Recommendations for Building 96 Treatment System

The current operations of the Building 96 Treatment System combined with the 2010 source area excavation have resulted in a dramatic reduction in groundwater contaminant concentrations and overall areal extent of groundwater contamination (Figure 3.2.1-6). However, the rate of groundwater contaminant concentration decrease at source area well 085-379 means that this area will likely not achieve the cleanup goal for PCE of 5 ug/L by 2030.

085-379: A limited source area groundwater treatment is warranted to achieve the cleanup goals in the 2030 specified timeframe. Several groundwater treatment technologies were considered to treat source area mass and reduce the cleanup timeframe. The first consideration is that a source area treatment must be compatible with the existing pump and treat system. Extraction well RTW-1 has been successful in containing contaminated groundwater and treating dissolved source area mass. Additionally, the interbedded silts and clays in the vadose zone encountered during the excavation must be considered.

Anaerobic Bioremediation: A remedial technology such as anaerobic bioremediation would involve the injection of a carbon substrate to degrade PCE to its daughter products. However, highly reducing conditions must be achieved to be successful which will be difficult to achieve in the highly conductive and generally aerobic aquifer. Additionally, reduced groundwater will increase the likelihood of iron and bio fouling of extraction well RTW-1 negatively impacting its effectiveness.

In-situ Chemical Oxidation: In-situ chemical oxidation is a commonly used remedial technology for the treatment of chlorinated solvents such as PCE. Chemical oxidants such as potassium permanganate or potassium persulfate can chemically oxidize PCE into harmless compounds. However, chemical oxidation was previously used in a pilot test at Building 96 with limited impact and also resulted in hexavalent chromium as a byproduct.

Trap and Treat Products: A relatively new remedial technology attempts to capture dissolved compounds and treat them in-situ. Examples include a product manufactured by Regenesis called

"Plumestop" and a product manufactured by Bos call "Bos 100". These products both involve using activated carbon that is made into a slurry and can be impregnated with zero valent iron or bacteria that can degrade the contaminants. These products are typically injected via direct push technology. The activated carbon captures the dissolved contaminants as they partition into the activated carbon and are then treated via the processes mentioned above.

If an additional active remediation technology is considered to reduce concentration near source area monitoring well 085-379, the trap and treat technology should be very effective to achieve the remedial goals. Because the treatment area is relatively small and not very deep, this technology is cost effective compared to other source area treatment approaches. The approach is not expected to negatively impact groundwater geochemistry or the operation of the groundwater treatment system. Interbedded silts and clays that extend into to the saturated zone may make the injections more difficult to distribute evenly but should not prevent the necessary distribution to achieve the cleanup goals.

095-159: The increased pumping rate at extraction well RTW-1 that began in June 2019 should have the desired effect of reducing the contaminant concentrations at monitoring well 095-159. Additionally, continued remediation of the upgradient groundwater concentrations and the Building 96 source area will further reduce the concentrations at this location.

MIDDLE ROAD TREATMENT SYSTEM

Introduction

The Middle Road Treatment System began operation in October 2001. This treatment system is the next treatment system for the VOC groundwater contamination downgradient from the Building 96 Groundwater Treatment System. This system is currently utilizing extraction wells RW-2, RW-3, and RW-7 (Figure 3.2.3-1). The groundwater contamination primarily migrates along the base of the Upper Glacial Sands and the Upton Unit in a zone that is approximately 50 ft thick (Figures 3.2.3-2 and 3.2.3-4).

Review of Middle Road Treatment System

Groundwater contaminant concentrations and area extent in this portion of the plume have decreased significantly due to the operation of the Middle Road Treatment System. However, several monitoring wells are not declining at a rate that will definitively achieve the cleanup goal of 5 ug/L for PCE by 2030. These monitoring wells include 104-37, 105-68, and 105-66.

104-37: Monitoring well 104-37 is located approximately 1000 ft upgradient of extraction well RW-7. Previous investigations conducted in 2017 upgradient of this monitoring well location confirmed there is no upgradient source of contamination. Groundwater contaminant concentrations are steadily declining from a maximum concentration of 866 ug/L TVOCs in April 2010 to just under 100 ug/L in 2019. The rate of decline to go from 200 ug/L to 100 ug/L (or for the concentration to reduce by half) was approximately 5 years. This rate of decline will be close to the cleanup goal by 2030 but would likely not achieve it (Figure 3.2.3-3).

105-68: Monitoring well 105-68 is located approximately 500 ft upgradient of extraction well RW-7. This well is located directly downgradient of monitoring well 104-37. Groundwater contaminant concentrations

are steadily declining from 600 ug/L TVOCs in 2014 to 300 ug/L TVOCs in 2019. The rate of decline will not likely achieve cleanup goals by 2030 at this location (Figure 3.2.3-3).

105-66: Monitoring well 105-66 is located approximately 300 ft upgradient of extraction well RW-2. Groundwater contaminant concentrations have slowly been declining in recent years but concentrations of TVOCs are nearly 200 ug/L. The rate of decline will not likely achieve cleanup goals by 2030 (Figure 3.2.3-3).

Recommendations for Middle Road Treatment System

Although several monitoring wells are not on track to achieve cleanup goals by 2030, changes to the existing groundwater extraction system should be able to achieve remedial goals. The less than expected rate of contaminant concentration decline in the monitoring wells mentioned in the previous section could be due to a number of factors such as historical operation of the HFBR Pump and Recharge System (shallower portions of the contamination) and variations in the hydraulic conductivity where the Upton Unit (typically fine-grained resulting in lower hydraulic conductivity) transitions into the Magothy Aquifer (deeper portions of the contamination). A complete change in the remediation technology should not be necessary. The groundwater plumes cover a large areal extent and in a highly conductive aquifer. The most effective remedial technology for this portion of the contaminated groundwater is the existing pump and treat technology.

In order to accelerate the rate of decline of groundwater contaminate concentrations, it is recommended that additional extraction wells be added to the system to increase the rate of removal of contaminated groundwater. For example, an additional extraction well immediately downgradient of monitoring well 104-37 and an additional extraction well immediately upgradient of 105-68 may be sufficient to achieve cleanup goals by 2030. A pre-design investigation consisting of one or two vertical profile borings (VPBs) to confirm distribution of VOC concentrations in the area of the additional extraction well(s) location is suggested. Groundwater modeling could also be used to help determine the best location, extraction rates, and number of extraction wells to optimize the system. Periodically varying the pumping rates of the various extraction wells in the system will help eliminate dead zones or areas of minimal groundwater flow (stagnation) caused by extraction wells pulling groundwater in opposite directions.

OU III SOUTH BOUNDARY TREATMENT SYSTEM

Introduction

The OU III South Boundary Treatment System began operation in June 1997. The treatment system is the next treatment system for the VOC groundwater contamination downgradient from the Middle Road Treatment System. This system is currently utilizing extraction wells EW-4 and EW-17. EW-4 was placed into a pulsed pumping mode in October 2017. The groundwater contamination primarily migrates along the base of the Upper Glacial Sands and the Upton Unit (Figures 3.2.4-2 and 3.2.3-4).

Review of OU III South Boundary Treatment System

This section of the groundwater plume is progressing much like the previous systems discussed. Monitoring wells along the fringe of the plumes and near the extraction wells are on track to achieve cleanup goals by the 2030. Monitoring well 121-45 along the eastern edge of the groundwater

contamination has decreased steadily with TVOC concentrations greater than 500 ug/L in 2006 and current concentrations are below cleanup goals (Figure 3.2.3-3). Monitoring well 121-49 near the extraction wells for the South Boundary Treatment System has had contaminant concentrations decrease from 1,265 ug/L TVOCs in November 2011 to less than 100 ug/L in 2019. However, similar to the Middle Road Treatment System, a monitoring well (121-54) located approximately halfway between the Middle Road treatment system has groundwater contaminant concentrations that are not decreasing at a rate that will likely achieve cleanup goals by 2030.

121-54: For the South Boundary Treatment System, monitoring well 121-54 has had persistent TVOC concentrations between 100 and 250 ug/L since 2015. This monitoring well is located approximately 800 ft upgradient of extraction well EW-4 and is approximately 800 ft downgradient of extraction well RW-2 (Middle Road Treatment System).

Recommendations for OU III South Boundary Treatment System

In order to accelerate the rate of decline of groundwater contaminate concentrations, it is recommended that an additional extraction well be added to the system to increase the rate of removal of contaminated groundwater. For example, an additional extraction well near monitoring well 121-54 may be sufficient to achieve cleanup goals by 2030. Groundwater modeling could be used to help determine the best location, extraction rate(s), and number of extraction well(s) to optimize the system. A pre-design investigation consisting of one or two VPBs to confirm distribution of VOC concentrations in the area of the additional extraction well location is also suggested. Periodically varying the pumping rates of the various extraction wells in the system will help eliminate dead zones or areas of minimal groundwater flow caused by extraction wells pulling groundwater in opposite directions.

INDUSTRIAL PARK TREATMENT SYSTEM

Introduction

The Industrial Park Treatment System began operation in September 1999. The treatment system is the next treatment system for the VOC groundwater contamination downgradient from the OU III South Boundary Treatment System. All extraction wells are currently in standby mode.

Review of Industrial Park Treatment System

All extraction wells as part of the treatment system have been placed on standby because monitoring wells in this area are generally below 50 ug/L. Extraction wells IP-EW-8 and IP-EW-9 were installed in 2014 to capture deeper upgradient VOCs (Figure 3.2.6-1). TVOC concentrations in these extraction wells during 2019 were below 5 ug/L and these extraction wells were subsequently placed in standby mode in July 2019. However, the deeper VOCs seem to be migrating very slowly and attenuating as they migrate south.

Recommendations for the Industrial Park Treatment System

While the existing data appear to be on track to achieve cleanup goals by 2030, there is some uncertainty to contaminant concentrations upgradient of monitoring wells such as 000-541, 000-529, and 000-548. Additional monitoring wells are not possible in this area given access constraints due to the presence of

buildings, utilities and other structures. Continued groundwater monitoring and tracking contaminant trends in existing monitoring wells and extraction wells IP-EW-8 and IP-EW-9 is recommended at the present time.

LIPA/AIRPORT TREATMENT SYSTEM

Introduction

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 had migrated past the LIPA extraction wells and the North Street extraction wells prior to their installation.

1) The Magothy extraction well (EW-4L) on Stratler Drive (Figure 3.2.10-1) addressed high-level VOCs identified in the Magothy aquifer immediately upgradient of this well on Carleton Drive. The capture goal for this well has been met and it is currently in standby mode.
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 wells 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. Extraction wells RTW-1A, RTW-4A, and RW-6A are in full operation. Extraction wells RTW-2A and RTW-3A, are in pulsed pumping operation, and well RTW-5A is shutdown.

Review of LIPA/Airport Treatment System

The capture goals for all of the LIPA extraction wells have been met and the extraction wells have been placed in standby mode. Groundwater contaminant concentrations in this area are generally below 10 ug/L. Further downgradient and approaching the Airport System, the contaminant concentrations are a bit higher with concentrations as high as 50 ug/L at monitoring well 800-94 on Crestwood Drive. Figures 3.2.8-2 (Cross-Section J-J') and 3.2-2 (Cross-Section B-B') provide a cross-sectional view along the spine of the plumes as they migrate downgradient. Figure 3.2.10-2 (Cross-Section L-L') provides a cross-sectional view perpendicular to groundwater flow at the location of the extraction wells of the western plume.

Recommendations for LIPA/Airport Treatment System

The 2019 Groundwater Status Report recommended a shutdown of Airport extraction wells RTW-2A and RTW-3A that were being pulsed pumped. There are no TVOC concentrations detected in the vicinity of these wells greater than 10 ug/L. The report also recommended continued full time operation of wells

RTW-1A, RTW-4A, and RW-6A. For the time being, these recommendations make sense. As these concentrations are expected to continue to decline, there should be an opportunity to shut these wells down soon. For the eastern portion of the plume, additional monitoring wells may be helpful to understand the extent of contaminant concentrations upgradient of RTW-4A and better determine the required time of operation of the extraction well to achieve cleanup goals. However, there is limited access for additional monitoring in this area. In the western portion of the plume there are limited monitoring wells upgradient of monitoring wells such as 800-94, primarily due to access constraints, so there is uncertainty as to the extent of the contaminant concentrations upgradient. Given access constraints, continued monitoring of the existing monitoring well network is recommended and once the decline in concentrations is observed representing the upgradient edge of the contaminant plume, this area can be re-evaluated and a more confident timeframe estimate can be made.

WESTERN SOUTH BOUNDARY TREATMENT SYSTEM

Introduction

The Western South Boundary System was designed to capture VOCs in the Upper Glacial aquifer along portions of the BNL western south boundary. The system was designed to reduce additional off-site migration of the contamination, and potential impacts of the VOC plume to the Carmans River. The system began operating in September 2002 and was changed to pulsed pumping mode in late 2005. During 2018 four new extraction wells were added to the system. They began operations in March 2019.

Review of Western South Boundary Treatment System

During characterization efforts in 2016-2017 to define the extent of the deeper Freon-12, a zone of high VOC concentrations was encountered with most of the plume at slightly greater depths than previously seen in the area (140-210 feet bgs). A total of 21 temporary vertical profile wells were installed from 2016 through the end of 2018 to characterize these VOCs and a total of 17 new monitoring wells were installed. As a result of the characterization efforts, new extraction wells WSB-3, WSB-4, WSB-5, and WSB-6 were installed and began operation in 2019.

Most monitoring wells have declining groundwater contaminant concentrations throughout this period. These new extraction wells have greatly increased the rate of VOC mass withdrawal for this system as shown on Figure 3.2.5-5 and are expected to greatly increase the rate of remediation of the groundwater contamination as these extraction wells are located in a deeper zone than extraction wells WSB-1 and WSB-2.

Monitoring well 126-14 is located immediately upgradient of extraction well WSB-1. After having steady concentrations for many years around 20 ug/L, TVOC concentrations increased to more than 150 ug/L in 2017 and have been steadily declining since then. It appears that changes in the operation of the groundwater extraction wells WSB-1 and WSB-2 have changed the flow direction and resulted in the initial increase in contaminant concentrations. However, the changes to the overall system have allowed for an increased rate of VOC mass withdrawal which will eventually bring the contaminant concentrations to below the cleanup goals.

Recommendations for the Western South Boundary Treatment System

At this time, no additional changes to remedial system operations are warranted. The addition of the 4 extraction wells and continued operation of extraction well WSB-1 is expected to achieve groundwater cleanup goals by 2030. Because the 4 new extraction wells have only been operational for just over a year, careful tracking of groundwater contaminant concentrations and trends in monitoring wells in the vicinity, including downgradient of the system, will determine if additional changes in pumping rates are required.

OU VI EDB PLUME

EDB TREATMENT SYSTEM

Introduction

The OU VI EDB Treatment System addresses an ethylene dibromide (EDB) plume in groundwater extending from south of North Street for approximately 2,500 ft. 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). EDB has not been detected on BNL property since 2009. The groundwater remediation system to address the off-site EDB plume began operations in August 2004. The OU VI EDB Treatment System includes 2 extraction wells and 2 recharge wells.

Review of EDB Treatment System

The EDB groundwater contamination continues to migrate to the south and be captured by the treatment system (Figure 3.5-4). As indicated on Figure 3.5-4, in the last 20 years, the EDB contamination has migrated several thousand feet south and reduced in overall concentration as it is being captured by extraction wells EW-1E and EW-2E. As is shown on Figure 3.5-3, the peak concentrations have migrated through most monitoring wells leaving relatively low levels of EDB concentrations remaining in the aquifer.

There is a concern that further EDB groundwater contamination may be deeper in the aquifer than is currently being monitored (Figure 3.5-2). There is an on-going groundwater investigation to further delineate the aquifer deeper than the existing monitoring well and hydraulic capture network. The existing monitoring well network is generally screened between 100 and 150 ft bgs.

Recommendations for the EDB Treatment System

Once the groundwater investigation is complete, further assessment will be completed regarding potential changes to the monitoring well network or hydraulic capture system. Groundwater modeling will then be used to aid in the assessment of the hydraulic capture system to achieve the cleanup goals in the specified timeframe. While no changes to the existing hydraulic capture system are warranted based on the existing data, additional extraction wells could be used to increase the rate of groundwater contamination capture based on the results of the groundwater investigation and modeling evaluation. Additional data and groundwater modeling of the new data will be incorporated into the Five-Year Review.

BGRR/WCF STRONTIUM 90

STRONTIUM 90 TREATMENT SYSTEM

Introduction

The Brookhaven Graphite Research Reactor (BGRR)/Waste Concentration Facility (WCF) Treatment System addresses the Sr-90 plumes in groundwater downgradient of these facilities. A total of 9 extraction wells using ion exchange to remove Sr-90 have been used to treat the groundwater contamination with discharge of the treated water to dry wells. The goal is to achieve cleanup goals by 2070. There are three primary areas of elevated Sr-90 in groundwater: one extending south from the former WCF area, one extending south from 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 3.2.14-1).

Review of Strontium 90 Treatment System

Figure 3.2.14-10 shows the significant reduction in areal extent and contaminant concentrations from 2004 until 2019. In recent years extraction wells SR-4, SR-5, SR-6, and SR-7 have been placed in stand-by mode.

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 southward migration of the plume (Figure 3.2.14-1). Several source area investigations were conducted in 2018 and 2019 to better define the source area concentrations (Figure 3.2.14-1). It was concluded that recent increases in Sr-90 concentrations in the source area were due to remediation work in this area. This included the demolition of Building 810 and 811 in 2015 and contaminated soils and piping located underneath and adjacent to the buildings were removed. The excavated areas were backfilled in 2016. Extraction wells SR-1 and SR-2 have been effective in capturing the increasing concentrations, but it is expected that these concentrations will again decline in the near future. While the downgradient migration of Sr-90 concentrations has seen some lateral shift, the concentrations are continuing to decline and are expected to achieve cleanup goals in the expected timeframe.

BGRR (Building 701 Area) Plume: The source area is capped by Building 701 and an engineered cap that was completed in 2011. Monitoring well 075-701 is screened at the surface of the water table and within the source area immediately upgradient of extraction well SR-3 (Figure 3.2.14-2). Contaminant concentrations at this monitoring well have fluctuated significantly in the last 10 years from periods of time that are predominantly below cleanup goals to concentrations as high as 1,170 picocuries per liter (pCi/L) in October 2019. The increases in Sr-90 concentrations (Figure 3.2.14-6) and extraction well SR-3 appears to be caused by the water table elevation increase during 2018-2019 which has resulted in mobilization of residual Sr-90 contaminant mass beneath the Building 701 area. Contaminant concentrations downgradient of extraction well SR-3 are relatively low and continue to decrease indicating that contaminant concentrations are not migrating beyond SR-3 near the source area and downgradient concentrations are declining. The attenuation mechanisms are due to dilution and the relatively short half life for Sr-90, which is 28.8 years.

PFS/Building 801 Area Plume: Sr-90 concentrations have increased in several wells located in the area just south of the former Pile Fan Sump and Building 801 during 2019, most notably in monitoring well 065-325 at a concentration of 186 pCi/L in January 2020 (Figure 3.2.14-5), which is a historical high concentration for this well. Monitoring well 065-325 is located immediately downgradient of Building 801 and immediately upgradient of the former Pile Fan Sump (Figure 3.2.14-1) and is screened across the water table (Figure 3.2.14-3). Underground piping and Sr-90 contaminated soils related to the former Pile Fan Sump, which was associated with the BGRR, were removed back in 2000 as part of a BGRR removal action. Downgradient monitoring wells have exhibited Sr-90 concentrations less than 50 pCi/L (Figure 3.2.14-3), although monitoring well 065-405 located approximately 40 feet south of Building 801 has started to show an increase in Sr-90 concentrations in 2019. The attenuation mechanisms are due to dilution and the relatively short half life for Sr-90, which is 28.8 years. This plume is not being actively remediated.

Recommendations for the Strontium 90 Treatment System

WCF Plume: The recent remediation work and continued operation of the extraction wells has effectively controlled contaminant migration. Recent increases due to the remediation work in the source area appears to be temporary and is supported by recent source area investigations. It does not appear that significant changes need to be made to existing operation of the remedial groundwater system to achieve cleanup goals in groundwater.

BGRR (Building 701 Area) Plume: The primary remaining issue for the BGRR Plume are the relatively significant increase in contaminant concentrations at the source area well 075-701 when the water table elevation increases. Contaminant concentrations downgradient of extraction well SR-3 are on track to achieve cleanup goals in the expected timeframe. However, there is source mass within the vadose zone that is mobilized when the water table rises above a certain elevation. While extraction well SR-3 is effective at controlling this mobilized contaminant mass, this source area may not achieve cleanup goals by 2070 given the unknown quantity of Sr-90 inventory beneath Building 701 and the Below Ground Ducts (BGDs). Additionally, extraction well SR-3 would be required to be operated on a continuous basis to provide control for the source area.

The amount of source area mass in the vadose zone is unknown. The existence of Building 701 and the contamination associated with it and the relative depth of the water table (~65 ft bgs) make addressing the issue complicated and perhaps impractical. A review of other Sr-90 source areas in the United States (such as at Hanford, Washington) have seen the effective use of apatite injections to stabilize the Sr-90. The use of pump and treat technology at BNL has been effective in controlling and remediating the large plumes at BNL. While the use of apatite at the BGRR Plume source area may be effective at controlling this issue temporarily, until the Sr-90 contamination source associated with Building 701 is either depleted or remediated, such a solution would only be temporary and unlikely to be more effective than the current approach. It is recommended that the current approach be continued and reassessed as decisions regarding the source area are made.

PFS/Building 801 Area Plume: Similar to the BGRR (Building 701 Area) Plume, the primary issue for the PFS/Building 801 Area Plume are the relatively significant increase in contaminant concentrations at monitoring well 065-325 when the water table elevation increases (as observed in nearby monitoring 075-701 during similar timeframe). Although this plume is not being actively remediated and while the

downgradient plume is expected to attenuate and meet the ROD cleanup goals, the recent increase may suggest that a potential source area exists beneath Building 801.

The existence of Building 801 and the relative depth of the water table (~65 ft bgs) make investigating and addressing the issue complicated and perhaps impractical. Based on rationale similar to the BGRR (Building 701 Area) Plume, it is recommended that the current approach of monitoring existing monitoring wells be continued and reassessed as decisions regarding a potential source area are made.

In closing, this letter report summarizes Arcadis' evaluation related to the selected groundwater treatment systems in support of the 2021 Five-Year Review. Please let us know if you have any questions or require additional information as you incorporate our evaluation into the technical assessment portion of the Five-Year Review.

Sincerely,

Arcadis U.S., Inc.

Eric Panhorst
Principal Engineer

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Project Manager

Copies:
File

MEMO

ARCADIS Design & Consultancy for natural and built assets

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From:

Hope Nemickas, Arcadis

Date:

August 28, 2020

Arcadis Project No.:

30054719

Subject:

Technical Support on Question B for the Five-Year Review

The purpose of this memo is to provide supporting information for Question B in the Technical Assessment, regarding whether there are changes in standards, toxicity values (based on the IRIS Agenda), or exposure assumptions related to Brookhaven National Laboratory's (BNL's) contaminants of concern (COCs) since the 2016 Five Year Review Report (BNL 2016). The comments provided by the United States Environmental Protection Agency (EPA) and BNL responses that require addressing in the 2021 five-year review were reviewed and information to support responses to those comments is provided. As we've discussed, it has been my experience on at least one other site that the EPA has required evaluation of the screening values, toxicity parameters, and exposure assumptions used in the risk assessment that supported remedy selection be reviewed for potential changes in chemicals of potential concern and in resulting risk estimates. The following sections are directly from the EPA guidance on addressing Question B. As stated in Section 4.2 of the EPA Comprehensive Five-Year Review Guidance (EPA 2001a):

> "**Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?**
>
> In conducting your five-year review, you should evaluate the effects of significant changes in standards and assumptions that were used at the time of remedy selection. Changes in the promulgated standards or "to be considereds" (TBCs) may impact the protectiveness of the remedy. Similarly, you should ***investigate the effect of significant changes in the risk parameters that were used to support the remedy selection, such as reference doses, cancer potency factors, and exposure pathways of concern***. Finally, you

> should evaluate whether the original assumptions regarding current and future land/groundwater uses and ***contaminants of concern are still valid***, and whether any physical features (or understanding of physical sites conditions) have changed (e.g., changes in anticipated direction or rate of groundwater or identification of a new groundwater divide). All of these factors may have a bearing on the validity of the remedial action objectives and may affect the protectiveness of the remedy."

The EPA also provided the following clarification in question 24 of their *Five-Year Reviews, Frequently Asked Questions (FAQs) and Answers* (EPA 2001b):

> "**Is it necessary to evaluate toxicity data for chemicals that were not carried forward as contaminants of concern in the original risk assessment?**
>
> Generally, when evaluating remedy performance, data should be collected and reviewed to ***determine if contaminants of concern (as stated in the Record of Decision), are being remediated so that the remedy remains protective***. In Question B of the Technical Assessment section of the five-year review report, the toxicity data evaluation done in the risk assessment should be reviewed to ensure that any assumptions made at the time of the original risk assessment continue to be protective. In addition to reviewing the toxicity information from the original risk assessment, Regions generally should evaluate ***new toxicity information for other chemicals identified at the site***. New toxicity information may result in the determination that the additional contaminant sources poses a risk to human health or the environment. The review of both the original risk assessment and any new site contaminant information is intended to ensure that the implemented remedy continues to be protective both currently and in the future. (See section 4.2 of the FYR guidance)"

While Section 4.2 of the Five-Year Review Guidance seems less specific, it does state that assumptions used at the time of remedy selection be evaluated. The time of remedy selection for TBCs is interpreted as the risk assessment conducted during Remedial Investigation/Feasibility Study as incorporated into the Record of Decision (ROD). Question 24 of the FAQs in OSWER 9355.7-21 specifically asks whether chemicals in the risk assessment not carried forward as COCs in the ROD require evaluation. The answer clearly states that the evaluation should determine if COCs are being remediated so that the remedy is protective. However, the answer also states that "new toxicity information for other chemicals identified at the site" should also be evaluated. Therefore, an evaluation of the risk assessment accounting for changes in screening values used to select chemicals of potential concern and incorporation of new chemicals of potential concern, along with changes in toxicity and exposure parameters could theoretically lead to updated risk estimates that would result in the TBCs no longer being protective (i.e., estimated cancer risks greater than the cumulative goal of 10^{-4} and/or estimated noncancer hazards greater than the goal of 1).

As we've discussed, EPA has not required BNL to review toxicity data (and therefore screening levels) for non-COC constituents from the past risk assessments. Therefore, this memo focuses on changes in toxicity values for the COCs as discussed in Section 3.4 of the 2016 Five Year Review Report (BNL 2016). The memo also addresses changes in exposure parameters and exposure modeling for vapor intrusion.

TOXICITY VALUES

The following table lists the predominant COCs and several constituents detected more recently (listed by date) and summarizes the last significant changes to toxicity values on the EPA Integrated Risk

Information System (IRIS). The Operable Unit (OU) or area for the COC and other sources of toxicity information are also shown.

Constituent	Last Significant IRIS Update [1]	OU/Area	Other Sources [2]
Bromomethane	Apr-01-1992	May 2018	
Bromodichloromethane	Feb-01-1993	May 2018	CalEPA IUR
Carbon tetrachloride	Mar-31-2010	OU III-Groundwater	
Chloroethane	Apr-01-1991	OU I-Leaking Tanks	
Copper	Sep-07-1988	OU V-STP	
1,1-Dichloroethane	Oct-01-1990	OU I- Leaking Tanks	PPRTV RfD, Cal EPA SFO and IUR
1,2-Dibromo-3-chloropropane (DBCP)	Oct-01-1991	June 2015	PPRTV RfD, SFO, IUR
1,2-Dibromoethane (EDB)	Jul-29-2004	OU VI	
Ethylbenzene	Mar-01-1991	OU IV-Oil/Solvent Tank	Cal EPA SFO and IUR
Freon-11 (Trichlorofluoromethane)	Jan-31-1987	Building 452	
Freon-12 (Dichlorodifluoromethane)	Jan-31-1987	(OU III)	PPRTV Screening Level RfC
Lead and compounds (inorganic) Tetraethyl lead	Jul-08-2004 Jan-31-1987	OU I-Former Landfills	
Mercury (elemental) Mercury (methyl) Mercuric chloride	Jun-01-1995 Jul-27-2001 May-01-1995	OU I-Former Landfills OU V-STP	
Methylene chloride (Dichloromethane)	Nov-18-2011	June 2015	
Polychlorinated Biphenyls (PCBs)	Oct-01-1996	OU V-STP	

(continued on next paged)

Constituent	Last Significant IRIS Update [1]	OU/Area	Other Sources [2]
Radionuclides" Cesium-137 Strontium-90 Tritium	Strontium stable - Oct-01-1992	OU I-Former Landfills (Cs-137 and Sr-90) OU II/VII (Cs-137) OU III-Groundwater (Sr-90, tritium) OU IV (Sr-90) OU V-STP (Cs-137) BGRR (Cs-137, Sr-90) g-2/BLIP/USTs HFBR-Tritium	
Semi-volatile Organic Compounds (SVOC) Polycyclic Aromatic Hydrocarbons (PAHs)	Benzo(a)pyrene Jan-19-2017	OU IV-Oil/Solvent Tank	
Silver	Dec-01-1991	OU V-STP	
Tetrachloroethene (PCE)	Feb-10-2012	OU III-Groundwater	
Toluene	Sep-23-2005	OU IV-Oil/Solvent Tank	
Trichloroethene (TCE)	Sep-28-2011	OU V-STP	
1,1,1-Trichloroethane (TCA)	Sep-28-2007	OU III-Groundwater	
Trimethylbenzenes (1,2,3-; 1,2,4-; and 1,3,5-)	Sep-09-2016	June 2017	

Notes:

[1] EPA IRIS accessed online at: https://www.epa.gov/iris

[2] Sources other than IRIS identified by EPA in the Regional Screening Level Table (May 2020 update) available online at: https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables. These sources are Tier 2 (PPRTVs) and Tier 3 (CalEPA) sources identified in the EPA's hierarchy of human health toxicity values (EPA 2003) and include:

- EPA's Provisional Peer Reviewed Toxicity Values (PPRTVs) developed by the Office of Research and Development/National Center for Environmental Assessment/Superfund Health Risk Technical Support Center (STSC) on a chemical specific basis when requested by EPA's Superfund program.
- The California Environmental Protection Agency (Cal EPA) toxicity values are peer reviewed and address both cancer and non-cancer effects. Cal EPA toxicity values are available on the Cal EPA internet website at http://www.oehha.ca.gov/risk/chemicalDB//index.asp.

Additionally, mercury salts (inorganic), methyl mercury, and PCBs are currently being reassessed under IRIS and all are in Step 1 of the process, which is *Draft Development* and includes with a comprehensive search and systematic review of the scientific literature. Steps 2 through 6 involve agency review, interagency consultation, public comment and external peer review, revised assessment, and final agency

review and interagency discussion. The process ends at Step 7 with a Final IRIS Assessment. Comment 3 on the 2016 Five Year Review Report (BNL 2016) regarding toxicity values for PCBs indicates changes were anticipated in the five years since the last Five Year Review; however, the IRIS reassessment process is still listed as being on Step 1.

As shown in the table above, changes in toxicity values since the 2016 Five Year Review Report (BNL 2016) include the trimethylbenzenes and benzo(a)pyrene, to the extent that polycyclic aromatic hydrocarbons (PAHs) are SVOC COCs at OU IV. As a note, the toxicity value change for benzo(a)pyrene results in less conservative risk-based values for all carcinogenic PAHs since the IRIS reassessment indicates benzo(a)pyrene is less potent as a carcinogen than previously thought. While these changes in toxicity values do not have bearing on the New York State Soil Cleanup Objectives developed in 2010 or maximum contaminant levels, which are not necessarily risk based, they are changes from what was estimated at the time of the RODs.

Lead

Lead, a COC in soil at OU I has a cleanup level of 400 mg/kg, which is the EPA Regional Screening Level for residential soil and the New York State soil cleanup objective for residential and restricted residential use, and commercial or industrial use. This cleanup level is protective of residential exposure to lead in soil based on a target blood lead level of 10 µg/dL in children. Since the time that target blood lead level was set and recommended by EPA (1994 and later), increasing evidence has shown that blood lead levels below 10 micrograms per deciliter (µg/dL) may also have negative health impacts to sensitive receptors of children and pregnant women which may not be applicable to soil at BNL OU1 I. On December 22, 2016, the Office of Land and Emergency Management (OLEM) issued Directive 9200.2-167 (EPA 2016), stating:

> "The current scientific literature on lead toxicology and epidemiology provides evidence that adverse health effects [in children] are associated with blood lead levels less than 10 µg/dL."

The Directive specifically referenced the 2012 National Toxicology Program's (NTP's) Monograph on Health Effects of Low-Level Lead (NTP 2012), which found sufficient evidence of effects including delayed puberty, reduced post-natal growth, and decreased hearing for children with blood lead levels below 10 µg/dL, and on academic achievement, IQ, other cognitive measures, attention-related behaviors, and problem behaviors at blood lead levels below 5 µg/dL. The Directive also referenced the USEPA's 2013 Integrated Science Assessment for Lead (EPA 2013), which found clear evidence of cognitive function deficits at blood lead levels between 2 and 8 µg/dL.

Although EPA has yet to formally recommend the use of the lower target blood lead level of 5 µg/dL, EPA is considering various options to accelerate protective and efficient Superfund residential lead cleanups in support of the Federal Action Plan to Reduce Childhood Lead Exposures and Associated Health Impacts, released by the President's Task Force on Environmental Health Risks and Safety Risks to Children in December 2018. There has been renewed discussion within EPA on the possibility of revising the target blood lead level for CERCLA. If the USEPA revises the target blood lead level of concern to a value less than 10 µg/dL, then the 400 mg/kg cleanup level for lead in soil would require review in future Five-Year Reviews for continued protectiveness.

Radionuclides

Federal Guidance Report 15, entitled *External Exposure to Radionuclides in Air, Water and Soil* (EPA 2019), updated and expanded the 1993 Federal Guidance Report No. 12 to include age-specific reference person effective dose rate coefficients based on external exposure. The changes include updated tissue

weighting factors as recommended in ICRP Publication 103 and radionuclide decay data as provided in ICRP Publication 107, and with updated computing power, provides more precise calculations. While this change does not affect maximum contaminant levels, risk-based levels and risk assessment for external exposure would be affected.

Additionally, the 2016 Five Year Review Report (BNL 2016) indicates soil cleanup levels for radionuclides at OU1 are based on 15 millirem per year (mrem/year) above background. As stated in the EPA memorandum on *Radiation Risk Assessment At CERCLA Sites: Q&A* (EPA 2014a), the Superfund recommendation is now 12 mrem/year as the dose/based level protective of a target cancer risk of $1x10^{-4}$. This could also have some effect on risk-based levels of radionuclides in soil.

EXPOSURE PARAMETERS

In general, the changes in standard default exposure parameters from the EPA's memorandum *Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors*, OSWER Directive 9200.1-120 issued on February 6, 2014 (EPA 2014b) (2014 Standard Default Exposure Factors) served to raise risk-based concentrations. In most cases the mix of higher and lower individual parameters result in higher risk-based concentrations. For example, while the adult tapwater ingestion rate was increased from 2 liters per day (L/day) to 2.5 L/day, the child tapwater ingestion rate was decreased from 1 liter per day (L/day) to 0.78 L/day, and while the adult total body skin surface area was increased from 18,000 squared centimeters (cm^2) to 19,652 cm^2 the child's was decreased from 6,600 cm^2 to 6,365 cm^2. Combined with the increase in adult body weight from 70 kilograms (kg) to 80 kg and decreased total residential exposure duration from 30 years to 26 years, resulting tapwater regional screening levels increased overall.

The USEPA 2014 Standard Default Exposure Factors also indicate that the fish consumption rate which was 54,000 milligrams per day (mg/day) or 54 grams per day (g/day) should be determined on a site-specific basis. Note that a fish consumption rate of 54 g/day equates to approximately 2 meals per week and the Peconic River in the vicinity of BNL may not support sustained catches for 2 meals per week over a 52-week year for a 30- or 26-year residential exposure duration. The fish consumption rate used to establish national ambient water quality criteria is now 22 g/d, which represents the 90^{th} percentile consumption rate of fish and shellfish from inland and nearshore waters for the United States adult population 21 years of age and older, based on NHANES data from 2003 to 2010 (EPA 2014c). Recreational fish consumption is likely lower. Fish consumption rates should be reviewed in the event risk assessment or risk-based values protective of fish consumption are required in future Five Year Reviews or other documentation.

VAPOR INTRUSION

EPA guidance on conducting five-year reviews for vapor intrusion considers the following question:

> "Do components of the existing overall site remedy, even if not specifically designed to eliminate a vapor intrusion exposure pathway, currently prevent a potential vapor intrusion pathway or provide protection under a future vapor intrusion scenario?"

With respect to the statement in the 2016 Five-Year Review Report that MCLs are protective of vapor intrusion, there are constituents for which risk-based concentrations protective of vapor intrusion are lower than the MCLs. Carbon tetrachloride, a COC at OU III, being one of those constituents. One way to

assess whether remedies are protective of vapor intrusion is to compare shallow groundwater data to the EPA Vapor Intrusion Screening Levels (VISLs). When using the VISLs it is recommended to use site-specific system temperature. Certain site characteristics that can result in unattenuated or enhanced vapor transport preclude the use of the VISLs; these include:

- Significant openings to the subsurface that facilitate soil gas entry into the building (e.g., sumps, unlined crawl spaces, earthen floors) other than typical utility penetrations.
- Very shallow groundwater sources (e.g., depths to water less than five feet below foundation level).
- Significant routes for preferential, subsurface vapor migration whether naturally occurring (e.g., fractured bedrock) or anthropogenic routes.

As stated in the response to Comment 8 on the 2016 Five Year Review Report, the most recent guidance, OSWER Publication 9200.2-154, OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway From Subsurface Vapor Sources to Indoor Air, dated June 2015, will be referenced. In evaluation of shallow groundwater data in comparison to VISLs calculated with site-specific groundwater temperature, the buffer distances of 100 feet laterally or vertically from the boundary of a subsurface vapor source apply for non-petroleum-related COCs. For petroleum-related COCs, the EPA *Technical Guide For Addressing Petroleum Vapor Intrusion At Leaking Underground Storage Tank Sites* (EPA 2015) should also be consulted. For sources of vapors from dissolved petroleum constituents in groundwater, 6 feet of clean and biologically active soil is required to sufficiently attenuate vapors.

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BNL. 2016. Five-Year Review Report for Brookhaven National Laboratory Superfund Site (NY7890008975) Town of Brookhaven, Hamlet of Upton Suffolk County, New York. June 21, 2016

EPA. 2001a. Comprehensive Five-Year Review Guidance. EPA 540-R-01-007. OSWER Directive 9355.7-038-P. June.

EPA. 2001b. Five-Year Reviews, Frequently Asked Questions (FAQs) and Answers. OSWER Directive 9355.7-21. June.

EPA. 2003. Human Health Toxicity Values in Superfund Risk Assessments. OSWER Directive 9285.7-53. December.

EPA. 2013. Integrated Science Assessment for Lead. EPA/600/R-10/075F. June.

EPA. 2014a. Memorandum on Distribution of the “Radiation Risk Assessment At CERCLA Sites: Q&A”. OSWER 9285.6-20. June.

EPA. 2014b. Memorandum on Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. OSWER Directive 9200.1-120. February.

EPA. 2014c. Estimated Fish Consumption Rates for the U.S. Population and Selected Subpopulations (NHANES 2003-2010). EPA-820-R-14-002. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

EPA. 2015. Technical Guide for Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites [EPA 510-R-15-001]. Office of Solid Waste and Emergency Response, Office of Underground Storage Tanks.

EPA. 2016. Memorandum on Updated Scientific Considerations for Lead in Soil Cleanups. OLEM Direction 9200.2-167. December.

EPA. 2019. External Exposure to Radionuclides in Air, Water and Soil. EPA-402/R19/002. August.

National Toxicology Program (NTP). 2012. NTP Monograph, Health Effects of Low-Level Lead. June.

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for the U.S. Department of Energy

Memo

date: *October 23, 2020*
to: *Bill Dorsch* 10/23/20
from: *Steve Moss, Dennis Quinn, CHP (DAQ, Inc.)*
subject: *High Flux Beam Reactor (HFBR) Review Update for 2020*

In terms of changes to the prior Review Memo dated October 1, 2015, (Ref. 1); note the following changes or additions:

Section 2 – Review of Remedy Selection

In the 4th Line, insert "The control rod blades were removed and shipped offsite in 2009."

In subsection b) Phased Decontamination and Dismantlement, delete the phrase "by the Fiscal Year (FY) 2020" from the first sentence.

Section 3 – Actions to Date

The HFBR has a routine surveillance and maintenance performed on a quarterly basis. An annual structural and roof inspection is also performed of the facility and documented in a report. Routine radiological surveys are performed and inspections conducted to ensure radiological postings are maintained. Over the period of October 2015 through September 2020, several minor repairs were made to the leak detection system, repairs to the alarm system, and replacement of lighting, along with several other minor issues associated with the maintenance of the facility. The Long-Term Surveillance and Maintenance Manual for the High Flux Beam Reactor (Ref. 2) documents the required inspections and frequencies.

The old Reactor Maintenance Group Shop, previously considered a part of the HFBR Facility, attached to but outside the Dome structure has been segmented (removed) from Facility Authorization Basis, and is no longer considered a part of the HFBR D&D Project for Safety Basis Document commitment purposes. It may be used by other organizations in accordance with BNL Standards and Practices defined by BNL SBMS documents.

In 2016, isolation valves were added to the exterior sample line for the environmental monitoring system at the HFBR. Also in 2016, the outer door to the HFBR Generator Room (outside though connected to the dome with an isolation door), was provided with exterior louvers to resolve a long-standing problem with condensation in the Generator room. The interior of the Generator Room remains isolated from the dome structure interior.

In 2018, repairs/replacement of a sheet metal vent cover attached to the outer concrete at the HFBR on the southwest side was done, requiring drilling into the concrete about 1" deep to secure with bolts.

In August 2020, the start of the HFBR Stack Demolition Project mobilized and is currently underway. It is entirely under the control of DOE, with technical oversight provided by the Army Corps of Engineers, with work being performed by the selected contractor(s). Physical demolition of the stack is currently scheduled for completion this calendar year, notwithstanding COVID-19 or; severe weather conditions precluding work on the stack. Administrative closeout is planned by July 2021.

(It should be noted that previously the stack silencer baffles were removed and final status survey for remaining HFBR Outside Area was performed ~ 2011, which should have been included in the 2015 memo,)

Section 4 – Review of Improvements in Decontamination Techniques and Decommissioning Activity

2nd Paragraph should be revised to read as follows:

"We are not aware of any changes in the dismantling methods that would significantly change the time of dismantlement or the risk to personnel performing the work, since the last report (2015). Long term storage of nuclear facilities prior to dismantlement and decommissioning is a common practice in the U.S. commercial sector. Currently ten (10) power plants are undergoing or transitioning to active decommissioning while fourteen (14) power plants are in long-term safe storage. The length of time planned for long-term safe storage varies, but the estimated final closure dates for several plants extend to between 2031 and 2065."

Section D – Review of DOE Requirements for Changing the Current Plans

At the end of the 10th Bullet is a discussion of the V-14 Port radiation measurements in 2010 and 2015 provided to confirm that radioactive decay is occurring at the modeled rate. By way of radiological update see the new attached analysis, which continues to confirm the measured values closely correspond with initial modeling estimates. [See attached]

5 Year Review of Radiological Decay for the High Flux Beam Reactor (HFBR) 65 Year Safe Storage (Decay) Period (Ref. 3 – copy attached).

In the final section – Summary and Conclusion, should be revised to say:
"Based on the close agreement between actual (2010, 2015 and 2020 dose readings) and predicted radiation levels, the calculated dose rates for the large activated components are also expected to be reasonably accurate. Therefore, there is no reason to change the safe storage (decay) period of 65 years."

References

(1) BNL, 2015, Memo dated October 1, 2015, from T. Sullivan to W. Dorsch, with subj: High Flux Beam Reactor (HFBR) Review.

(2) BNL, 2018, Long-Term Surveillance and Maintenance Plan for the High Flux Beam Reactor (HFBR) Brookhaven National Laboratory, New York, Rev 5, August, 2018.

(3) DAQ, Inc. High Flux Beam Reactor – 5 Year Review of Radioactive Decay for the High Flux Beam Reactor (HFBR) 65-Year Safe Storage (Decay) Period, prepared by Dennis Quinn, CHP, August 2020.

* * *

BROOKHAVEN
NATIONAL LABORATORY

High Flux Beam Reactor

5 Year Review of Radiological Decay for the High Flux Beam Reactor (HFBR) 65-Year Safe Storage (Decay) Period

August 2020

Prepared by:

DAQ, Inc. for

Brookhaven National Laboratory
Environmental Restoration Projects
Upton, New York 11973

Prepared by: Dennis Quinn **Date:** 8/19/2020

Dennis Quinn, CHP

5 Year Review of Radiological Decay for the HFBR 65-Year Safe Storage Period

Purpose

The purpose of this document is to calculate the expected decay for HFBR large activated components over the previous 5 years and to determine if the information gathered from radiation surveys warrant a change in the 65-year safe storage period specified in the High Flux Beam Reactor (HFBR) Record of Decision (ROD).

Background Information

The HFBR ROD stated that the following additional investigations would be performed:

- Perform radiation surveys (measurements of radiation levels) after the removal of the Control Rod Blades (CRB) from the reactor vessel. (complete)
- Reevaluate the dose rate at 1 ft from the large activated components (reactor vessel, thermal shield, and biological shield) based on the radiation surveys. (complete)
- Using the reevaluated dose rates, determine the decay period necessary for the dose rate at 1 ft to fall below 100 mrem/hr for the large activated components, including the limiting component. (complete)
- Use the results of the radiation surveys every 5 years to assess the feasibility of shortening the decay period.

Basis for the 65-year Safe Storage (Decay) Period

For activated components involving short-lived radioisotopes, decay-in-storage results in a substantial reduction in dismantlement and waste management risks, hazards, project complexity, and cost.

The 65-year safe storage (decay) period was selected based on the estimated time when the radiation dose rates associated with the large components (reactor vessel, thermal shield, and biological shield) would be reduced below 100 mrem/hr at a distance of 1 ft in air from the component. These large components will need to be segmented because they are too large and too heavy to fit into transportation casks in one piece. Currently, because of the high radiation dose rates, these components would need to be segmented and handled under water. Several feet of water would be needed to serve as a radiation shield to protect the workers from the high radiation levels. Therefore, a waiting period to allow radioactive decay to reduce the radiation dose rate to below 100 mrem/hr at a distance of 1 ft. At this dose rate, it would not be necessary to perform the segmentation and handling operations under water.

The 100 mrem/hr value was selected because it is the standard nuclear industry benchmark used to distinguish a “radiation area” from a “high radiation area.” More importantly, the segmentation of the large components could be carried out in “air” (i.e., without the need to perform the work under water).

Based on detailed activation analysis conducted in 2007, the 100 mrem/hr dose rate for the limiting large component (the component with the highest dose rate, the thermal shield) will be

reached after a decay period of approximately 65 years. Figures 1 and 2 show, in increasing detail, the dose rates for the large activated components from 2007 to 2072 and 2032 to 2087, respectively. As shown in Figures 2 and 3, the 100 mrem level for the thermal shield is reached after a decay period of approximately 65 years.

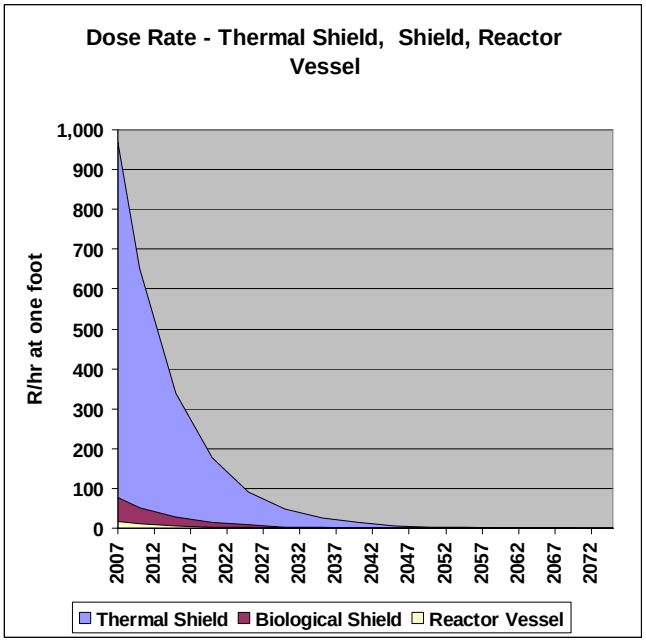

Figure 1 – Dose Rate 2007 – 2072

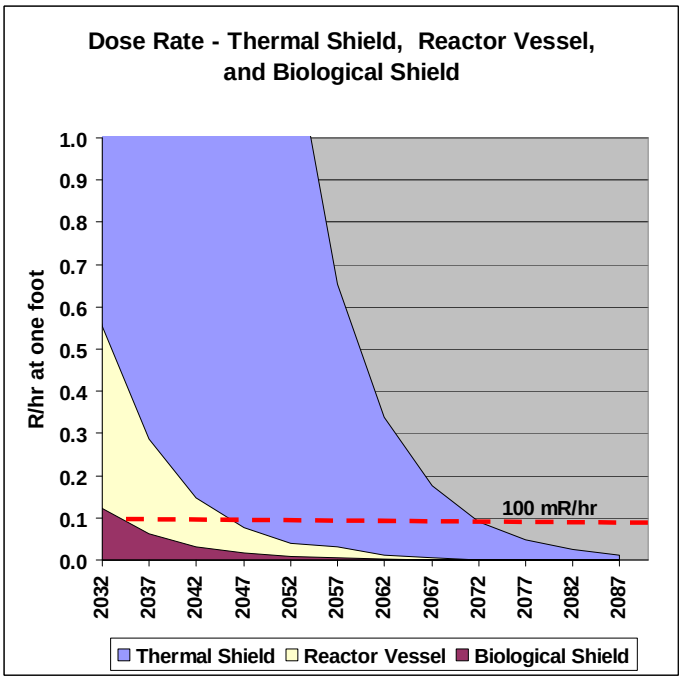

Figure 2 – Dose Rate (Detail) 2032 – 2087

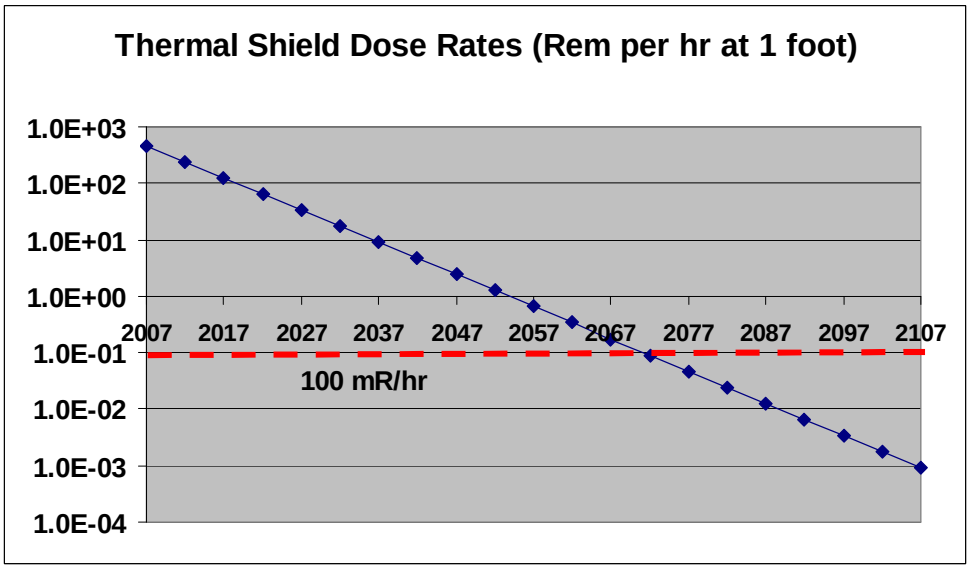

Figure 3 – Thermal Shield Dose Rates 2007 – 2107

The calculated dose rates for large activated components (based on activation analysis) are presented in Table 0.

Table 0 - HFBR Large Activated Components: Calculated Dose Rates with Radioactive Decay

Component	Dose Rate 2007	Dose Rate - 50 years (2057)	Dose Rate - 65 years (2072)
Reactor Vessel	15,000 mR/hr	21 mR/hr	3 mR/hr
Thermal Shield	471,000 mR/hr	650 mR/hr	91 mR/hr
Biological Shield	3,000 mR/hr	5 mR/hr	< 1 mR/hr

Recognizing that there are uncertainties inherent in activation analyses, the requirement to conduct an evaluation based on radiation surveys conducted after the removal of the CRBs from the reactor vessel was included in the HFBR ROD.

Radiation Decay Calculations

Inventories of HFBR components were calculated based on the previously determined radionuclide mix and the radioactivity was decayed to 7/1/2020. These calculations include the following:

- Table 1: Reactor Vessel Internals
- Table 2: Reactor Vessel
- Table 3: Thermal Shield
- Table 4: Biological Shield and Liner

Table 1: HFBR Reactor Vessel Internals – Radiological Inventory 7-1-2020

Internal Component	C-14	Fe-55	Co-60	Ni-59	Ni-63	Zn-65	Nb-94	Tc-99	Total for Component
Grid Plate w/ Aux Blade Guide		7.9E-01	9.2E-01	1.0E-01	3.0E+01	9.9E-09			**3.14E+01**
Saddle		7.6E-02	8.9E-02	9.8E-03	2.9E+00	9.6E-10			**3.06E+00**
Flow Shroud		3.6E-02	4.2E-02	4.6E-03	1.3E+00	4.5E-10			**1.42E+00**
Core Edge Thimble		1.3E-01	1.6E-01	1.7E-02	5.0E+00	1.7E-09			**5.31E+00**
Fast Thimble		1.4E-01	1.7E-01	1.8E-02	5.4E+00	1.8E-09			**5.71E+00**
Transition Plate	1.0E+01	1.2E+02	8.5E+02	2.3E+01	4.8E+03		4.7E-02	4.2E-04	**5.84E+03**
Anti-Critical Grid	7.6E-01	9.2E+00	1.1E+02	4.7E+00	5.2E+02		4.1E-03	3.7E-05	**6.48E+02**
Anti-Critical Grid Holdown Nuts	7.4E-02	8.9E-01	7.4E+00	2.3E-01	4.0E+01		3.6E-04	3.2E-06	**4.84E+01**
Grid Plate Holdown Bolts	1.5E-01	1.7E+00	1.2E+01	3.1E-01	6.6E+01		6.6E-04	5.9E-06	**7.99E+01**
Grid Plate Holdown Studs	5.6E-02	6.7E-01	5.6E+00	1.8E-01	3.0E+01		2.7E-04	2.4E-06	**3.67E+01**
Saddle Holdown Cap Screws	1.2E-01	1.5E+00	1.2E+01	3.9E-01	6.6E+01		5.9E-04	5.3E-06	**8.01E+01**
Grid Plate Locating Pins	2.1E-02	2.5E-01	1.7E+00	4.5E-02	9.5E+00		9.4E-05	8.4E-07	**1.14E+01**
CRB Support Tubes	2.7E-05	3.3E-04	4.0E-03	1.8E-04	1.9E-02		1.4E-07	1.5E-07	
Main CRB Rack Assembly	3.2E-05	3.9E-04	4.8E-03	2.1E-04	2.2E-02		1.7E-07	1.8E-07	
Aux CRB Rack Assembly	3.8E-02	4.6E-01	5.6E+00	2.5E-01	2.6E+01		2.0E-04	2.2E-04	
Total Reactor Internals	**1.2E+01**	**1.4E+02**	**1.0E+03**	**3.0E+01**	**5.6E+03**	**1.5E-08**	**5.4E-02**	**7.0E-04**	**6.82E+03**

Table 2: HFBR Reactor Vessel – Radiological Inventory 7-1-2020

Portion of Reactor Vessel	Fe-55	Co-60	Ni-59	Ni-63	Zn-65	Total for Component
Vessel Sphere - top 1/3	1.1E+00	1.3E+00	1.4E-01	4.3E+01	1.4E-08	**4.52E+01**
Vessel Sphere - Center 30"	2.7E+00	3.1E+00	3.4E-01	1.0E+02	3.4E-08	**1.08E+02**
Vessel Sphere - Bottom 1/3	9.7E-01	1.1E+00	1.2E-01	3.6E+01	1.2E-08	**3.87E+01**
Vessel Cylinder Bottom 3 ft	3.4E-03	4.1E-03	4.4E-04	1.3E-01	4.3E-11	**1.38E-01**
Total	**4.8E+00**	**5.6E+00**	**6.1E-01**	**1.8E+02**	**6.0E-08**	1.92E+02

Table 3: HFBR Thermal Shield - Radiological Inventory 7-1-2020

Portion of Thermal Shield	C-14	Fe-55	Co-60	Ni-59	Ni-63	Nb-94	Tc-99	Total for Component
Upper Thermal Shield	1.5E+00	1.4E+02	1.1E+02	3.6E+00	3.8E+02	9.3E-03	9.0E-08	**6.3E+02**
Lower Thermal Shield	5.7E+00	5.1E+02	3.9E+02	1.1E+01	1.3E+03	3.4E-02	3.1E-07	**2.2E+03**
Total	**7.2E+00**	**6.5E+02**	**4.9E+02**	**1.4E+01**	**1.7E+03**	**4.3E-02**	**4.0E-07**	**2.9E+03**

Table 4: HFBR Bioshield and Liner - Radiological Inventory 7-1-2020

Portion of Biological Shield	H-3	C-14	Ca-41	Fe-55	Co-60	Ni-59	Ni-63	Nb-94	Tc-99	Total for Component
Bioshield Concrete	3.4E+00	2.7E-02	3.4E-02	2.4E+00	1.5E+00	4.8E-02	5.1E+00	1.3E-04	4.4E-09	**1.24E+01**
Bioshield Liner	0.0E+00	8.8E-03	0.0E+00	8.0E-01	6.1E-01	2.1E-02	2.2E+00	5.3E-05	5.1E-10	**3.61E+00**
Total Bioshield	**3.4E+00**	**3.6E-02**	**3.4E-02**	**3.2E+00**	**2.1E+00**	**6.9E-02**	**7.3E+00**	**1.8E-04**	**4.9E-09**	**1.60E+01**

Radiation Surveys

Following the removal of the CRBs, a radiological survey was conducted inside the HFBR Reactor Vessel inside the V-14 port on 6/29/2010. The detector was lowered into the reactor vessel at locations 2 feet, 4 feet, and 10 feet below the Reactor Vessel Flange. This survey was then repeated on 6/3/2015 and most recently on 7/29/2020. The July 2020 survey is included as Attachment 1.

Table 5 provides a comparison of the survey data from 2010, 2015, and 2020. The readings at 10' below the flange are expected to be the most accurate, as they will be the closest to the activated components, in particular, the transition plate. The transition plate dose rate is dominated by Cobalt-60 (Co-60), so the dose rate is expected to follow the decay of Co-60. The reduction of the 10' reading dose closely follows the fraction of Co-60 in the transition plate.

Table 5: HFBR Measured Dose Rates inside Reactor Vessel

Survey Location	6/29/2010 (mR/hr)	6/3/2015 (mR/hr)	7/29/2020 (mR/hr)
2' below vessel flange	0	0	1
4' below vessel flange	2	3	1
10' below vessel flange	12	6	3
fraction of 6/29/10 dose rate	1.00	0.50	0.25
Co-60 in transition plate (Curies)	3166	1656	840
Fraction of 6/29/10 Curies	1.00	0.52	0.27

Summary and Conclusion

1. Calculations were performed to update the radiological inventory of the HFBR.
2. A survey was performed to determine if the radiological decay was proceeding as expected based on the previously determined radionuclide mix, and the reduction in dose rate closely matches the predicted reduction.
3. Based on this close agreement between actual and predicted radiation levels, the calculated dose rates for the large activated components are also expected to be reasonably accurate. Therefore, there is no reason to change the safe storage (decay) period of 65 years.

Attachment 1: Radiation Survey of HFBR Reactor Vessel on 7/29/2020

RADIOLOGICAL SURVEY FORM
FS-SOP-1000

REASON FOR SURVEY: ■ ROUTINE 5 Year ☐ SPECIAL ____ ■ RWP# GPG-20-001 ☐ WP# ____

LOCATION / EQUIPMENT: Bldg 750 OPS Level Pile Top | DATE: 07/29/20 | TIME: 1430

Notes:

-5 Year survey of V-14 Port for dose rates.

-Reading at 2 feet: 0.0 mR/hr

-Reading at 4 feet: 1.0 mR/hr

-Reading at 10 feet: 3.0 mR/hr

-LAW of flange and inside port opening, floor around cover plate and AMP-100 probe and cord after survey all < 1K dpm/LAW.

-Frisk of AMP-100 probe and cord ≤ BKG, BKG = 60 cpm.

Distances were measured out with a tape measure and marked with a smear on the cable prior to survey. The picture shows the probe in the V-14 port at 10 feet.

INSTRUMENT

Model #	Serial #	CAL DUE
Lud-3	50524	07/07/21
AMP-100	IN06945	07/27/21
N		A
N		A

LEGEND

○ - SMEAR SURVEY LOCATION △ - AIR SAMPLE LOCATION
□ - MASSLINN SURVEY LOCATION # - DIRECT FRISK LOCATION
C̄ - CONTAMINATION AREA * Contact Dose Rate
XXXY/ZZZ XXX = contact reading Y = radiation type ZZZ = reading @ 30cm

AIRBORNE ACTIVITY SURVEY

Sample #	Duration	Flow Rate	Field Analysis cpm	Field Analysis µCi/cc	% DAC
N/A					

DOSE RATE (HIGHEST)

CONTACT READING	See Notes
GENERAL AREA READING	NA

MASSLINN SURVEY RESULTS (in dpm)

1.	<1K dpm	5.	N/A
2.	NA	6.	
3.		7.	
4.		8.	

SMEAR SURVEY LOCATIONS (dpm/100cm²) α, β-γ, ³H

1. NA	8.	15.
2.	9.	16.
3.	10.	17.
4.	11.	18.
5.	12.	19.
6.	13.	20.
7.	14.	21. NA

Surveyed By: Rovig Date: 7/30/20 Reviewed By: Date: 8-4-20

FS-SOP-1000
Attachment 9.2

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managed by Brookhaven Science Associates
for the U.S. Department of Energy

BROOKHAVEN NATIONAL LABORATORY

Memo

date: *October 1, 2015*
to: *Bill Dorsch*
from: *Terry Sullivan*
subject: *High Flux Beam Reactor (HFBR) Review*

1) Introduction

As part of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Environmental Protection Agency (EPA) requires a review of Brookhaven National Laboratory's (BNL) environmental remediation efforts on a five year cycle. As part of this review an evaluation of the remediation of the High Flux Beam Reactor (HFBR) is required (BNL, 2009). The 2007 High Flux Beam Reactor (HFBR) Feasibility Study (FS) provided several options for decontamination and decommissioning (D&D) of the HFBR (BNL, 2007). The cleanup alternative that best balances the National Contingency Plan's remedy selection criteria was Phased Decontamination and Dismantlement with Near-Term Control Rod Blade Removal. This alternative is known as Alternative C in the Proposed Remedial Action Plan. The selected remedy involves land use and institutional controls (LUICs) to protect the site and surveillance and maintenance (S&M) to allow radioactive decay to reduce the dose rates to levels that minimize risk to workers and minimize costs associated with D&D.

The Record of Decision (ROD) states that the Department of Energy will conduct five-year technical reviews of the remedy in accordance with DOE five-year review guidance to determine the feasibility of reducing the safe storage (decay) period and completing the HFBR cleanup earlier taking into consideration the following factors (BNL, 2009):

- Advancements in cleanup technologies and transportation methods
- Availability of waste disposal facilities
- Changes in standards and regulations for worker, public, and environmental protection
- Worker safety impacts
- Environmental impacts
- Public health impacts
- Economic impacts
- Land use
- Existing stabilization and safety of the facility and hazardous materials
- Projected future stability and safety of the facility and hazardous materials

If this technical review identifies a remediation method that demonstrates the potential to be implemented before the selected decay period ends while showing substantial improvements

to the above criteria, analysis of that potential method will be initiated and possibly implemented.

2) Review of Remedy Selection

In 2007 the estimated inventory of the HFBR complex was 65,000 Curies and the peak dose rate from the most activated component was close to 1000 Rem/hr at a distance of one foot in air. The most radioactive components were the thermal shield, control rod blades, and reactor internals. The activated components are large and would require cutting to fit into transportation casks. The initially high dose rate would make handling of the activated components difficult and would require cutting operations to be performed under water to provide shielding. The nuclear industry standard to separate a high radiation area from a radiation area is a dose rate 100 mrem/hr at 1 foot in air. For this reason, a dose rate of 100 mrem/hr was chosen as the level to begin dismantlement of the reactor components if a long storage period was selected. Figure 1 shows the predicted dose rate at 1 foot from the major reactor components over time. The dose rate from the highest activity component will decrease below 100 mrem/hr in 2072.

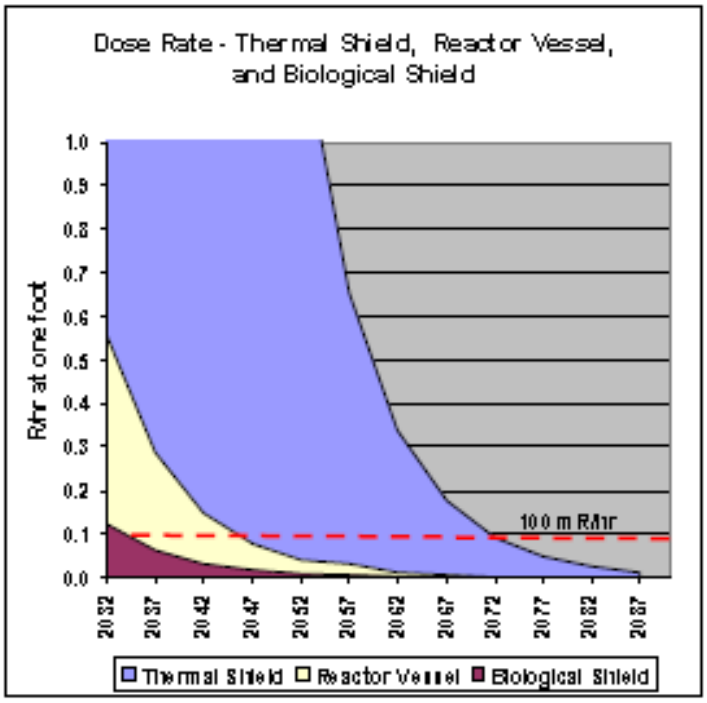

Figure 1 Predicted dose rate in various components in 2032 - 2087.

In the Feasibility Study four potential remediation approaches were considered:

a) ***No Additional Action*** would include those actions already completed. Alternative A would also include the continuation of S&M and the use of LUICs for an indefinite period of time to ensure the protection of human health and the environment.

b) ***Phased Decontamination and Dismantlement*** would include the near-term removal, by Fiscal Year (FY) 2020, of the HFBR ancillary structures as described in Section 1.2, contaminated underground duct and piping systems, and small areas of contaminated soil outside the confinement building footprint. The activated components would remain in

place inside the confinement building for a decay period not to exceed 65 years to allow for the natural decay of these high dose rate radioactive components. At the conclusion of this radioactive decay period, the balance of the HFBR complex would be dismantled and removed. This alternative provides for the complete removal of the HFBR complex with the possible exception of the subsurface concrete structures of the confinement building base mat and stack foundation. However, the final decision to leave either of these sub-structures in place will be determined on the basis of radiological sampling and dose assessment. Alternative B would also include the continuation of S&M and the use of LUICs throughout the period of radioactive decay to ensure the protection of human health and the environment. The cleanup, after dismantlement of the confinement building, would satisfy the dose-based cleanup goal of 15 mrem/year and methodology specified in the Operable Unit I (OU I) ROD. After dismantlement, there will be no need for any additional period of LUICs.

c) ***Phased Decontamination and Dismantlement With Near-Term Control Rod Blade Removal,*** consists of the same actions as those included in Alternative B. Alternative C results in the same end state as that of Alternative B, the complete removal of the HFBR complex. The difference is limited to the timing of the decontamination and dismantlement activities. Alternative C would include the near-term removal of the HFBR ancillary structures, contaminated underground duct and piping systems, and small areas of contaminated soil. Alternative C also includes the near-term removal, transportation, and disposal of the CRBs and beam plugs by FY 2020.

d) ***Near-Term Decontamination and Dismantlement,*** includes the complete near-term removal of the HFBR complex by FY 2026.

Alternative C was selected as the Selected Alternative, This plan removes the control rods and beam plugs by 2020, stores the remaining reactor structure and activated components for 65 years (until 2073) and removes the remaining equipment at that time.

3) Actions to Date

After the reactor shutdown in 1998 BNL has made significant efforts to remove and dispose of contaminated components, structures, water, and soil at the HFBR complex. These include:

- The spent fuel was removed and sent to an off-site facility (1998).
- The primary coolant (heavy water) was removed and sent to an off-site facility (2001). Scientific equipment was removed and is being reused or has been sent to an off-site disposal facility (2003).
- Shielding and chemicals were removed and are being reused at BNL and other facilities (2000--2005).
- The cooling tower superstructure was dismantled and disposed of as waste in 1999.
- The confinement structure and spent fuel canal were modified to meet Suffolk County Article 12 requirements (2004).
- Stack monitoring facility (Building 715) was dismantled and removed (2006).
- Cooling tower basin and pump/switchgear house (Buildings 707/707A) were dismantled and removed (2006).
- Water treatment house (Building 707B) was dismantled and removed (2006).

- Cold neutron facility (Building 751) contaminated systems were removed and the clean building has been transferred to another BNL site organization for re-use (2006).
- Guard house (Building 753) was dismantled and removed (2006).
- Cleanup of the Waste Loading Area and removal of Building 801-811 waste transfer lines (A/B waste lines with co-located piping) and associated soil were completed and documented in completion/closeout reports (2009).
- Stabilization activities for the HFBR confinement building (Building 750) were completed (2009 – 2010).
- Control rod blades and beam plugs were removed and disposed (2009).
- The HFBR underground utilities and associated contaminated soils were removed and disposed. (2010).
- Final Status Survey (FSS) and Independent Verification Survey (IVS) were completed for HFBR outside Areas (2010).
- The Fan Houses (Buildings 704 & 802) were dismantled, the associated contaminated soil was removed and project wastes were disposed (2010 – 2011).

In addition to removal actions the HFBR operates with Land Use and Institutional Controls to prevent unintended access to the site and routine surveillance and maintenance (S&M).

HFBR Land Use and Institutional Controls (LUICs)
The HFBR remedy includes the continued implementation of LUICs in accordance with the LUCMP.
These include:

- Measures for controlling future excavation and other actions that could otherwise disturb residual subsurface contamination.
- Land use restrictions and an acceptable method for evaluating potential impact that the remaining contaminants have on future development.

Periodic certification to EPA and NYSDEC stating that the institutional and engineering controls put in place are unchanged from the previous certification, and that nothing has occurred that would impair the ability of the control to protect public health or the environment or constitute a violation or failure to comply with the site management plan.

HFBR System Operations/O&M
Long-term S&M activities are being conducted in accordance with the *Long-Term Surveillance and Maintenance Plan for the HFBR (BNL 2010a*) to ensure effectiveness of the remedy. The BNL LUCMP contains site wide control measures and land-use restrictions to prevent exposure to environmental contamination and to protect the integrity of remedies specified within the ROD.

4) Review of Improvements in Decontamination Techniques and Decommissioning Activity

Decommissioning of nuclear reactors is primarily a deconstruction project. As such the field is mature and the technologies for cutting, scabbling, and other surface removal processes have been used for many years. In communications with Larry Boing, Decommissioning Subject Matter Expert at Argonne National Laboratory, he said the major advances have been in cutting and scabbling tools using pressurized liquid nitrogen. The advantages of these tools are that they can be remote operated, have a high efficiency (>95%) waste

collection, they do not use chemicals, do not produce a secondary waste stream, and do minimal damage to the surface. The operating speed for cutting or scabbling is better than conventional techniques. The equipment has been hardened to allow use in a nuclear facility. The main disadvantage of the system is expense. For large jobs, the increased operating rates can lead to cost savings. While this tool is an improvement over existing tools, it cannot be used underwater as would be required for the activated components of the HFBR. Mr Boing stated that there has not been any major improvement in underwater cutting techniques in the last five years.

Long term storage of nuclear facilities prior to dismantlement and decommissioning is a common practice in the U.S. commercial sector. Currently three power plants are undergoing decommissioning while twelve plants are in long-term storage. A major concern with commercial power plants is that there is no disposal pathway for spent fuel. This causes all of the power plants to develop an Independent Spent Fuel Storage Installation (ISFSI). The ISFSI are often a cause for public concern as the facility becomes a defacto spent fuel storage facility. Vermont Yankee Nuclear power plant stopped operations in December 2014 planning for long term storage before decommissioning. The potential presence of the ISFSI has led to major public concerns and the local community is trying to find a way to make the site owners remove the fuel from the site.

Savannah River has used an entombment process for decommissioning their nuclear reactors. In this approach, all below grade piping is filled with concrete and left in place. The reactor fuel is removed and the remaining core structure is also filled with concrete. Above grade equipment is removed from the building. This technique reduces the decommissioning costs by a factor of about 4. However, the entombed reactors are effectively low-level waste disposal sites, which are not allowed in New York State.

At the DOE Hanford site they have used the process of “cocooning” for interim safe storage (ISS) before decommissioning. Cocooning is the process of demolishing all but the shield walls surrounding the reactor core, removing or stabilizing all loose contamination within the facility, and placing a new roof on the remaining structure. A single doorway in the structure is installed to provide access for surveillance and maintenance work. This doorway is welded shut, and all other openings in the shield walls are sealed to prevent intrusions and the release of radioactive materials. The facility is inspected every five years and remotely monitored at all times for changes in moisture and temperature. Cocooning was chosen at Hanford to reduce the foot print and remove any concerns with the concrete buildings built in the 1940’s and early 1950’s. The structural stability of the HFBR hemispherical dome is sound and removal of the dome is problematic as compared to the rectangular walls for the Hanford Reactors. The eight reactors at the Hanford site were originally supposed to undergo safe storage for 75 years prior to a one-piece removal action and disposal at the Hanford site. The original cost estimates for this approach were much less than for dismantlement and disposal. Experience in the one-piece removal of two other reactors showed that the costs were more expensive than originally estimated and costs are comparable to the dismantlement and disposal approach. Therefore, the Hanford site has received agreement to consider dismantlement and disposal within 20 years. At this time, it is still planned to store the reactors for 75 years.

D) Review of DOE requirements for changing the current plans.

- ***Advancements in cleanup technologies and transportation methods***

Removal of the reactor and its components would require underwater cutting for size reduction to fit into shipping containers. There have been no major advances in this field in the past several years. However, operating experience has improved and the process has become more efficient in minimizing cloudiness in the water due to cutting debris.

- ***Availability of waste disposal facilities***

The availability of waste disposal facilities has not changed. This option is likely to remain available in the future. The larger more radioactive pieces of waste will be disposed of at a DOE facility. Smaller less radioactive waste may be disposed of at a commercial facility. The country needs at least one commercial facility to handle medical wastes and wastes from nuclear power plants. Therefore, commercial capacity is likely to be available in the future.

- ***Changes in standards and regulations for worker, public, and environmental protection***

There has not been a change in the standards for worker, public or environmental protection in the last five years. Although these may change in the future, there is no current activity to change existing limits and regulations. There has been activity to revise 10 CFR part 61, the Nuclear Regulatory Commission's, regulations for low-level waste disposal. The proposed changes primarily address waste acceptance criteria and the time period for performance assessment. Protective limits in the proposed revised standard are unchanged.

- ***Worker safety impacts***

The current concept for storage until 2073 is more protective of the worker than removal at an earlier time. Earlier removal will cause higher worker dose and risk.

- ***Environmental impacts***

The activated materials are contained within the HFBR structure and do not provide an immediate environmental risk. To confirm that the storage process does not degrade the environment, an active Surveillance and Maintenance (S&M) program monitors for groundwater contamination from the building. Periodic inspections of the building interior are performed to confirm there is no water intrusion and that major degradation of the reactor structure is not occurring.

- ***Public health impacts***

There are no public health impacts from the long-term storage of the HFBR. Over 99% of the radioactivity is in the activated components of the reactor. These components are encased in the biological shield which is made of eight feet of steel reinforced concrete. There are several physical barriers to the site that prevent access of the public to the areas of contamination. The S&M program monitors the air, soil, and groundwater around the HFBR to confirm that release is not occurring and that the public is not impacted.

- ***Economic impacts***

The FS examined costs for each remedial option. The option to remove all of the components by the year 2025 was $205M, while the cost for the selected alternative was $144 M. The selected alternative involved removing the beam plugs and storing the reactor for 65 years. This storage time allows for substantial radioactive decay that leads to reductions in worker dose, shipping costs, and disposal costs.

- ***Land use***

The HFBR is located within BNL boundaries. BNL is a DOE research facility and is expected to remain so for the foreseeable future. Access to the BNL site is restricted and controlled. The use of this land for safe storage does not impact other operations at BNL. BNL has adequate land to expand as research and operational needs dictate and the long-term storage at the HFBR facility is not an issue.

- ***Existing stabilization and safety of the facility and hazardous materials***

The existing facility is stable and undergoes a routine surveillance and maintenance plan. The air, soil, and groundwater around the facility are monitored to make sure that releases of hazardous or radioactive materials are not occurring.

- ***Projected future stability and safety of the facility and hazardous materials***

Access to the site is controlled. The facility will be maintained following the agreed upon Surveillance and Maintenance Plan. If conditions change in the future actions will be taken to ensure the stability of the facility.

Additional reasons that could lead to a reduction in the storage time include:

a) The desire by DOE to reduce institutional risks at an earlier time
b) Concerns over the stability of the HFBR facility, and
c) Discovering that the initial estimates of radioactivity remaining in the structure are biased high. The original estimates were based on calculations that require a detailed operational history and knowledge of the exact composition of the radiological components. The calculated estimates are then compared with the measured radiation field and refined if there is not good agreement.

The original determination by DOE was that the additional cost (>$50 million) for earlier removal was not sufficient to select to remove the equipment sooner to reduce institutional risks at an earlier date. Additionally, worker risks would increase with earlier removal and this is not desireable.

At the current time, there is little public pressure to remove the reactor components at an earlier time. The facility has controlled access and is monitored for releases of radioactive material and undergoes an active surveillance and maintenance program. Any issues must be reported to federal and state regulators.

As part of the surveillance plan, measurements of the radioactivity level in the reactor core are made every five years (BNL, 2012). Dose rate measurements were made in 2009 during the Control Rod Blade removal process (BNL, 2010). The measured values were within the expected range based on calculations. Additionally, radiation measurements were made of the control rod blades and end plugs when they were removed in 2009. The control rod blades contained two parts, the main control rod blade and the auxiliary control rod blade. Predicted dose rates were within 1% on the main control rod blade and 8% on the auxiliary control rod blade. This agreement suggests that the selected decay period is appropriate.

Radiation measurements of the V-14 port were conducted in 2010 and 2015 as a means to confirm that radioactive decay is occurring at the modeled rate. The V-14 port is at the top

of the reactor vessel. An AMP-100 probe is lowered into the port to depths of 2, 4, and 10 feet. The measured radiation dose is recorded at each level and provided in Table 1.

Table 1 Measured radiation doses at the V-14 port.

Depth (ft)	Dose (mr/hr) Sample Date (6/29/2010)	Dose (mr/hr) Sample Date (6/3/15)
2	0	0
4	2	3
10	12	6

Characterization and modeling suggest that the gamma dose measured by the probe is primarily from Co-60 with a 5.27 year half-life. Thus, it is expected that the dose will decrease by approximately a factor of 2 in the five years between measurements. The reading at 10 feet does show a factor of two decrease as expected. The reading at 4 feet shows an increase in dose between 2010 and 2015. This is likely due to measurement error as the inventory of radioactivity could not have increased over this time period. Attention should be paid to this reading in subsequent measurements. Additionally, it would be beneficial to report the dose rate to tenths of mr/hr to aid future evaluations of the decay rate. To summarize, the data at ten feet down the V-14 port suggest that decay is occurring as expected and the selected decay period (until 2073) is justified.

Conclusions

Based on the evaluation criteria specified in the ROD (BNL, 2009) and the match between the predicted and measured dose rates there is no reason to alter the current remedial action plan. This will be reviewed in five years.

References

BNL, 2007, Feasibility Study, Brookhaven High Flux Beam Reactor, Decommissioning Project, prepared by Brookhaven Science Associates for the U.S. Department of Energy, September 2007.

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BNL, 2010a, Long-Term Surveillance and Maintenance Plan for the High Flux Beam Reactor (HFBR) Brookhaven National Laboratory, New York, Rev 2, November, 2010.

BNL, 2012, Long-Term Surveillance and Maintenance Manual for the High Flux Beam Reactor (HFBR), Brookhaven National Laboratory, New York, Rev 3, November, 2012.

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Attachment 6

Operable Unit Cleanup Levels Matrix

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Operable Unit Cleanup Levels Matrix

OU	Contaminants of Concern	Cleanup Levels			Note any Changes to Cleanup Levels	Remedial Action Objectives
		Soil		Groundwater		
		Residential	Industrial			
I	Cesium-137	23 pCi/g	67 pCi/g			Prevent or minimize: 1. Leaching of contaminants from soil into groundwater, 2. Human exposure from surface and subsurface soil, 3. Uptake to ecological receptors. Rad soil cleanup levels are based on 15 mRem/year above background. The State ALARA goal is 10 mRem/year above background.
	Strontium-90	15 pCi/g	15 pCi/g	8 pCi/L		
	Radium-226	5 pCi/g	5 pCi/g			
	Lead	400 mg/kg				
	Mercury	1.84 mg/kg				
	1,2-Dichloroethane			0.6 µg/L		
	Chloroethane			5 µg/L		
II/VII	Cesium-137	23 pCi/g	67 pCi/g			Documented in the OU I, OU III and g-2/BLIP/USTs RODs.
	Tritium			20,000 pCi/L		
	Sodium-22			400 pCi/L		
III	1,1,1-Trichloroethane			5 µg/L		1. Meet MCLs for VOCs and tritium in Upper Glacial aquifer within 30 years, 2. Meet MCLs for VOCs in Magothy aquifer within 65 years, 3. Meet MCLs for Sr-90 in Upper Glacial aquifer within 40 years and 70 years at Chemical Holes and BGRR/WCF plumes, respectively.
	Tetrachloroethylene			5 µg/L		
	Carbon tetrachloride			5 µg/L		
	Ethylene dibromide			0.05 µg/L		
	Tritium			20,000 pCi/L		
	Strontium-90			8 pCi/L		
	PCBs	1 mg/kg - Surface NYSDEC TAGM	10 mg/kg - Subsurf. NYSDEC TAGM			
IV	Ethylbenzene			5 µg/L		Restore groundwater quality to MCLs or background, and prevent or minimize: 1. Leaching of contaminants from soil into groundwater, 2. Human exposure from surface and subsurface soil. Cleanup of radiologically-contaminated soil was performed under the OU I comprehensive soil cleanup.
	Toluene			5 µg/L		
	Strontium-90			8 pCi/L		

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OU	Contaminants of Concern	Cleanup Levels			Note any Changes to Cleanup Levels	Remedial Action Objectives
		Soil		Groundwater		
V	Mercury	2 mg/kg				Protect public health and the sole-source aquifer, monitor the groundwater, and prevent or minimize: 1. Migration of contaminants present in surface soil via surface runoff, 2. Human and environmental exposure from surface and subsurface soil, 3. Reduce site-related contaminants (e.g., mercury) in sediment to levels that are protective of human health, 4. Reduce or mitigate, to the extent practicable, existing and potential adverse ecological effects of contaminants in the Peconic River, 5. Prevent or reduce the migration of contaminants off BNL property.
	Cesium-137	23 pCi/g				
	Trichloroethene			5 µg/L		
VI	Ethylene dibromide			0.05 µg/L		1. Meet MCL for EDB in the Upper Glacial aquifer within 30 years, 2. Prevent or minimize further migration of EDB in groundwater vertically and horizontally.
VIII	PFOS			10 ng/L	New State MCL issued August 2020	Time Critical Removal Action underway in 2020 for installation of groundwater treatment systems downgradient of the Current and Former Firehouse PFOS/PFOA source areas.
	PFOA			10 ng/L	New State MCL issued August 2020	
	1,4-Dioxane			1.0 µg/L	New State MCL issued August 2020	

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OU	Contaminants of Concern	Cleanup Levels			Note any Changes to Cleanup Levels	Remedial Action Objectives
		Soil		Groundwater		
g-2/BLIP	Tritium			20,000 pCi/L		1. Prevent additional rainwater infiltration into activated soil shielding, 2. Inspect and maintain the caps and other stormwater controls at the source areas, 3. Conduct groundwater monitoring to verify the effectiveness of the stormwater controls, and monitor the downgradient portion of the g-2 plume until tritium concentrations decrease to below the MCL.
BGRR	Strontium-90	ALARA (1)	ALARA	8 pCi/L		1. Ensure protection of human health and the environment from the potential hazards posed by the radiological inventory that resides in the BGRR complex, 2. Use ALARA while implementing the remedial action, 3. Implement long-term monitoring, maintenance, and institutional controls to manage potential hazards.
	Cesium-137	ALARA	ALARA			

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OU	Contaminants of Concern	Cleanup Levels			Note any Changes to Cleanup Levels	Remedial Action Objectives
		Soil		Groundwater		
HFBR	Strontium-90	15 pCi/g	15 pCi/g	8 pCi/L		1. Control, minimize, or eliminate:1. All routes of future human and/or environmental exposure to radiologically contaminated facilities or materials, 2. The potential for future release of non-fixed radiological or chemical contamination to the environmen, 3. All routes of future human and/or environmental exposure to contaminated soils, and 4. The future potential for contaminated soils to impact groundwater.
	Cesium-137	23 pCi/g	67 pCi/g for WLA			

Notes:
pCi/g = picocuries per gram
pCi/L = picocuries per liter
mg/kg = milligrams per kilogram
µg/L = micrograms per liter
ng/L = nanograms per liter
TAGM = Technical and Administrative Guidance Memorandum
BLIP = Brookhaven Linac Isotope Producer
BGRR = Brookhaven Graphite Research Reactor
HFBR = High Flux Beam Reactor
ALARA = As Low as Reasonably Achievable
OU = Operable Unit
WLA = Waste Loading Area
MCL = Maximum Contaminant Level
EDB = Ethylene dibromide
PFOS = perfluorooctane sulfonate
PFOA = perfluorooctanoic acid
VOC = Volatile Organic Compound
ROD = Record of Decision
WCF = Waste Concentration Facility